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INVESTIGATIONS ON CLOVER NUTRITION IN THE EAST MORETON DISTRICT OF QUEENSLAND

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SUMMARY

The effect of major elements (except nitrogen) and of trace elements on the yield of white clover in the establishment period in the East Moreton district of Queensland was investigated on a number of sites between 1958 and 1967.

Lime increased the dry-matter yields in some trials, but higher applications than used may be needed to obtain a more general response on very acid soils.

Superphosphate significantly increased the yields of clover in four of five main experiments and in five supporting experiments.

At one site high rate of added potash without addition of superphosphate reduced the yield significantly. At another site, on an old cultivation, there was a response to potash independent of superphosphate.

Responses to trace elements were very small, except in the case of molybdenum at two sites.

I. INTRODUCTION

White clover (*Trifolium repens* L.) is a valuable component of both native and improved pastures during the cooler part of the year in the coastal area of south-eastern Queensland. A definition of its place in pastures of the area receiving at least the minimum rainfall and temperature requirements for its growth is considered timely.

Generally, the fertility of the soil along the coastal strip of south-eastern Queensland is too low to support satisfactory clover growth. A fertilizing programme is necessary to facilitate establishment and persistence of this legume.

The experiments reported here were aimed at determining the effect of various fertilizers used singly or in combination on the yield of clover on selected sites in the East Moreton district.

II. MATERIALS AND METHODS

(i) *Sites.*—Five different sites were selected for conducting the main fertilizer trials. Their descriptions and the management techniques used are as follows:—

Currumbin.—Flats adjoining Currumbin Creek, frequently flooded, with poor drainage, peaty. Recent cover of paspalum (*Paspalum dilatatum*) and mat grass (*Axonopus affinis*). Planted on March 26, 1958. The trial area became heavily infested with weeds. Two cuts were taken, the last on October 23, 1958, after which, because of dry weather, the clovers dried off.

Ormeau.—Cleared forest hillsides with poor drainage, covered with mixed native pasture. Planted on April 10, 1958. Young stand of clover was heavily attacked by caterpillars. Throughout the flush growing period a very strong response was observed to superphosphate. The period between the first and second cuts was very dry. Many plots completely dried off, but good growth was evident in plots lower down the slope. Because of this, the second cut was not included in the analysis. A third cut was taken on February 5, 1959, on all plots.

Oxenford.—Alluvial flats of satisfactory drainage, adjacent to Coomera River. Area previously under fodder crops. This area received superphosphate regularly for a number of years before being planted on May 14, 1958. Heavy growth of weeds in the early stage was checked by mowing down the trial area. High yields were obtained but no significant responses occurred. Two cuts were taken, the last one on November 25, 1958.

TABLE 1

CHEMICAL ANALYSES OF SOILS FROM THE MAIN EXPERIMENTAL SITES

Site	Soil Type	pH		Avail.P_2O_5 (p.p.m).		Repl. K+ (m—equiv.%)	
		0–6 in.	6–12 in.	0–6 in.	6–12 in.	0–6 in.	6–12 in.
Currumbin ..	dark grey peaty loam	4·8	4·6	170	102	0·68	0·50
Ormeau ..	grey brown clay loam	5·3	5·2	70	44	0·37	0·24
Oxenford ..	brown grey alluvial	6·2	6·2	400	410	0·60	0·30
Springbrook ..	brown grey clay loam	4·9	4·9	74	38	0·76	0·55
Pimpama ..	grey brown clay loam	5·5	5·5	30	24	1·00	0·81

pH—a 1–2½ soil/water suspension method.
Avail. P_2O_5—Bureau of Sugar Experiment Stations method.
Repl. K+—1/20th normal HCl extract.

Springbrook.—Undulating, cleared rain-forest with good drainage. High altitude and very high rainfall. Area under kikuyu grass (*Pennisetum clandestinum*). Planted on March 24, 1959. The establishment of this trial was very

slow, probably due to the cold, cloudy weather prevailing during the winter months. Three cuts were taken, the first to check weed growth. The second cut showed strong response to superphosphate. The third cut, taken on November 24, 1959, represented a high percentage of kikuyu grass which was rapidly invading the trial.

Pimpama.—Low-lying flats carrying a cover of mat grass and paspalum. Planted on April 19, 1962. Four cuts were taken, the last on January 30, 1963.

(ii) *Soils.*—The analyses of soils obtained from the trial areas are given in Table 1.

(iii) *Rainfall.*—Rainfall registered from the date of planting to the date of last cut obtained from each trial is given in Table 2. Average yearly rainfall and an estimate of the antecedent moisture in the soil are also given.

TABLE 2

RAINFALL (IN.) AT THE MAIN EXPERIMENTAL SITES

—	Currumbin 26.iii.58–23.x.58	Ormeau 10.iv.58–5.ii.59	Oxenford 14.v.58–25.xi.58	Springbrook 24.iii.59–24.xi.59	Pimpama 10.iv.62–30.i.63
Antecedent moisture in the soil	good	good	good	very good	very good
March	0·30	—	—	5·65	—
April	5·60	5·10	—	4·91	0·30
May	1·41	0·61	0·76	5·07	3·86
June	11·80	10·88	10·91	2·49	0·55
July	0·20	0·14	0·14	6·63	10·97
August	5·12	1·91	5·30	2·01	5·74
September	1·22	1·88	1·95	7·02	2·67
October	1·35	1·66	1·28	8·86	0·62
November	—	2·24	2·97	18·30	3·86
December	—	5·06	—	—	10·61
January	—	4·22	—	—	7·85
February	—	3·21	—	—	—
Totals	27·00	36·91	23·31	60·94	47·03
Average Annual Rainfall ..	60·99*	48·00†	51·32	119·73	48·00†

* Recorded at Burleigh Heads.

† Recorded at Beenleigh.

(iv) *Design and treatments.*—Fractional factorial trials in a $\frac{1}{2}$ x 2^6 design of 32 plots were established at each of the five main sites. Plot size was 10 ft x 6 ft.

Treatments were as follows:

(Ca) Carbonate of lime—10 cwt/ac (at Springbrook, 20 cwt/ac).

(P) Superphosphate (22% P_2O_5)—4 cwt/ac.

(K) Muriate of potash—1 cwt/ac (at Springbrook, 2 cwt/ac).

(Mo) Ammonium molybdate—8 oz/ac.

(B) Sodium borate—14 lb/ac.

(Cu) Copper sulphate—28 lb/ac.

(Zn) Zinc sulphate—14 lb/ac.

(Mn) Manganese sulphate—14 lb/ac.

(Mg) Magnesium sulphate—56 lb/ac (at Springbrook, 200 lb/ac).

Copper, zinc, manganese and magnesium sulphates were combined into a single treatment. Because of a higher rainfall, application rates of carbonate of lime, muriate of potash and magnesium sulphate were increased at Springbrook.

A mixture of New Zealand white, Ladino white, Louisiana white and Montgomery red clover comprised the indicator species. Seed was inoculated with an appropriate strain of rhizobium.

A number of fertilizer trials of varying design using Ladino white clover were laid down during 1961, 1962, 1963, 1966 and 1967 to confirm the results obtained from the main experiments outlined above.

TABLE 3

CUMULATIVE DRY-MATTER YIELD OF CLOVER (CWT/AC)

	Currumbin	Ormeau	Oxenford	Springbrook Site*	Pimpama
No. of Cuts	2	2	2	3	4
Ca 0	31·2	18·6	58·4	184	23·0
Ca 1	34·0	21·2	60·0	217	33·8
P0	30·2	16·6	59·2	156	17·8
P1	34·8	23·2	59·2	245	39·0
K0	30·8	19·4	58·2	212	28·2
K1	34·4	20·4	60·4	189	28·8
M0	33·6	20·2	60·0	200	30·4
M1	31·6	19·6	58·6	202	26·4
B0	31·6	20·8	59·6	192	30·0
B1	33·4	19·2	59·0	210	26·8
Cu, Zn, Mg, Mn0 ..	31·6	19·4	58·2	204	28·0
Cu, Zn, Mg, Mn1 ..	33·4	20·4	60·2	197	28·8
Significant differences ..	P1 > P0	P1 ⩾ P0		Ca1 > Ca0 P1 ⩾ P0	Ca1 ⩾ Ca0 P1 ⩾ P0

* Green-matter yields only were obtained.

(v) *Sampling.*—Samples were taken when enough growth for sampling was present, usually when the stand was about 6-7 in. high. A strip 10 ft x 3 ft was mown in the middle of each plot with an Allen Oxford autoscythe. This allowed a 1½ ft border area along a length of each plot and a 3 ft border area along a width of each plot. After yields of green weight were measured, a composite sample of 2 lb was taken for dry-matter estimation. The samples were air-dried.

After each sampling the whole of the trial area was mown and clippings were raked off.

III. RESULTS

Table 3 shows the effect of nutrients on the yield of clover at the five main sites. Significant interactions are shown in Table 4.

TABLE 4

INTERACTIONS—CUMULATIVE DRY MATTER YIELD OF CLOVER (CWT/AC)

Currumbin (2 cuts)

	PO	P1
B0	31·6	31·6
B1	28·8	38·2

P x B interaction significant at 5% level

Oxenford (2 cuts)

	Ca0	Ca1	Mo0	Mo1
Tr. el. 0	58·8	57·6	60·4	56·2
Tr. el. 1	58·0	62·6	59·4	61·0

Mo x Cu, Zn, Mn, Mg and Ca x Cu, Zn, Mn, Mg interactions significant at 5% level

Springbrook* (3 cuts)

	K0	K1
P0	183	130
P1	242	248

P x K interaction significant at 5 % level

* Green-matter yields only were obtained.

Results of the supporting trials appear in Tables 5-7.

A factorial fertilizer trial at Numinbah Valley in 1961, on a grey clay loam, showed a 41% yield increase to application of 4 cwt/ac of superphosphate, a 13% increase to sodium borate and an 18% increase to a mixture containing copper, zinc, manganese and magnesium.

In a replicated trial at Pimpama during 1963, on a grey brown clay loam, with lime at nil, 10 and 20 cwt/ac and superphosphate at nil, 3, 6 and 9 cwt/ac, responses occurred to both superphosphate and lime (Table 5).

TABLE 5

GREEN-MATTER YIELDS OF WHITE CLOVER (CWT/AC)

Calcium Carbonate (cwt/ac)	Superphosphate (cwt/ac)				Mean
	0	3	6	9	
0	14·7	22·0	27·2	22·5	21·6
10	16·8	21·2	30·2	24·2	23·1
20	20·3	27·2	38·9	32·8	29·8
Mean	17·3	23·4	32·1	26·5	

During 1962, one year after termination of a factorial fertilizer trial on native pastures on a grey sandy loam at Mt. Mee, a strong occurrence of white clover was observed on some plots. The yields of white clover obtained are shown in Table 6.

TABLE 6

EFFECT OF RESIDUAL PHOSPHATE AND MOLYBDENUM ON DRY-MATTER YIELD OF WHITE CLOVER IN NATIVE PASTURE (CWT/AC)

P0	0·16	Mo0	0·22
P1	0·88	Mo1	0·82
Significant Difference		Mo1 > Mo0	

On an observational plot at Beechmont in 1966, the green-matter yield of white clover increased from 44 cwt/ac to 172 cwt/ac after application of 8 cwt of superphosphate per acre and from 76 cwt/ac to 140 cwt/ac after application of 1 ton of lime per acre.

On a plot on old cultivated land at Narangba during 1967, the response to superphosphate, muriate of potash and sodium molybdate from two cuts was as shown in Table 7.

IV. DISCUSSION

In all the main experiments red clover made a minor contribution to the yields so all further references are made to white clover only.

A significant response in yield of white clover to lime occurred in only two of the five main experiments. A more general response on acid soils could be expected with higher application rates, as is shown by the 1963 trial

TABLE 7

DRY-MATTER YIELD RESPONSES OF WHITE CLOVER TO P, K AND Mo (CWT/AC)

		Superphosphate (cwt/ac)			
		0	3	9	Mean
Muriate of potash	0	9·2	12·8	24·6	15·5
(cwt/ac)	3	22·1	22·8	27·4	24·1
Mean		15·6	17·8	26·0	
Sodium molybdate	0	9·2	12·8	24·6	15·5
(oz/ac)	20	24·0	26·4	31·6	27·3
Mean		16·6	19·6	28·1	

on acid soils at Pimpama, where a much greater response occurred to 1 ton of lime than to ½ ton. The response to 1 ton of lime at Springbrook was significant at the 5% level of probability. Comparing results from Springbrook with those of the Pimpama 1963 trial, and considering the very acid soils and a very high rainfall at Springbrook, a greater response to higher rates of lime could also be expected at this site. Similar reasoning applies to the Currumbin site with peaty and extremely acid soils.

Clover was generally highly responsive to applications of 4 cwt of superphosphate per acre. The fertile alluvial and only slightly acid soils at Oxenford with a history of regular topdressing with superphosphate are an exception. On the Currumbin peaty soil a response to superphosphate only at the 5% level of significance was evident. A consideration here is that the soil had a very high level of available phosphate (170 p.p.m.) in the top 6 in. The supporting calcium carbonate x superphosphate trial at Pimpama suggests that on similar coastal soils the optimum initial dressing of superphosphate given in one application will be in the vicinity of 6 cwt/ac.

Response to muriate of potash was not significant. In the Springbrook experiment, application of muriate of potash without added superphosphate resulted in a significant yield depression. However, in one of the supporting trials on old cultivated land at Narangba, a strong response to muriate of potash was observed. In this case the response to muriate of potash was independent of the response to superphosphate. The very low soil levels for K^+ of 0·11 m-equiv. % and of available P_2O_5 of 10 p.p.m. explain the marked response obtained from 3 cwt of muriate of potash per acre and from 9 cwt of superphosphate per acre.

Ammonium molybdate had a non-significant effect in four of the five main experiments. However, in two of the supporting trials a marked response to molybdenum was obtained, in one case from white clover in native pasture,

and in another from clover on old cultivation land. It will be noted that in the latter case response to sodium molybdate was independent of response to superphosphate. Responses to superphosphate and sodium borate occurred on peaty soils at Currumbin only when the fertilizers were applied together. A similar significant interaction occurred on the alluvial soil at Oxenford between the trace elements mixture and lime, and the trace elements mixture and ammonium molybdate.

During the period of investigation, it was evident that, in addition to its nutritional requirements, white clover is sensitive to available moisture. Negligible growth occurred during drier periods. When growth of white clover is seen in relation to precipitation, it is evident that growth and consequent yields are strongly influenced by rainfall. All sites received good rains during the first few weeks after planting. Midwinter rains were adequate, except at Ormeau, where drought at this time resulted in a very poor growth of clover during the ensuing spring months. At Springbrook and Pimpama, where the rainfall was evenly distributed during the winter and spring, white clover continued to grow well into summer. The excellent winter rainfall during the period of investigation was higher than would normally be expected. Clover growth will be adversely affected during seasons with a poorer and less even distribution of rainfall.

The results reported here with fertilizers on white clover agree in broad terms with those of other workers, both in Australia and overseas.

Responses to phosphorus, potassium and lime in clover were demonstrated by Andrew (1960) on a low humic grey soil in Queensland. He obtained maximum yield from an application of 6 cwt of superphosphate per acre. The results of the lime-superphosphate trial on the grey-brown clay loam at Pimpama are in agreement with this. He obtained the highest response to muriate of potash at the level of 1 cwt/ac. Higher levels than this depressed the yield below the optimum. The Springbrook trial seems to support this. Lime was most effective at 8 cwt of calcium carbonate. Results of the Pimpama supporting trial suggest rather a higher rate of application.

In an experiment carried out by Truong, Andrew, and Skerman (1967) on solodic soils of the Beaudesert district, Queensland, white clover responded in the establishment period to phosphorus (yield not measured), molybdenum, calcium carbonate and sulphur, but the application of small amounts of molybdenum eliminated the need for calcium carbonate. The above interaction between calcium carbonate and molybdenum did not appear in the experiments described in this work, probably because all the soils used for experiments were much more acid than that described by the authors.

Experiments carried out in Florida (U.S.A.) by Blaser (1938) demonstrated that a combination of lime, superphosphate and potash is generally required to grow clovers of various types successfully. The nutrient combination of

2,000 lb of lime, 600 lb of superphosphate and 100 lb of muriate of potash per acre has given good results. Good clover growth was obtained with soil acidity varying from pH 4·9 to pH 6·0.

In North Carolina (Dobson *et al.* 1954) under average conditions 1½ to 2 tons of lime per acre is recommended for good Ladino clover growth. In addition, on soils medium in phosphate and potash, 800-1,000 lb of a N2-P12-K12 mixture is suggested.

For northern-eastern States of the U.S.A., Hollowell (1947) suggests for Ladino clover that, after the required addition of lime, an application of 400-600 lb of superphosphate and, when potash is deficient, an additional 200 lb of muriate of potash are necessary.

Sears (1953) remarked that over most clover/grass pastures in New Zealand the correction of phosphate deficiency is a prerequisite for vigorous growth of a balanced pasture. The application of potassium and molybdenum has been found necessary in some areas. A need for lime was also recorded.

From the results obtained in this study the general use of superphosphate on clovers is indicated. On many acid soils lime would also be needed, but the rate of application should be first checked in small-scale experiments, especially if the high cost of liming is a consideration. Potassium, molybdenum, and some other trace elements are deficient for some sites only. Virgin potassium seems to be adequate on most of the sites tested, but this element may be diminishing in old cultivations.

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