THE EFFECTS OF THE INTERACTIONS BETWEEN SEED INOCULATION, PELLETING AND FERTILIZER ON GROWTH AND NODULATION OF DESMODIUM AND GLYCINE ON TWO SOILS IN S.E. QUEENSLAND

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ABSTRACT

The interaction of seed inoculation, pelleting and fertilizing of Glycine wightii *cvs Tinaroo and Clarence and* Desmodium intortum *cv. Greenleaf was examined in the field.*

Seed inoculation was necessary for satisfactory nodulation of both species. The major growth and nodulation responses were to phosphorus. Where phosphorus and nitrogen levels in the plant were determined the greatest recovery of both elements was from inoculated treatments.

Lime application to the soil generally favoured growth and nodulation of glycine more than desmodium but lime pelleting had little effect on either species. Under manganese toxicity conditions, pelleting failed to reduce the uptake of manganese or to lessen the foliar symptoms although lime broadcast was efficacious. The results indicate a higher lime requirement for nodulation and growth than is provided by a seed pellet and the significance of this is discussed.

INTRODUCTION

A serious decline in pasture productivity on the Maleny krasnozems has been reported by White (1967). Soils with a nutrient status too low to maintain kikuyu—white clover pastures have been invaded by *Axinopus affinis* (mat grass). A similar fertility decline has occurred with latosol soils around Cooroy (Luck and Douglas 1966). Some success in regaining productivity has been achieved in these areas by introducing *Desmodium intortum* cv. Greenleaf or *Glycine wightii* cvs Tinaroo and Clarence into the grassland. Slow establishment of the legume component has been a problem, but the legume gains vigour in the second year. Poor initial nodulation of Tinaroo glycine has been commonly noted and similarly Mears (1967) in Northern New South Wales reports a connection between early nodulation and greater productivity in the variety Clarence.

This paper reports experiments aimed at improving the early nodulation of Tinaroo, Clarence and Greenleaf.

EXPERIMENTAL METHODS

Selection of Sites and Soils

Sites 1, 2 and 4 were adjacent sites on Krasnozem at Maleny originally cleared of rain forest and sown to grass for many years. Following cultivation and fertilizing in the autumn before experimentation, oats were grown. At the time of planting the soils had a reaction of pH 4.7-4.8 with nitrogen levels of 10-20 p.p.m. N as nitrate and 35 p.p.m. N as ammonium ion except for site 1 which had a higher nitrate level of 30 p.p.m. N. Site 3 nearby at Cooroy, was a latosol originally cleared of scrub and carried grass until cultivated for the experiment, (pH 4.8-5.2, 10-20 p.p.m. N as nitrate and 35-80 p.p.m. N as ammonium ion).

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Field Trials

1966: A 2^5 factorial trial with two replicates was laid down in randomised blocks of eight in each of the sites 1, 2 and 3.

The treatments were:—

- Inoculum at nil and commercial rate (4g inoculant per lb seed)
- Superphosphate at nil and 4 cwt/ac applied in the furrow
- Lime at nil and 1 ton/ac broadcast
- Lime pellet (plasterer's whiting) applied over the inoculum in half the inoculated treatments.

Tinaroo glycine and Greenleaf were sown on January 27, 1966. Commercial peat cultures with strains CB756 and CB627 respectively were used as the inoculum with a 45% gum arabic solution as sticker. The seeds were inoculated and pelleted approximately 1 hr before planting in all inoculated treatments. A basal fertilizer of 1 cwt/ac of muriate of potash and 16 oz/ac sodium molybdate was applied one week before planting whereas the lime treatment was applied one month earlier. A single row was planted in the centre of each plot (8 ft x 3 ft) by making a furrow 2 in. deep, applying the superphosphate, covering with 1 in. of soil onto which the seeds were laid and covered with top soil. Prompt germination occurred on all sites. The trials were sampled after eight weeks and an additional sample was taken from the first replication on site 1 after 15 weeks.

Fifty plants were removed at random from each row and examined for crown and lateral nodulation. Nodules on the top 1½ in. of tap root and within ¼ in. of it on the lateral roots were classed as crown nodulation, the remainder as lateral nodulation. The dry weight yields of tops of 50 plants in the first sample and 15 plants in the second were measured. Nitrogen and Phosphorus analyses were performed on the second sample from site 1.

1967: A 3 x 2^3 factorial trial with two replicates was laid down at Maleny site 4 in randomised blocks of six.

The treatments were:—

- Inoculum at nil and commercial rate (4g inoculant per lb seed)
- Pelleting with either lime (plasterer's whiting) or rock phosphate (Florida/Nauru phosphate)
- Lime at nil and 1 ton/ac broadcast.

The rock phosphate was a composite sample of Florida and Nauru rock phosphate having a pH of 7.0 taken from air filters in a crushing plant. A basal dressing of 6 cwt/ac of molybdated superphosphate and 1 cwt/ac of muriate of potash together with the lime treatment was applied two weeks prior to planting.

Tinaroo, Clarence and Greenleaf were sown on March 21, 1967, and examined after 11 weeks. Nodulation was assessed on the same criteria as in the preceding experiment.

RESULTS

1966 Trials

The field data are summarised in Tables 1, 2 and 3. Data from the inoculated treatments with and without a pellet have been combined in Tables 2 and 3 on the basis of a nil response to pelleting.

Both Tinaroo and Greenleaf established well at all sites. However, some marginal and interveinal chlorosis appeared in glycine on unlimed plots in site 2. The manganese levels in leaf tissue after eight weeks were 621 p.p.m. in unlimed plots, 556 p.p.m. in lime pelleted plots and 335 p.p.m. in lime broadcast plots at site 2.

TABLE 1

Selected nodulation data eight weeks after sowing inoculated and lime pelleted seed in superphosphate treated plots at Site 2 (Means of two replications)

	% Nodulated Plants			
	Tinaroo		Greenleaf	
	At Crown	Elsewhere	At Crown	Elsewhere
Inoculated seed	19	40 (8.30)*	74	19 (5.87)*
Inoculated lime pelleted seed	34	29 (8.73)	87	9 (5.84)
Inoculated seed + lime broadcast	40	43 (10.36)	92	8 (6.88)
Inoculated lime pelleted seed + lime broadcast	64	26 (11.78)	84	13 (5.91)

* Dry Wt. Tops g (50 plants)

Indigenous rhizobia suited to either species were generally absent although at site 3 a low level of nodulation appeared on the controls. Crown nodulation served to confirm that the inoculum had taken although total nodulation appeared a more significant criterion in view of little interference from native rhizobia (Table 1). The nodulation of Greenleaf was dominantly influenced by inoculation but with Tinaroo there was an inoculum x lime interaction on all sites (Tables 2 and 3).

There was no significant response in total nodulation to lime pelleting by either legume on any of the sites, although a response generally occurred in crown nodulation (Table 1). This was not reflected in the dry weights of tops.

The major yield responses in both species were to superphosphate although on site 1 a strong interaction of inoculum x superphosphate x lime was also evident (Table 2). The total nitrogen contents of the tops at 15 weeks in both species were significantly increased by each component in the interaction although the early harvest (eight weeks) showed only small growth difference, due probably to the high initial level of mineralised nitrogen in the soil. Similarly, there was a greater recovery of phosphorus from inoculated and limed plots.

1967 Trial

Prompt germination occurred but the early emergence was reduced by insect attack which was controlled by a foliar spray of dieldrin six days after sowing. The nodulation assessment therefore was based on those plants emerging after eight days (Table 4).

The establishment was further affected by prolonged wet and misty weather so that no differentiation in growth occurred between treatments. This could account for the poor overall nodulation in Tinaroo and Greenleaf. Dry weights were therefore not taken.

A nodulation response to lime pelleting ($P < 0.05$) was obtained in the absence of broadcast lime by Tinaroo but not by Clarence or Greenleaf (Table 4). Rock phosphate pelleting in the absence of lime improved nodulation ($P < 0.05$) with both Tinaroo and Clarence but not with Greenleaf. In the presence of lime this nodulation effect was significant only in Tinaroo.

Clarence nodulated with indigenous rhizobia whereas Tinaroo and Greenleaf failed to nodulate in the uninoculated control rows.

TABLE 2

The effect of seed inoculation and fertilizing on the nodulation and yields of Tinaroo and Greenleaf at Maleny (Site 1) 1966

Treatment	Total Nodulation % (8 weeks)		First harvest (8 weeks) Dry Wt. Tops (50 plants)		Second Harvest (15 weeks) Mineral Content Tops (15 plants)			
	Tinaroo	Greenleaf	Tinaroo g	Greenleaf g	Tinaroo N mg	Tinaroo P mg	Greenleaf N mg	Greenleaf P mg
Uninoculated	0 (0)	1.3 (0.12)	4.80	2.96	53.5	10.4	54.1	13.1
Inoculated	34.9 (0.63)*	86.2 (1.19)*	5.30	3.68	209.0	18.2	232.4	17.9
Uninoculated + super	0.1 (0.03)	0.2 (0.05)	8.97	4.57	100.0	21.1	91.4	18.9
Inoculated + super	61.1 (0.89)	94.7 (1.34)	8.01	6.27	385.5	31.7	348.9	26.1
Uninoculated + lime broadcast	0 (0)	0 (0)	5.81	4.14	138.3	23.9	82.5	16.3
Inoculated + lime broadcast	48.3 (0.77)	88.9 (1.23)	4.54	4.73	260.5	21.4	328.4	30.6
Uninoculated + super + lime broadcast	0.2 (0.04)	0.4 (0.07)	8.93	3.97	122.2	30.0	104.4	19.5
Inoculated + super + lime broadcast	87.6 (1.21)	99.6 (1.51)	11.55	6.17	575.1	51.8	666.0	59.7
L.S.D.								
$P < 0.05$	(0.11)*	(0.11)*	1.43	1.43	59.6	7.3	59.6	7.3
$P < 0.01$	(0.15)	(0.15)	1.93	1.93	83.1	10.2	83.1	10.2

*Inverse sine transformation

TABLE 3

The effect of seed inoculation and fertilizing on the nodulation and yields of Tinaroo and Greenleaf at Maleny (Site 2) and Cooroy (Site 3) 1966

Treatment	SITE 2 Total Nodulation %		SITE 2 Dry Wt. Tops (50 plants)		SITE 3 Total Nodulation %		SITE 3 Dry Wt. Tops (50 plants)	
	Tinaroo	Greenleaf	Tinaroo g	Greenleaf g	Tinaroo	Greenleaf	Tinaroo g	Greenleaf g
Uninoculated	0	0	3.31	4.61	0.5 (0.07)*	4.4 (0.21)*	3.55	2.02
Inoculated	17.9 (0.44)*	84.0 (1.16)*	4.39	3.48	1.4 (0.12)	50.9 (0.79)	4.03	6.90
Uninoculated + super	0.1 (0.08)	0.7 (0.08)	7.49	14.05	14.7 (0.39)	27.4 (0.55)	17.01	12.45
Inoculated + super	58.2 (0.87)	94.6 (1.34)	10.49	15.34	10.6 (0.33)	96.4 (1.38)	17.07	10.17
Uninoculated + lime broadcast	0	0	4.66	4.00	4.9 (0.23)	2.0 (0.14)	3.81	2.86
Inoculated + lime broadcast	35.3 (0.64)	86.9 (1.20)	4.11	4.99	5.0 (0.23)	78.4 (1.09)	3.63	2.22
Uninoculated + super + lime broadcast	0	0	9.18	15.32	18.7 (0.45)	29.3 (0.57)	19.55	11.92
Inoculated + super + lime broadcast	85.5 (1.18)	99.9 (1.54)	12.69	16.81	47.3 (0.76)	99.9 (1.53)	21.74	13.31
L.S.D.								
$P < 0.05$	(0.07)*	(0.07)*	2.68	2.68	(0.19)*	(0.19)*	4.82	4.82
$P < 0.01$	(0.09)	(0.09)	3.62	3.62	(0.25)	(0.25)	6.49	6.49

*Inverse sine transformation

TABLE 4

The effect of inoculating and pelleting seed on the nodulation of Tinaroo, Clarence and Greenleaf planted with and without lime at Maleny (Site 4) 1967

		Total Nodulation %	
	Tinaroo	Clarence	Greenleaf
Uninoculated	0	1.3 (0.11)	0
Inoculated	0	10.9 (0.34)	16.8 (0.42)
Inoculated + lime pellet	29.3 (0.57)*	32.0 (0.60)*	20.5 (0.47)*
Inoculated + rock phosphate pellet	19.6 (0.46)	49.0 (0.77)	32.9 (0.61)
Uninoculated + lime broadcast	1.8 (0.13)	5.8 (0.24)	0
Inoculated + lime broadcast	9.4 (0.31)	50.5 (0.79)	37.9 (0.66)
Inoculated + lime pellet + lime broadcast	23.5 (0.51)	59.7 (0.88)	14.9 (0.39)
Inoculated + rock phosphate pellet + lime broadcast	51.0 (0.79)	81.4 (1.12)	33.3 (0.61)
L.S.D.			
P < 0.05	(0.38)*	(0.38)*	(0.38)*
P < 0.01	(0.52)	(0.52)	(0.52)

* Inverse sine transformation

DISCUSSION

The Maleny krasnozems and adjacent latosol carried very few rhizobia suited to Tinaroo, Clarence and Greenleaf and so seed inoculation was necessary to produce satisfactory nodulation in both legumes. These conditions permitted a fair assessment of nodulation and growth benefits accruing from seed and soil treatments.

The major growth and nodulation responses in all three legumes were to phosphorus. Even in the absence of nodulation, phosphorus increased plant growth twofold whereas in nodulated plants a fourfold increase was obtained. Where phosphorus levels were determined the greatest phosphorus recovery also occurred in the inoculated treatments in both species. Rock phosphate when used in pelleting, improved the overall nodulation in two of three instances but failed to give any visible growth responses.

The lime responses differed both between species and between soils. Lime pelleting while increasing the early crown nodulation in several instances, failed to increase the overall proportion of nodulated plants. The only exception in nine instances was with Tinaroo in contrast to Clarence.

The particularly rigorous conditions of site 2 of both acidity and low calcium levels would appear most likely to elicit any responses to lime pelleting. Marginal and interveinal leaf chlorosis occurred in glycine in the absence of lime, the levels of manganese in leaf tissue being as high as 621 p.p.m. Even under these conditions lime pelleting failed to improve the overall nodulation of 58% or to reduce the manganese uptake or to lessen the foliar symptoms although lime broadcast was efficacious in all aspects. These results agree with those of Döbereiner and Aronovich (1965) obtained with lime pelleted *Centrosema pubescens* under manganese toxicity conditions except that they reported a significant increase in nodulation with pelleting which was not reflected in yield responses.

Lime additions to the soil generally favoured growth and nodulation of Tinaroo under phosphorus sufficiency and to a lesser extent of Greenleaf. Mears and Barkus (1970) similarly recorded growth responses in Clarence on a krasnozem. The nodulation of Tinaroo appears even more lime sensitive than Clarence while Greenleaf was often insensitive.

It is apparent from these experiments that Tinaroo has a higher lime requirement for optimum growth and nodulation on these soils than is provided by a pellet and that the placement of the lime in close proximity to the inoculum is of little importance. These further suggest that poor nodulation was not the result of adverse survival of the inoculum but rather of nutritional inadequacies. Superphosphate for example could increase nodulation from 17% to 58% of the plants nodulated and broadcast lime improved nodulation by indigenous rhizobia. The negative superphosphate x lime interaction confirms in addition that the fertilizer banding did not interfere with the inoculum. It is also worth noting that in no instances was nodulation significantly depressed by lime either broadcast or as pellet. These results agree only in part with those of Norris (1967) obtained from seed sown after one day storage. Our interest in seed pelleting in the present study was an aid to improving nodulation above conventional farm techniques. Since the inoculum-pellet interaction occurs in the soil and not under prolonged storage it is not surprising that these results differ from those of Norris (1967) following seed storage for one week where suppression of nodulation occurred.

The lack of a response from lime pelleting on the tropical species contrasts sharply with benefits obtained from lime pelleting temperate species in other parts of Australia, (Brockwell 1963) and in our own concurrent trials with clover and lucerne at Maleny (unpublished data). The lesser acid sensitivity of the slow growing "cowpea-type" organism to which both strain CB756 and CB627 belong is the most likely explanation (Norris 1967).

The somewhat different results obtained in the 1967 trial showing a response to lime pelleting in Tinaroo as well as responses to rock phosphate pelleting by both Tinaroo and Clarence could be attributable to experimental conditions. Since only late emerging plants were sampled, the pellet and the inoculum interacted longer than usual so that under such conditions the pellet probably afforded the inoculum some protection.

In conclusion it appears that both lime and phosphorus are necessary to establish Tinaroo and Clarence on these soils although for Greenleaf only phosphorus is suggested. Lime pelleting seems unnecessary for these three cultivars.

ACKNOWLEDGEMENTS

We wish to thank Messrs. T. C. Thynne and C. Porter as well as Cooroy Seed Producers for making land available for experimentation. The statistical analyses were preformed by Biometrics Branch and the chemical analyses by the Agricultural Chemical Laboratory Branch, Queensland Department of Primary Industries. Financial assistance was provided by the Australian Dairy Produce Board.

REFERENCES

BROCKWELL, J. (1963)—Seed pelleting as an aid to legume seed inoculation. *World Crops,* **15**: 334-8.

DOBEREINER, J., and ARONOVICH, S. (1965)—Efeito da calagem e da temperatura do solo na fixacao de nitrogênio de *Centrosema pubescens* Benth. em solo com toxidez de manganês. Proceedings of the IXth International Grassland Congress, Sao Paulo, Brazil, Vol. 2. pp. 1121-4.

LUCK, P. E., and DOUGLAS, N. J. (1966)—Dairy pasture research and development in the near North Coast centred on Cooroy, Queensland. Proceedings of the Tropical Grassland Society of Australia, No. 6: 35-50.

MEARS, P. T. (1967)—Tropical pastures in the Richmond-Tweed region of New South Wales—recent experiences and future development. *Tropical Grasslands,* **1**: 98-104.

MEARS, P. T., and BARKUS, B. (1970)—Response of *Glycine wightii* to molybdenized superphosphate on a krasnozem. *Australian Journal of Experimental Agriculture and Animal Husbandry,* **10**: 415-25.

NORRIS, D. O. (1967)—The intelligent use of inoculants and lime pelleting for tropical legumes. *Tropical Grasslands,* **1**: 107-21.

WHITE, R. E. (1967)—Nutrient requirements of white clover based pastures on a krasnozem basalt at Maleny, south-eastern Queensland. *Australian Journal of Experimental Agriculture and Animal Husbandry,* **7**: 509-14.

[Accepted for publication September 28, 1971]