APPLICATION OF MOLYBDENUM TRIOXIDE IN THE SEED PELLET FOR SUB-TROPICAL PASTURE LEGUMES

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ABSTRACT

The application of molybdenum trioxide in a rock phosphate pellet was as effective as soil application in correcting molybdenum deficiency. Nodulation, yield and molybdenum concentration of the legumes, Desmodium intortum, Glycine wightii, Lotononis bainesii *and* Macroptilium atropurpureum, *were similar whether molybdenum was applied with the seed pellet or to the soil.*

INTRODUCTION

Molybdenum deficiency has usually been corrected by application of molybdenum in a carrier fertilizer when establishing legume based pastures. This has generally proved a satisfactory method but there have been some instances of failure to correct deficiency. In some cases this has been due to uneven distribution of fertilizer and in others to an apparent inadequate mixing of molybdenum in the carrier fertilizer. Mixing of molybdenum in a carrier fertilizer is an additional cost. The alternative method of spraying molybdenum over the newly established pasture is a costly procedure.

Application of molybdenum with the inoculated legume seed has not been recommended because of possible toxic effects on rhizobia and high plant molybdenum levels. Direct contact of either soluble or insoluble forms of molybdenum with the inoculant may be toxic to the rhizobia (Giddens, 1964) but the inclusion of molybdenum in the coating material used to pellet seeds could protect the inoculant *Rhizobium.* With *Trifolium subterraneum,* the highly soluble sodium molybdate severely inhibited field nodulation (Gartrell, 1969) whereas the relatively insoluble molybdenum trioxide did not effect rhizobium survival or inhibit nodulation in pots (Date and Hillier, 1968). However this method of application has not been generally recommended for use with tropical and sub-tropical legumes because of the high plant molybdenum levels recorded in these experiments.

To determine if there was an inhibitory effect on nodulation and on plant molybdenum concentration molybdenum application in a rock phosphate pellet was included as one of the treatments in a series of long-term experiments on the use of molybdenum as a fertilizer for sub-tropical legumes. The first year results, as they relate to use of molybdenum by seed pelleting, are reported here for those sites where there was a significant response to molybdenum.

EXPERIMENTS

Site 1. *Eungella* (*near Mackay*)

Soil—xanthozem on granodiorite; pH: $CaCl_2$, 4.7; H_2O, 5.5.
Species and seeding rate—*Desmodium intortum* cv. Greenleaf, 5 kg/ha, with *Setaria anceps* cv. Nandi, 2.5 kg/ha.
Treatments—0, 50, 100, 200, 400 g Mo/ha (soil application); 100 g Mo/ha (pellet application).
Design—randomised block. Four replications.
Sowing—30.1.70; harvest 3.2.71.

Site 2. *North Deep Creek* (*near Gympie*)

Soil—red podzolic on phyllite; pH: $CaCl_2$, 4.9; H_2O, 5.9.
Species and seeding rate—*Macroptilium atropurpureum* cv. Siratro, 14 kg/ha,

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Lotononis bainesii cv. Miles, 4 kg/ha, each with *Panicum maximum* cv. Gatton, 5 kg/ha.

Treatments—0, 50, 100, 200 g Mo/ha (soil); 100 g Mo/ha (pellet).

Design—split block. Four replications.

Sowing—21.12.71; harvest—3.3.72 (Siratro), 28.4.72 (Lotononis).

Site 3. *Glastonbury* (*near Gympie*)

Soil—prairie on andesite; pH: $CaCl_2$, 5.3; H_2O, 6.1.

Species and seeding rate—*M. atropurpureum* cv. Siratro, 14 kg/ha, *Glycine wightii* cv. Tinaroo, 12 kg/ha, each with *P. maximum* cv. Gatton, 5 kg/ha.

Treatments and design—as for site 2.

Sowing—23.12.71; harvest—5.4.72.

All seed was pelleted, using commercially prepared peat inoculants, methylcellulose (3% w/v) as the adhesive and rock phosphate (300 mesh) as the coating (Roughley, Date and Walker, 1966). The proportion of rock phosphate to seed was 1 : 2 for *L. bainesii*, 1 : 3 for *D. intortum* and 1 : 4 for *G. wightii* and *M. atropurpureum*. Pelleting was carried out 1, 4 and 7 days prior to sowing at Sites 1, 2 and 3, respectively, and the pelleted seed was stored under refrigeration until it was sown. A commercial grade of molybdenum trioxide (57% Mo) was used as the source of molybdenum. The rate of 100 g Mo/ha was chosen for comparison of pellet and soil application as this was the recommended rate of application for deficient soils. Basal phosphorus, sulphur and potassium were applied as monocalcium phosphate, calcium sulphate and potassium chloride, respectively. Molybdenum applied to the soil was mixed with the basal fertilizer. Molybdenum incorporated in the pellet was mixed with the rock phosphate coating prior to pelleting. Seed and fertilizer were hand broadcast and raked into the surface. Rain fell within one week after sowing at all sites.

Nodulation was assessed at eight weeks after sowing. At sites 2 and 3, six plants were removed at random from each plot, washed and examined for effectiveness and position of nodules. At site 1, effectiveness was assessed by colour of the plants and examination of plant roots.

Yield determinations were made by cutting two 0.5 m^2 quadrats from each plot at a height of 10 cm. Separate samples of shoots (five expanded leaves plus stem) were collected for chemical analysis. Nitrogen and molybdenum were determined by emission spectroscopy (Johnson and Simons, 1972).

RESULTS

Nodulation was equally effective whether molybdenum trioxide was applied in the rock phosphate pellet or to the soil. *D. intortum* was dark green in all molybdenum treatments and roots had effective crown nodulation. Plants in the nil molybdenum treatment were chlorotic but abundantly nodulated. There was predominantly crown nodulation of *M. atropurpureum* at Site 2 and both crown and lateral nodulation at Site 3. Plants in the molybdenum treatments were dark green while those on the nil treatment were chlorotic. *L. bainesii* had effective crown nodulation in all treatments with some plants also having lateral nodules. There were a few non-nodulated plants in the nil and soil molybdenum treatments. Plants in the nil treatment were only slightly chlorotic as compared with those in the molybdenum treatments. *G. wightii* was effectively nodulated in all treatments but with the nodules occurring on the lower crown and laterals. Approximately five per cent of plants in all treatments were not nodulated. Plants in the nil treatment were strongly chlorotic and those in the molybdenum treatments were dark green.

Legume dry matter yields and nitrogen concentrations for the 0 and 100 g Mo/ha treatments are shown in Table 1. With the exception of *L. bainesii* at Site 2, all legumes showed significant yield responses to molybdenum at each site, and there were no significant differences between molybdenum applied to the soil or with the pellet. Soil applications greater than 100 g Mo/ha did not produce significantly higher yields.

TABLE 1

Effect of method of application of molybdenum trioxide on dry matter yield and nitrogen concentration

Species		Mo (g/ha)	Yield (kg/ha)	N (%)
		Site 1		
D. intortum		0	70	1.9
		100-soil	1220	3.2
		100-pellet	1380	3.4
L.S.D.	0.05		290	
		Site 2		
M. atropurpureum		0	740	2.8
		100-soil	2240	3.4
		100-pellet	2090	3.3
L.S.D.	0.05		520	
L. bainesii		0	770	2.8
		100-soil	880	3.1
		100-pellet	930	3.1
L.S.D.	0.05		380	
		Site 3		
M. atropurpureum		0	2210	2.6
		100-soil	2910	3.2
		100-pellet	3060	3.3
G. wightii		0	230	1.6
		100-soil	1940	2.9
		100-pellet	2560	3.0
L.S.D.	0.05		690	

Nitrogen values supported the yield data. Plant molybdenum concentrations were less than 1 ppm and were no higher when molybdenum was applied in the pellet than to the soil.

DISCUSSION

Although plants nodulated when molybdenum was incorporated in the pellet, nodulation may have been from indigenous rhizobia. *M. atropurpureum* and *G. wightii* will nodulate from native *Rhizobium* strains. *D. intortum* will nodulate slowly from native strains but such stands usually contain some non-nodulated (chlorotic) plants. The rapid and complete crown nodulation which was observed in this study suggests that nodulation was due to the applied *Rhizobium* strain. In contrast, *L. bainesii* is quite specific in its *Rhizobium* requirements (Norris, 1958), and since legumes had not been sown previously on the experimental sites, nodulation would have been from the applied *Rhizobium* strain. We can infer that the inclusion of molybdenum trioxide in the rock phosphate pellet does not appear to have reduced the viability of the inoculant *Rhizobium* strains.

The viability of the inoculant *Rhizobium* strains might have been reduced with longer storage prior to sowing. However the results of Date and Hillier (1968), where viability in the 100 g Mo/ha treatment was not reduced more than that of the control after 12 weeks storage, suggests this would not happen.

The low plant molybdenum concentration in the pellet treatment of this study, < 1 ppm, contrasts with the high concentrations reported by Date and Hillier (1968), 15 ppm using 100 g molybdenum trioxide on 4.5 kg seed, and Gartrell (1969), 8 ppm using 42 g sodium molybdate on 13 kg seed. A similar pelleting technique was used in all studies but different coating materials, species, culture conditions and forms of molybdenum may account for the differences in uptake.

Lime coating would increase the pH around the seed subsequent to wetting following sowing and result in greater availability of molybdenum. This may account for high molybdenum concentrations where the relatively insoluble molybdenum trioxide was used (Date and Hillier, 1968). A high uptake would be expected from the more soluble sodium molybdate.

For these four legumes, the addition of molybdenum trioxide to a rock phosphate pellet can be considered as an alternative to mixing it with basal fertilizer for initial application. Application of molybdenum in a basal fertilizer has the disadvantages of possible uneven distribution in the fertilizer and uneven spread over the ground. Incorporating molybdenum in the pellet has advantages of economy and ensuring the nutrient is where it is required, with the disadvantage of an additional step in seed preparation where pelleting is not necessary. Norris (1971) found that the use of a coating material, as compared with adhesive alone, did not benefit the nodulation of several tropical and sub-tropical legumes. In this study by Norris (1971) the seed was applied separate from the fertilizer and covered with soil. A rock phosphate coating was recommended where legume seed is to be banded with a fertilizer. However, caution should be observed in applying other minor nutrients in the seed pellet. There were severe toxic effects on the inoculant *Rhizobium* strains and slight toxic effects on the plants when copper, zinc, and molybdenum in the oxide forms were applied together in the seed pellet (D. Norris, personal communication).

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REFERENCES

DATE, R. A., and HILLIER, G. R. (1968)—Molybdenum application in the lime of lime-pelleted subterranean clover seed. *Journal of the Australian Institute of Agricultural Science* **34**: 171-2.

GARTRELL, J. W. (1969)—The effect of sodium molybdate mixed in the lime seed pellet on nodulation, nitrogen content and growth of subterranean clover. *Australian Journal of Experimental Agriculture and Animal Husbandry* **9**: 432-6.

GIDDENS, J. (1964)—Effect of adding molybdenum compounds to soybean inoculant. *Agronomy Journal* **56**: 362-3.

JOHNSON, A. D., and SIMONS, J. G. (1972)—Direct reading emission spectroscopic analysis of plant tissue using a briquetting technique. *Communications in Soil Science and Plant Analysis* **3**: 1-9.

NORRIS, D. O. (1958)—A red strain of Rhizobium from *Lotononis bainesii* Baker. *Australian Journal of Agricultural Research* **9**: 629-32.

NORRIS, D. O. (1971)—Seed pelleting to improve nodulation of tropical and sub-tropical legumes. 2. The variable response to lime and rock phosphate pelleting of eight legumes in the field. *Australian Journal of Experimental Agriculture and Animal Husbandry* **11**: 282-9.

ROUGHLEY, R. J., DATE, R. A., and WALKER, M. H. (1966)—Inoculating and lime pelleting legume seed. *Agricultural Gazette N.S.W.* **77**: 142-6.

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