MOLYBDENUM RESPONSES OF *MACROPTILIUM ATROPURPUREUM* CV. SIRATRO ON A RED VOLCANIC SOIL IN COASTAL SOUTH-EAST QUEENSLAND

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ABSTRACT

Responses of Siratro (Macroptilium atropurpureum *cv. Siratro) to initial rates and to frequency of maintenance applications of Mo were measured in two experiments on a red-brown volcanic soil in coastal south-east Queensland. Both experiments were conducted concurrently and were adjacent to each other.*

Dry matter yields did not respond to Mo in one experiment, run for three years, while responses occurred during the first two seasons in the second experiment, run for five years. The lack of later response in this experiment is discussed.

INTRODUCTION

Molybdenum deficiency occurs on a wide range of soil types in south-east Queensland (Andrew and Bryan 1955, 1958, Truong *et al.* 1967, Johansen *et al.* 1977). The rate of molybdenum application recommended for pasture establishment by these and other authors is about 140 g of elemental molybdenum per hectare. However, the sensitivity of various legumes to molybdenum deficiency differs, *Macroptilium atropurpureum* and *Medicago sativa* being more responsive than *Lotononis bainesii* and *Stylosanthes guianensis*, and less responsive than *Glycine wightii* and *Desmodium intortum* (Johansen *et al.* 1977).

There is little information about the residual effect of Mo in soil under sub-tropical conditions. Results obtained by Swain (1959) and 't Mannetje *et al.* (1963) on red basaltic soil in the Richmond River district of New South Wales and on prairie-like soil in sub-tropical Queensland respectively, indicate that molybdenum should be reapplied every 3 to 4 years. Although Johansen *et al.* (1977) calculated the long-term molybdenum requirements for some legumes grown on some contrasting soils in south-east Queensland, their work does not clearly indicate the rate that should be reapplied on a regular basis.

Two experiments are described; one investigates the response of *Macroptilium atropurpureum* cv. Siratro to four initial rates of Mo application, and the other the response of this legume to maintenance dressings. A strong response by the legumes Siratro and *Desmodium uncinatum* cv. Silverleaf to molybdenum had been obtained previously on similar soils in the same locality (Ostrowski 1970).

MATERIALS AND METHODS

Site

The experiments were located at Mt. Mee, 70 km north of Brisbane, on a gentle slope with a north-easterly aspect and on well drained, acid (pH 5.5) red friable earth (Gn 3.14, Northcote 1971) of volcanic origin with no previous fertilizer history. The average annual rainfall is 1 453 mm. Light frosts occur each winter.

Design and treatments

Randomized block designs were used with plot sizes of 3 m × 3 m and lanes 1.8 m wide between replicates. Plots in each replicate were contiguous.

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Experiment 1 consisted of 4 treatments with 6 replications. Treatments were: 0, 140, 280 and 420 g Mo ha^{-1}.

Experiment 2 consisted of 6 treatments with 4 replications. This experiment was designed to study residual effects. The recommended rate of Mo application (142 g ha^{-1}) was applied only in year 1, in years 1 and 5, in years 1 and 4, in years 1, 3 and 5 and in all years. These were compared with a treatment receiving no Mo.

Establishment and maintenance

Seed of Siratro inoculated with *Rhizobium* strain CB756 and fertilizer was distributed by hand at the rate of 5 kg ha^{-1} on a well prepared seed-bed and lightly raked into the soil on 17 December, 1969.

Basal fertilizers were:

At planting	— Experiments 1 and 2 —	750 kg superphosphate and 125 kg KCl ha^{-1}
Maintenance	— Experiment 1 —	500 kg and 355 kg superphosphate ha^{-1} in years 2 and 3 respectively
	— Experiment 2 —	355 kg superphosphate ha^{-1} $annum^{-1}$. 125 kg KCl ha^{-1} in year 4

Initial Mo applications were as sodium molybdate ($Na_2MoO_4.2H_2O$) and maintenance dressings as molybdenum trioxide (MoO_3) in commercial molybdenized superphosphate (0.04% Mo).

Measurements

The following data were collected in Experiment 1: annual and total yields of dry matter (D.M.); average annual percentages of N and P and total yields of these elements for three years; average annual percentages of Mo in the second and third year and total yields of Mo for these two years; nodulation 12 weeks after planting (number, size and weight of nodules); nodulation in the second season (number and weight of nodules); Mo content of the oven dried nodule tissue at the end of the second season.

A sample strip 0.9 m × 3 m was cut at 10 cm height with an autoscythe from the centre of each plot at each yield harvest, weighed and subsampled for dry matter, N, P and Mo analysis. Sub-samples were dried at 62° for 48 hours. Mo content was determined colorimetrically by the reaction with sodium thiocyanate in the presence of stannous chloride (Chapman and Pratt 1961). One cut was taken in the first season (mid May) and two cuts in each of the second and third seasons (early February and late April). After each harvest the remaining plant material on each plot was mown and removed.

Nodulation in the first season was assessed on five plants dug from each plot. In the second season, when the individual plants were well developed, an auger was used to take two cores (10 cm in diameter and 20 cm deep) from each plot. One core was taken from the zone including the tap root and the other from lateral roots. There were two such samplings during the season. Nodules collected were washed in distilled water.

In experiment 2 only D.M. yields and N and P concentrations were measured. One harvest was taken in the first season, and two harvests in each of the second to fifth seasons.

Disease incidence

During the third season Siratro was severely affected by halo blight (*Pseudomonas phaseolicola*). Mild infestation with this disease was also evident in Experiment 2 during the fourth and fifth season. The resulting leaf drop varied between seasons from moderate to very heavy.

RESULTS

In Experiment 1 D.M. yield did not respond to Mo application in any of the three seasons. Total N and P yields over three seasons responded to an application of 420 g Mo ha^{-1}, but there were no significant responses in any of the individual seasons. Mo content in the plant and total Mo yields responded strongly to the two higher rates of Mo application. There was no correlation between the Mo and N content of the plants (Table 1).

A substantial increase in the number of nodules occurred only at the highest rate of Mo application, in the early sampling of Experiment 1. However, there was a large increase in weight of nodules at all levels of applied Mo. During the second season, both nodule number and nodule weight showed a strong reverse trend in the earlier sampling, although the later sampling showed no clear cut trend. Mo content in the nodule tissue increased with Mo application up to 280 g ha^{-1} (Table 2).

Significant D.M. yield responses to the initial application of Mo were obtained in the first and second seasons of Experiment 2, but no responses to initial and further applications of Mo were evident thereafter. N and P yields followed the D.M. yield trend.

DISCUSSION

Evidence from past experiments on red soils in this locality (Ostrowski 1970) suggests that the experimental site is potentially molybdenum deficient for the production of legume pastures. However, the present trials have failed to demonstrate a consistent molybdenum response in different seasons and even in adjacent sites in the same season. The growth responses were restricted to the site of Experiment 2 and then only in the first two out of five seasons. The site of Experiment 1 was adjacent to the site of Experiment 2 but located lower down the slope and yield differences between the two experiments in the first two years suggest some difference in soil Mo content. Such differences within the same paddock have been detected elsewhere (Johansen, personal communication 1977).

The most probable explanation for the lack of yield response after the second season in Experiment 2 is that with time the legume was less dependent on symbiotic N because of absorption of more soil N resulting from the nitrification of fallen Siratro leaves. Leaf drop, which was a normal phenomenon of these experiments, was aggravated by the effects of halo blight. Decaying legume leaves can contribute substantially to soil N (Henzell *et al.* 1966). Since molybdenum has a particular role in the legume-rhizobium symbiosis (Anderson and Spencer 1950), any potential responses could be masked by this alternative N source. Cross-contamination of control plots through traffic or waterflow and the intermingling of runners from neighbouring plots (difficulties, common to all small plot experiments) are less likely explanations. The use of commercial molybdenized superphosphate as a maintenance source of Mo in nutritional experiments could also be queried (Teitzel, personal communication 1977).

N and P yields generally followed the dry matter yields, indicating a greater cumulative protein production at the highest level of molybdenum application (Table 2). The very low N and P percentages in the first year in Experiment 1 could be attributed to early partial defoliation due to cold weather before sampling. In addition, low N and P values could be accentuated by the chemical analyses being done on whole plants rather than on the uppermost leaves.

The increased recovery of molybdenum (Experiment 1) with increasing application rate, indicates that Siratro can absorb appreciably more molybdenum than is required for its functioning. Although no figures are available on the critical level required in Siratro tissue, a lack of growth response to higher concentrations of Mo in the plant tissue may suggest that it could be as low or lower than 0.1 p.p.m., a level accepted for lucerne (Stout *et al.* 1951).

TABLE 1

Effects of initial Mo application on dry matter (D.M.) yield and N, P and Mo content of Siratro (Experiment 1)

	1st Season				2nd Season				3rd Season				TOTAL (three seasons)			(two seasons)
	D.M. kg ha⁻¹	N %	P %	Mo p.p.m.	D.M. kg ha⁻¹	N %+	P %+	Mo p.p.m.+	D.M. kg ha⁻¹	N %+	P %+	Mo p.p.m.+	D.M. kg ha⁻¹	N kg ha⁻¹	P kg ha⁻¹	Mo g ha⁻¹
Mo nil	1 309	2.67	0.11	—	3 065	3.41	0.18	0.14	1 440	2.90	0.22	0.18	5 815	181.3a	10.3a	0.70a
Mo 140 g ha⁻¹	1 650	2.84	0.13	—	3 054	3.64	0.21	0.22	1 534	2.88	0.23	0.34	6 238	202.3a	12.1a	1.19a
Mo 280 g ha⁻¹	1 453	2.95	0.13	—	3 644	3.55	0.20	0.30	1 404	2.93	0.22	0.51	6 501	213.4a	12.2a	1.81b
Mo 420 g ha⁻¹	1 622	3.03	0.14	—	3 473	3.67	0.21	0.38	1 498	2.86	0.23	0.93	6 593	219.3b	13.1b	2.72c
					n.s.				n.s.				n.s.			

Means followed by different letters differ significantly ($P < 0.05$)
n.s.—non significant differences
+values are the mean of 2 cuts

TABLE 2

Effect of increasing levels of Mo application on number and wet weight of nodules and Mo content of nodule tissue (Experiment 1)

	1st Season 11/2/70		2nd Season 27/2/71		2nd Season 6/5/71		
	Nodule No. (per plant)	Nodule weight (mg)	Nodule No. (per 2 cores)	Nodule weight (mg)	Nodule No. (per 2 cores)	Nodule weight (mg)	Nodule Mo (p.p.m.)
Mo nil	6.1 ± 0.4	54.9 ± 4.2	71.4 ± 14.9	2 208 ± 347	7.6 ± 1.8	180 ± 49.3	3.33
Mo 140 g ha⁻¹	6.7 ± 0.5	155.4 ± 11.5	65.9 ± 14.2	1 762 ± 263	5.0 ± 1.1	64 ± 19.7	5.33
Mo 280 g ha⁻¹	6.4 ± 0.4	159.3 ± 11.6	55.4 ± 9.4	1 200 ± 185	10.6 ± 2.5	198 ± 50.7	10.28
Mo 420 g ha⁻¹	9.4 ± 0.6	219.8 ± 16.6	32.8 ± 7.6	783 ± 93	8.3 ± 2.4	240 ± 78.1	9.13

Where nodulation was examined, although there was a trend towards increased nodulation with higher molybdenum application in the first season, the trend was reversed in the second season. However, reduction in number but not in mass of nodules in response to supply of molybdenum has been shown by Anderson and Thomas (1946), so the inconsistency between seasons in this experiment cannot be simply explained. Despite this inconsistency in numbers and weight, the molybdenum content of nodular tissue trebled to about 10 p.p.m. with higher molybdenum treatments. While molybdenum levels of 3 to 10 and 4 p.p.m. for lucerne and subterranean clover respectively appear critical for nitrogen fixing efficiency (Jensen 1947), little information is available on the critical levels for tropical legumes.

The variability of Mo deficiency in related soils is well known. In addition, our studies suggest that similar variability may occur within the one soil type, between farms and within paddocks. Because precise recommendation on Mo requirements under these conditions is difficult, an overall application is warranted. Soil analyses offer very little guidance.

The rate of initial and maintenance application will depend on the sensitivity of the particular legume.

Mo application could possibly be viewed as a cheap form of insurance against loss of production through Mo deficiency.

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