QUEENSLAND DEPARTMENT OF PRIMARY INDUSTRIES
DIVISION OF PLANT INDUSTRY BULLETIN No. 714

NUTRIENT RESPONSES BY WHITE CLOVER ON A HUMIC GLEY SOIL AT CURRUMBIN, SOUTH-EAST COASTAL QUEENSLAND

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SUMMARY

The field nutrient requirements for white clover (*Trifolium repens* cv. Ladino) establishment and growth were examined on a humic gley soil at Currumbin, south-east coastal Queensland. Nutrient treatments applied in a $\frac{1}{2}$ x 2^6 factorial design were lime, phosphorus potassium, sulphur and molybdenum plus a composite treatment of copper, zinc, boron, manganese and magnesium. Dry matter yield and nitrogen and phosphorus contents of white clover and weeds were recorded from April 1969 to January 1970.

Lime application gave the highest dry matter response but the difference between 2·5 and 5·0 t ha^{-1} disappeared with time. It was concluded that lime was the principal requirement for white clover establishment on this soil.

I. INTRODUCTION

South of Brisbane, areas of humic gley soil occur adjacent to the coastline. Although small in area, the favourable physical characteristics of these soils, including a high soil moisture holding capacity, make them potentially highly productive. While the better drained areas situated near Woongoolba are used for sugar-cane (Franks 1971), the suitability for pasture of those located near Currumbin, about 100 km south-east of Brisbane, is largely unknown (Middleton and Roberts 1968).

Ostrowski (1969) obtained a small field response by white clover (*Trifolium repens*) to superphosphate and a positive superphosphate x boron interaction on a peaty soil at Currumbin. North of Brisbane, the soils of the coastal lowlands have been more widely investigated. Andrew and Bryan (1955) reported strong responses by white clover to phosphorus and calcium, and smaller responses to copper and zinc on a humic gley. Subsequently, Andrew (1960) obtained responses to phosphorus, potassium and calcium on a low humic gley.

The experiment reported was designed to determine field nutrient deficiencies affecting white clover establishment and growth on a humic gley soil at Currumbin.

II. MATERIALS AND METHODS

The experiment was located 2 km from the shoreline in an area receiving 1 600 mm average annual rainfall. The climate is humid subtropical and has been described in detail by Coaldrake (1961). The soil was a humic gley apparently similar to those described by Coaldrake (1961) and Franks (1971) and occurring in low-lying poorly drained areas dominated by *Melaleuca quinquenervia* (paper-bark tea-tree). Periodic flooding occurs and the water table rarely falls below 30 to 40 cm.

The peaty surface horizon extends to 20 to 30 cm, below which is a 10 to 15 cm gleyed, finer-textured zone. Analysis of the surface 15 cm showed extreme acidity (pH 3·7 to 4·0) but reasonable levels of available phosphorus (65 to 75 p.p.m.) and replaceable potassium (0·65 to 0·68 m—equiv. per 100 g).

The site had been cleared about 1967 and partially drained. After seedbed preparation with a rotary hoe, the area was sown to inoculated white clover (*Trifolium repens* cv. Ladino) on 23 April 1969. The fertilizer treatments (table 1) were applied in a $\frac{1}{2} \times 2^6$ factorial array to the surface of 4 m x 3 m plots which were then raked to cover seed and fertilizer.

TABLE 1

NUTRIENT TREATMENTS AND RATES

Treatment	Form of Application	Rates of Compound ha^{-1}
1. Lime	$CaCO_3$	Nil and 2·5 t*
2. P	$Na_3PO_4 \cdot 12H_2O$	Nil and 700 kg
3. K	KCl	Nil and 160 kg
4. S	S	Nil and 56 kg
5. Mo	$Na_2MoO_4 \cdot 2H_2O$	Nil and 125 g
6. Composite		
Mg	$MgCl_2 \cdot 6H_2O$	Nil and 56 kg
Cu	$CuSO_7 \cdot 5H_2O$	Nil and 16 kg
Zn	$ZnSO_4 \cdot 7H_2O$	Nil and 16 kg
B	$Na_2B_4O_7 \cdot 10H_2O$	Nil and 16 kg
Mn	$MnSO_4 \cdot H_2O$	Nil and 16 kg

* Rates changed to 2·5 and 5·0 t ha^{-1} subsequent to plant emergence.

A 0·9 m x 1·8 m quadrat was cut from each plot with an auto-scythe at 5 cm above ground on 8 September and 12 November 1969, and 7 January 1970, and used to determine botanical composition, dry matter yield and nitrogen and phosphorus contents.

III. RESULTS

Within a few days of emergence, all clover seedlings on the nil lime plots were showing severe calcium deficiency symptoms resembling those described by Andrew and Norris (1961). Complete seedling mortality appeared likely. To prevent this, the nil lime treatment was changed to 5·0 t ha^{-1}, the lime being applied on 5 May 1969. Since calcium is critical for the nodulation process (Loneragan and Dowling 1958; Andrew and Norris 1961), nodulation was examined at frequent intervals. After 4 weeks, it appeared that effective nodulation had occurred in all treatments, including those with the delayed lime application.

TABLE 2

Main Effects and Interactions in White Clover Dry Matter Yields, Nitrogen % and Nitrogen Yield

Effect	Dry Matter Yield				Nitrogen %			Nitrogen Yield			
	8 Sep 69	12 Nov 69	7 Jan 70	Cumulative	8 Sep 69	12 Nov 69	7 Jan 70	8 Sep 69	12 Nov 69	7 Jan 70	Cumulative
Main effects											
Lime	**			**		**		**	*		**
P	*							*			*
Interactions											
Ca x Mo ..		*									
K x Composite ..											*

* P < 0·05   ** P < 0·01

Total rainfall recorded for April 1969 to January 1970 inclusive was 1 575 mm and included above average rainfall in May (290 mm), August (210 mm), October (315 mm) and January (240 mm). Temporary flooding occurred in May and November 1969 and January 1970.

Significant responses occurred with lime, P, lime x Mo and K x composite. Except for lime, these responses were small and infrequent (table 2)

WHITE CLOVER RESPONSE TO LIME. The higher lime level produced a significantly higher ($P < 0\cdot01$) dry matter yield in the first harvest and in cumulative yield (table 3). This response pattern was also reflected in nitrogen yield. The nitrogen concentration of white clover was significantly higher ($P < 0\cdot01$) for the high lime treatment for the second harvest interval only.

TABLE 3

EFFECT OF LIME ON THE DRY MATTER YIELD, NITROGEN % AND NITROGEN YIELD OF WHITE CLOVER AND WEEDS

Attribute and Treatment	8 Sep 69		12 Nov 69		7 Jan 70		Cumulative	
	Clover	Weeds	Clover	Weeds	Clover	Weeds	Clover	Weeds
DRY MATTER YIELD ($kg\ ha^{-1}$)								
Lime at 2·5 $t\ ha^{-1}$	217	2 681	366	1 672	1 002	1 818	1 585	6 070
Lime at 5·0 $t\ ha^{-1}$	840	1 671	471	1 298	919	2 211	2 230	5 181
L.S.D. 5% ..	144	613	NS	280	NS	392	317	694
1% ..	208	881		438		563	456	996
NITROGEN %								
Lime at 2·5 $t\ ha^{-1}$	3·77	2·02	3·77	1·91	3·41	1·52		
Lime at 5·0 $t\ ha^{-1}$	4·05	2·18	4·03	2·14	3·38	1·50		
L.S.D. 5% ..	NS	NS	0·13	NS	NS	NS		
1% ..			0·18					
NITROGEN YIELD ($kg\ ha^{-1}$)								
Lime at 2·5 $t\ ha^{-1}$	8·6	53·3	13·9	31·9	34·6	25·7	57·1	110·9
Lime at 5·0 $t\ ha^{-1}$	34·0	36·2	19·0	28·2	31·7	33·0	84·7	97·4
L.S.D. 5% ..	6·2	13·9	4·9	NS	NS	5·0	11·9	NS
1% ..	8·7	20·1	7·2			7·2	17·1	

WHITE CLOVER RESPONSE TO PHOSPHORUS. Phosphorus application significantly increased dry matter yield ($P < 0\cdot05$) from 438 to 619 $kg\ ha^{-1}$ and nitrogen yield from 17·6 to 25·1 $kg\ ha^{-1}$ in the first harvest (data not presented). A small but non-significant response was also apparent in the second harvest but subsequently disappeared.

WHITE CLOVER NUTRIENT INTERACTIONS. On only two occasions were significant treatment interactions recorded. The first occasion was in the second harvest where white clover dry matter yield increased significantly ($P < 0\cdot05$) in the high lime treatment, but only in the presence of applied Mo. Secondly, the addition of K depressed the cumulative nitrogen yield ($P < 0\cdot05$) in the absence of the composite treatment.

WEED RESPONSES TO LIME. The weed content of the pasture was high, consisting almost entirely of rushes (*Juncus* sp.) and sedge (*Cyperus polystachyos*). The high lime treatment depressed weed yield at harvests 1 and 2 but increased yield at harvest 3.

IV. DISCUSSION

The very low soil pH (3·7 to 4·0) suggested that white clover may respond to lime and it is generally accepted that, under conditions of extreme acidity, calcium and molybdenum deficiency and aluminium and manganese toxicity can occur (Andrew and Norris 1961; Andrew 1962). On less acid soil (pH 5·3 (Andrew and Bryan 1958) and pH 5·2 (Andrew 1960)), white clover gave little yield response to rates of calcium carbonate above 250 kg ha^{-1} and it was concluded that the requirement was merely one of calcium as a nutrient.

In our experiment, the need for lime was evidenced by the severe seedling growth retardation and apparent calcium deficiency symptoms which occurred on those plots originally untreated with lime. After the inclusion of the two lime levels, the clover yields were similar at the 2·5 and 5·0 t ha^{-1} lime treatments, except at the first harvest. Thus it appears that the lower lime rate was sufficient to promote optimum clover growth. However, since a relatively low lime rate was not used in the experiment, it has not been possible to assess the mechanism of the response to the lime.

Apart from the significant Mo x lime interaction in the second harvest, no clover responses to Mo were recorded. Andrew and Bryan (1958), on lateritic podzolic and a low humic gley, and Ostrowski (1969), on a peaty soil, reported no white clover response to molybdenum.

The relatively small clover yield response to phosphorus is consistent with the initial soil analysis and the clover P levels recorded. The P concentration in clover during the experiment ranged from 0·24 to 0·34% and at no time fell below 0·23%, the critical level established by Andrew (1960). The yield response was much smaller than that recorded by Andrew and Bryan (1955, 1958) and Andrew (1960), but consistent with those of Ostrowski (1969) on a similar soil at Currumbin. Ostrowski recorded 74 p.p.m. available soil phosphorus in the surface 15 cm and obtained a small (16%) white clover yield response to 450 kg ha^{-1} superphosphate.

Similarly, the lack of response to potassium is consistent with the soil analysis and the lack of field response recorded by Ostrowski (1969).

The high weed content of this pure legume sowing is not surprising. In this case, the weeds were native species common to the poorly drained peaty soils. The weed responses to lime were too inconsistent for accurate interpretation. Nevertheless the results from the first and second harvests and the cumulative yields suggest a depression of weeds at high lime rate. This may indicate an intolerance of high calcium or pH or both by the weeds rather than direct competition from the lower growing white clover.

Since responses to lime and phosphorus were the only ones recorded at this site, it is concluded that the chemical fertility is relatively high. However, it was apparent during the progress of the experiment that seasonal flooding and poor drainage of the humic gley soils posed problems to pasture production as reported by Ebersohn *et al.* (1973).

V. ACKNOWLEDGEMENTS

The authors acknowledge the assistance of Biometry Branch for statistical analysis, and the Australian Dairy Produce Board for finance.

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Received for publication 19 November 1974)

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