RHIZOBIAL AND NUTRITIONAL RESPONSES OF DESMANTHUS VIRGATUS ON CLAY SOILS OF QUEENSLAND

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ABSTRACT

The objective of these studies was to determine the reasons for chlorosis of desmanthus observed at some sites in southeast Queensland. Inoculation with *Rhizobium* increased growth of desmanthus in 2 of 4 soils in the field and 4 of 8 soils in pots. Greatest responses occurred in soils with few or no effective native *Rhizobium*. Most soils however, contained native strains that were effective. Omission of sulphur significantly reduced dry weight of desmanthus grown in pots in 5 of 7 soils by 30-51% relative to plants supplied with all nutrients. Omission of P and Mo resulted in similar yield reductions in one soil each. Both S and Mo deficiency significantly reduced nitrogen concentrations in leaf tissue. Chlorosis therefore appears to be due to low or absent native *Rhizobium* and/or deficiency of S or Mo. More work needs to be done in the field to determine the extent of nutrient deficiencies and to improve methods of inoculation.

INTRODUCTION

Three cultivars of *Desmanthus virgatus* (L.) Willd have been commercialized in Australia with the aim of improving cattle liveweight gains and increasing nitrogen fertility of clay soils following extended periods of cropping. Prior to the introduction of desmanthus, few other pasture legumes existed for use on clay soils in tropical and sub-tropical regions of Queensland. However, since its introduction, chlorosis and poor vigour have been observed in some grass/legume pastures. This has led to the work on nutritional and rhizobial responses in desmanthus summarized in this paper.

METHODS

Growth was determined in desmanthus cultivars Marc, Bayamo and Uman at 6 and 18 months after planting in a field trial in 3 clay soils and 1 sandy textured soil and in the Marc cultivar at 8 and 14 weeks after planting in 8 clay soils in a pot trial. Three treatments were used: an uninoculated control, inoculation with *Rhizobium* strain CB3126 and fertilization with mineral nitrogen. Nutrients other than nitrogen were applied as a basal dressing. The proportion of nodules due to CB3126 was determined using serological techniques. Another study evaluated the effectiveness of native strains of *Rhizobium* isolated from the uninoculated treatments of the pot trial by comparing growth of desmanthus in nitrogen free media inoculated with the various native strains compared to that inoculated with CB3126. Another study looked at the survival of CB3126 as an inoculum on seed stored at temperatures of 25, 35, 45 and 55 °C for 14, 28 and 39 days. Survival following storage was determined using a grow-out test on desmanthus in N-free plant growth medium in sand culture. An omission trial in pots determined the growth limiting effects of P, S, Mo and Zn on desmanthus in 7 soils. A rate trial in 2 of these soils in pots established a critical S concentration in leaf tissue.

RESULTS

Rhizobium studies. Inoculation with strain CB3126 increased growth of desmanthus relative to uninoculated treatments in 2 of 4 soils in the field by 75-400% and in 4 of 8 soils in pots by 30-200%. The inoculum strain accounted for between 35 and 100% of nodules formed in pots (Table 1) and 0 and 65% in the field. Six of the 8 soils used in the pot trial contained native rhizobia, most of which were effective relative to CB3126. Largest responses to inoculation however occurred in the soils low or devoid in native strains (Table 1). Survival of inoculum on seed stored under dry conditions however was less than 2 weeks at temperatures of 45 and 55°C.

Nutritional studies. Omission of sulphur significantly reduced growth of desmanthus, relative to plants supplied with all nutrients, by 30-50% in 5 of the 7 soils used in the pot trial (Table 2). Omission of P also reduced growth in one soil by 60% and omission of Mo reduced growth in one soil by 51%. A tentative critical sulphur concentration in plant leaves of approximately 0.20% was determined from results of the S rate trial. Increasing application of S from 0 to a rate equivalent to 60 kg S/ha increased S concentration from 0.1 to 0.4%, doubled nodule mass and increased nitrogen concentration from 1.9 to 3.4%.

DISCUSSION

Both rhizobial and nutritional factors were identified as potential causes for chlorosis and poor growth of desmanthus in soils from southeast Queensland. The number of soils containing *Rhizobium* that effectively nodulate desmanthus was higher than expected. Although not confirmed, it is thought that this may be due to *Rhizobium* associated with Neptunia gracilis, a native legume species present in many clay soils. Despite this, strain CB3126 stimulated growth of desmanthus in soils with low or nil populations of the native rhizobial strains. It was competitive with the native strains in pots and persisted for the 2 year duration of the field trial. On the basis of these results, the strain is now available as a commercial inoculum in Australia. Results of nutrition experiments in pots indicated that sulphur deficiency also caused chlorosis and limited plant growth in 5 of 7 soils. This is consistent with concentrations of extractable S in the surface soil. These concentrations were lower than levels considered limiting in these soils (Blair *et al.*, 1991). Higher concentrations in sub-surface layers of the profile however can sometimes compensate for low levels in the surface soil and reduce responses in the field (Jones, 1970). Nonetheless, application of S and Mo at one site with low surface and sub-surface layers of available S (Prinsen *et al*., 1992) increased both S and N concentration in leaves of desmanthus (unpublished data), suggesting that one or both of these nutrients may be a limitation in some clay soils. The critical S concentration of 0.2% as determined in pot trials may be useful in determining the prevalence of S deficiency in other soils in the field. Further work on *Rhizobium* needs to look at ways of increasing survival of the inoculum on the seed since survival is less than 2-3 weeks at the temperatures normally experienced in dryland planting in surface soil during summer.

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Table 1

Growth response of desmanthus to the inoculation with the *Rhizobium* strain CB3126 in 8 clay soils with different native rhizobial populations,the proportion of nodules due to CB3126, and the effectiveness of native strains relative to CB3126 in N-free sand culture. Prevalence of native strains was assessed as "-" = no nodules "+" = few nodules and "++" = many nodules on uninoculated control plants of the pot trial.

Site	% growth increase due to CB3126	Proportion of nodules due to CB3126 (%)	Effectiveness of native rhizobia (%)	Presence of native rhizobia
Gayndah	66	86	60	+
Emerald	30	96	110	+
Theodore	0	72	100	++
Wandoan	0	35	70	++
Bauhinia	0	88	30	++
Mundubbera	90	100	-	_
Biloela	0	47	110	++
Roma	200	100	-	_

Table 2

Available sulphur and phosphorus concentrations in 7 clay soils and the effect of the omission of nutrients on growth of desmanthus in a pot trial.

Site	Soil Chemical Characteristics		% reduction in plant growth		
	S (KCl)	P (Bicarb)	-S	-P	-Mo
	(mg/kg)	(mg/kg)			
Gayndah	3	84	50	3	7
Emerald	2	8	36	18	23
Clermont	3	7	30	60	23
Theodore	3	7	31	47	14
Wandoan	8	6	5	15	0
Bauhinia	15	35	9	4	7
Walkamin	2	40	51	27	51