Queensland Journal of Agricultural and Animal Sciences Vol. 40 (2), 81-86 (1983)
Published by the Queensland Department of Primary Industries

Nitrogen and sulphur requirements of some soils of the Wyreema-Cambooya district, in the eastern Darling Downs of Queensland

D.E. Hibberd, J.W. Littler and R.G.H. Nielsen

Summary

A glasshouse experiment and field trials were used to assess the requirements for nitrogen and sulphur and, to a lesser extent, potassium for some soils of the Wyreema-Cambooya area of the eastern Darling Downs of Queensland.

Nitrogen deficiency was found in a number of soils in the area and a response can be expected to annual applications of nitrogen on most commercial crops.

Potassium fertilisers appear not to be needed but low soil P analyses and a response to phosphorus indicate the need for phosphorus fertiliser applications.

Sulphur may become limiting for cereal growth on some soils of the area. The responses at present are probably masked by adequate sulphur mineralisation during periods of fallow. Growers could apply single superphosphate as a source of phosphorus to annual crops. At the rate of 10 kg/ha P this would also supply 11 kg/ha S, to correct marginal sulphur levels.

INTRODUCTION

Crop yields have been declining on many soils of the Wyreema-Cambooya districts of the eastern Darling Downs of south east Queensland (Cummins, Robinson, Pink and Roberts 1973). Possible reasons for the decreased productivity are a decline in soil fertility due to the long history of cultivation (up to 75 years) and extensive erosion leading to loss of nutrients from already shallow soils of 10 to 45 cm depth (Cummins *et al.* 1973). Recent changes in farming practices, such as double cropping and stubble retention, may increase demands placed on the low supply of nutrients by increased micro-organism activity decomposing organic matter.

Responses to nitrogen have been found in oats (Cull and Muir 1969) and to several grass species by Mackenzie, Mayer and Bisset (1982) and Ivory (1982).

Lloyd (1969) reported plant growth responses in lucerne to applications of both sulphur and phosphorus fertilisers on similar soils further south in the Nobby area. Jones (1970) showed that established lucerne stands responded to dressings of sulphur and molybdenum but other evidence of deficiencies is less clear.

Potassium responses have been reported in maize and large growth differences have been observed in barley supplied with various mixtures of starter fertilisers (M.H. Roberts, pers. comm., 1970). When maize was supplied with ammonium sulphate, it appeared to grow better than when supplied with urea (M.H. Roberts, pers. comm., 1970).

The aim of the present study is to define the nutrient requirements of some soils of the Wyreema-Cambooya district with respect to nitrogen and sulphur and to a lesser extent potassium.

MATERIALS AND METHODS

A glasshouse experiment was conducted to gain information quickly on likely field responses on five of the more agriculturally important soil types of the Wyreema-Cambooya area. Field trials were then used to verify the findings in some locations.

Glasshouse investigations

The five soils used in the experiment were the Waco, Burton, Irving, Beauaraba and Purrawunda as described by Thompson and Beckmann (1959). Each had a history of double cropping or approached a double crop situation over the previous 18 to 24 months. Soil samples were collected randomly to a depth of 15 cm, air dried, crushed to pass a 5 mm sieve and placed in 15 cm plastic lined pots.

The following nine treatments were applied:

control plus N at 200 kg/ha (as calcium nitrate);

S at 11, 23, 45, 91, 182 kg/ha (as gypsum) as different treatments plus N at 200 kg/ha (as calcium nitrate) to each S level;

S at 182 kg/ha and N at 159 kg/ha (as sulphate of ammonia) plus N at 41 kg/ha (as calcium nitrate);

N at 200 kg/ha (as urea);

S at 182 kg/ha (as flowers of sulphur).

A basal dressing of phosphate and zinc was applied at the rate of 20 kg/ha P and 10 kg/ha Zn, respectively. Treatments and basal nutrients were applied on a surface area basis and covered by 200 g of air dry soil. There were four replications and treatments were re-randomised at weekly intervals.

Pots were watered regularly to field capacity for the duration of the experiment and Gamut wheat was grown for 6 weeks from date of planting. Dry matter production was measured to assess response to treatment.

Field investigations

Separate experiments were designed to assess field responses in summer and winter grain crops and perennial lucerne to various nutrients. The field experiments were conducted where land was made available by farmer co-operators. Soil analyses were carried out on soil samples taken from the sites and results are presented in Table 2.

Using maize (variety DK 805A) as the summer test crop, the following treatments were applied in a 5×5 latin square:

control;

N at 52 kg/ha (as urea);

S at 60 kg/ha (as gypsum);

S at 60 kg/ha and N at 52 kg/ha (as ammonium sulphate);

S at 60 kg/ha (as gypsum) and N at 52 kg/ha (as urea).

Plot size was 22.0×3.9 m with four rows. Grain yields were harvested from the inner two rows using 18.65×1.95 m as the datum area.

The winter trials used Clipper barley, the main winter cereal grown in the area, as the test crop. The experiment consisted of six levels of sulphur at 0, 11, 23, 34, 57, 114 kg/ha (as gypsum) by two levels of potassium at 0, 50 kg/ha (as muriate of potash) by two levels of nitrogen at 0, 34 kg/ha (as urea) in factorial randomised block design with two replicates. The investigation was carried out on two Irving soils and one Purrawunda soil.

The aim was to determine the effect of sulphur and potash fertilisers on winter cereals in the area. Basal phosphate was applied as sodium dihydrogen orthophosphate at the rate of 20 kg/ha P. Individual plot size was 2.4×26.1 m and grain yields were harvested by plot header harvester from a datum area of 1.5×26.1 m.

The investigation with lucerne was designed to determine which nutrients may limit production during the continuous growth of a crop over a period of time. Sulphur, for example, can become deficient under these conditions (Jones 1970). A similar deficiency is less likely to appear in summer and winter cereals since there is nearly always a fallow period between crops when mineralisation of sulphur to an available form can take place.

The experiment was laid down on a Waco soil on a 2 year old lucerne stand.

The design was a 2^5+1 factorial in randomised block design with two replicates. The treatments were applied by hand and incorporated by spray irrigation. The following rates were used:

K at 58 kg/ha (as muriate of potash);

Zn at 16 kg/ha (as zinc sulphate monohydrate);

Mo at 0.8 kg/ha (as sodium molybdate);

P at 20 kg/ha (as sodium dihydrogen orthophosphate);

S at 58 kg/ha (as gypsum);

B at 230 g/ha (as borax) plus Mn at 10 kg/ha (as manganese sulphate) plus K, Zn, Mo, P, S at the above rates.

Plot size was 3×3 m and dry matter yields were taken by hand harvesting 1 m square quadrats and drying in a forced air draught oven. The trial was discontinued after one harvest due to changes in the farming system.

RESULTS

Glasshouse investigations

Glasshouse investigations clearly showed a highly significant response to sulphate of ammonia in all five soils (Table 1) which was due in part to the nitrogen component in addition to the base level of nitrogen. All except the Irving and Beauaraba soils produced a significant response to urea.

Table 1. Mean dry matter yields of Gamut wheat in grams per pot harvested after 6 weeks from planting

Treatment	Waco	Burton	Irving	Beauaraba	Purrawunda
Control plus N at 200 kg/ha (as calcium nitrate)	1.3	1.6	3.4	5.3	2.2
S at 11 kg/ha (as gypsum) plus N at 200 kg/ha (as calcium nitrate)	3.3	1.8	3.5	6.2	2.0
S at 23 kg/ha (as gypsum) plus N at 200 kg/ha (as calcium nitrate)	3.0	1.9	2.9	6.0	2.1
S at 45 kg/ha (as gypsum) plus N at 200 kg/ha (as calcium nitrate)	3.1	2.0	3.6	6.3	2.1
S at 91 kg/ha (as gypsum) plus N at 200 kg/ha (as calcium nitrate)	3.0	2.1	3.3	6.1	2.1
S at 182 kg/ha (as gypsum) plus N at 200 kg/ha (as calcium nitrate)	3.0	1.9	3.6	6.0	2.1
S at 182 kg/ha and N at 159 kg/ha (as sulphate of ammonia) plus N at 41 kg/ha (as calcium nitrate)	3.1	2.4	4.2	7.3	3.1
N at 200 kg/ha (as urea)	1.9	1.9	3.9	6.0	3.3
S at 182 kg/ha (as flowers of sulphur)	3.4	1.5	3.7	6.2	2.4
l.s.d. 5%	0.4	0.2	0.6	0.7	0.3
1%	0.5	0.3	0.8	0.9	0.5

Dry matter yields from the Waco, Burton and Beauaraba soils were higher from sulphate of ammonia than those produced by the equivalent amount of nitrogen as urea ($P<0.01$). There was also a similar though non-significant trend on the Irving soil. This may be a simple sulphur response from sulphate of ammonia.

The Waco, Burton and Beauaraba soils produced highly significant responses to sulphur in dry matter yields. No significant difference existed in the forms of sulphur when applied as gypsum or as flowers of sulphur on the Waco, Irving and Beauaraba soils. Flowers of sulphur had no effect on the Burton soil, however, while gypsum produced a highly significant response.

Field investigations were required to verify sulphur responses and to determine the field importance of responses to two different nitrogen forms.

Summer crop investigations

Grain yields of maize on the Purrawunda soil were not improved by sulphur but were increased from 2730 to 5160 kg/ha by application of nitrogen either as urea or as sulphate of ammonia ($P<0.01$).

Winter crop investigations

No significant differences were obtained to sulphur and potash applications from dry matter yields from any of the three sites. The lack of response to potash was expected as all three sites showed figures comparatively high in native soil potassium (0.70 to 0.96 me % K in the 0 to 10 cm soil zone, Table 2). Rasmussen (1969) quoted a high level for the Irving-Purrawunda soils of 0.86 to 0.89 me % K. Reeve, Thompson and Beckmann (1960) found high potassium levels on the eastern Darling Downs.

Table 2. Soil analyses of 0 to 10 cm level from sites where field investigations were conducted in summer and winter

Soil analyses	Summer investigations	Winter investigations		
	Purrawunda	Site 1 Irving	Site 2 Irving	Site 3 Purrawanda
Available P ppm acid extraction	25	193	22	32
Replaceable K meq %	0.73	0.96	0.79	0.70
Total N %	0.09	0.11	0.08	0.14
pH	5.9	6.9	7.2	6.8
Organic C %				1.92

Table 3. Mean grain yield from barley in kilograms per hectare. Main treatments only are shown

Treatment	Site 1 Irving	Site 2 Irving	Site 3 Purrawunda
Control	2530	3370	1810
N at 34 kg/ha (as urea)	2870	3320	2300
S at 11 kg/ha (as gypsum) plus N at 34 kg/ha (as urea)	2860	3520	2230
S at 23 kg/ha (as gypsum) plus N at 34 kg/ha (as urea)	2740	3040	2000
S at 34 kg/ha (as gypsum) plus N at 34 kg/ha (as urea)	2790	3240	2520
S at 57 kg/ha (as gypsum) plus N at 34 kg/ha (as urea)	2700	3170	2230
S at 114 kg/ha (as gypsum) plus N at 34 kg/ha (as urea)	2970	3030	2340
S at 114 kg/ha (as gypsum) alone	2820	3180	1840
S at 114 kg/ha (as gypsum) plus N at 34 kg/ha (as urea) plus K at 50 kg/ha (as muriate of potash)	2900	3080	2440
l.s.d. 5%	n.s.	n.s.	180
1%			240

Grain yield response (Table 3) occurred only to nitrogen at Site 3. The other two sites were approaching a double crop situation but failure of the late planted maize crop during the previous dry summer may have left considerable soil nitrogen reserves.

Lucerne investigations

Dry matter yields for the first and only harvest are presented in Table 4. Only phosphate produced a significant difference in dry matter yields. However, the application of sulphur as gypsum alone produced a higher yield than the control which may have become significant as soil reserves of sulphur became depleted.

Table 4. Mean dry matter yields of lucerne in kilograms per hectare from one harvest to a number of applied nutrients in a (2^5+1) experiment on a Waco soil. Main treatments only are shown

Treatment	Dry matter yield (kg/ha)
Control	880
K at 58 kg/ha (as muriate of potash)	910
Zn at 16 kg/ha (as zinc sulphate monohydrate)	940
Mo at 0.8 kg/ha (as sodium molybdate)	990
P at 20 kg/ha (as sodium dihydrogen orthophosphate)	1210
K, Zn, Mo, P applied at the same rates as above	1350
S at 58 kg/ha (as gypsum)	1124
K, Zn, Mo, P and S applied at the same rates as above	1170
K, Zn, Mo, P, S applied as above plus Mn at 10 kg/ha (as manganese sulphate) plus B at 230 g/ha (as borax)	1140
l.s.d. 5%	280

DISCUSSION

On the evidence from glasshouse and field investigations, nitrogen deficiency commonly occurs in the area. This finding was expected considering the many years of cultivation, the intensive crop production and the losses from soil erosion. Nitrogen responses can be expected with annual applications on most commercial crops unless there is a carry-over of nitrogen from the previous crop.

Responses to sulphur at present are probably masked by adequate sulphur mineralisation during periods of fallow between crops. Sulphur responses on a perennial crop such as lucerne (Lloyd 1969) or a perennial native pasture (Loader 1979) do occur where available sulphur supplies become depleted in the absence of a fallow.

The need for phosphate fertiliser is indicated by the low soil phosphorus analyses on the three sites (Table 2), and by the fact that low soil phosphorus figures are more likely to occur on the eastern Darling Downs (Jones, Reeve and Thompson 1972). The response to phosphorus in lucerne on the Waco soil was not large but one harvest only was taken after a short time interval.

In view of low soil phosphorus levels and apparent marginal sulphur levels, it is recommended that growers apply single superphosphate (9% P) as a source of phosphorus to annual crops. At the rate of 10 kg/ha P this would cost $11.93/ha current Brisbane bulk prices and would also supply 11 kg/ha S.

ACKNOWLEDGEMENTS

Grateful appreciation is expressed to Messrs J. Kessler, P. Riethmuller and W. Martin, farmers in the Wyreema-Cambooya area, for their interest and co-operation in these investigations.

References

Cull, J.K. and Muir, C.A. (1969), Nitrogen lifts oat yields, *Queensland Agricultural Journal* **95**, 111-14.

Cummins, V.G., Robinson, I.B., Pink, H.S. and Roberts, M.H. (1973), *A Land Use Study of the Wyreema-Cambooya area of the Eastern Darling Downs.* Queensland Department of Primary Industries, Division of Land Utilization Technical Bulletin No. 10.

Ivory, D.A. (1982), Evaluation of temperate grass species for the Eastern Darling Downs of Queensland, *Tropical Grasslands* **16**, 63-72.

Jones, R.M. (1970), Sulphur deficiency of dryland lucerne in the Eastern Darling Downs of Queensland, *Australian Journal of Experimental Agriculture and Animal Husbandry* **10**, 749-54.

Jones, R.M., Reeve, R. and Thompson, C.H. (1972), Available phosphorus levels in some soils of the Eastern Darling Downs, *Tropical Grasslands* **6**, 61-63.

Littler, J.W. and Price, M.J. (1967), Correction of sulphur deficiency in lucerne in the Warwick District, Queensland, *Queensland Journal of Agricultural and Animal Sciences* **24**, 159-71.

Lloyd, D.L. (1969), The nutrition and growth of lucerne on a sedentry black earth overlying a perched water table on the Eastern Darling Downs, Queensland, *Tropical Grasslands* **3**, 99-107.

Loader, L.R. (1974), Green Panicmlucerne sward response to nitrogen, phosphorus and sulphur on the Darling Downs, *Queensland Journal of Agricultural and Animal Sciences* **31**, 317-27.

Loader, L.R. (1979), Effect of sulphur on the productivity of a native pasture containing *Medicago minima*, on the Eastern Darling Downs, Queensland, *Queensland Journal of Agricultural and Animal Sciences* **36**, 25-29.

Mackenzie, J., Mayer, R. and Bisset, W.J. (1982), Productivity of five subtropical grasses on a black earth of the Eastern Darling Downs of Queensland, *Tropical Grasslands* **16**, 170-80.

Rasmussen, J.S. (1969), Potassium status of some Darling Downs (Queensland) soils, *Queensland Journal of Agricultural and Animal Sciences* **26**, 475-82.

Reeve, R., Thompson, C.H. and Beckmann, G.G. (1960), CSIRO, Division of Soils, Divisional Report 1/60.

Thompson, C.H. and Beckmann, G.G. (1959), *Soils and Land Use in the Toowoomba area, Darling Downs, Queensland*, Soil and Land Use Series, CSIRO, Australia, No. 28.

(Received for publication 14 December 1981)

Mr Hibberd is an officer of Agriculture Branch, Queensland Department of Primary Industries stationed at Emerald, Q. 4720. Mr Littler (now retired) was formerly a member of Agriculture Branch. Mr Nielsen is a member of the Division of Land Utilisation, stationed at the Queensland Wheat Research Institute, Toowoomba, Q. 4350.