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EFFECTS OF SOIL MOISTURE ON THE SUCCESS OF SOIL-APPLIED INOCULA FOR SOYBEANS

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SUMMARY

A field trial was carried out on three sites on black soil comparing seed inoculation of soybeans with soil application of inoculum. Inoculum was applied into the furrow as a peat inoculum in a water suspension at three levels of application (80, 250, 500 *l* ha^{-1}) or carried on treated alkythene granules. The soil moisture at planting varied between sites. Seed inoculation gave a consistently high level of nodulated plants (*c.* 70%) and treated alkythene granules consistently low (*c.* 50%) at all sites. Nodulation results from the water suspension depended on the level of water applied and the planting moisture. At the low moisture site only high volume application (500 *l* ha^{-1}) produced satisfactory nodulation of 63%. Evidently, the tolerance of peat cultures to moisture stress is reduced by suspension in water before application to soil. The efficiency of the solid inoculant method could probably be improved by increasing the number of inoculum loci through decreased granule size.

I. INTRODUCTION

Soybeans do not nodulate naturally on the Darling Downs, Queensland (Diatloff 1970) so inoculation of seeds with root nodule bacteria is essential to bring about nodulation and is now a standard commercial practice. However, soil application can be more efficient when pesticide seed dressings are used, when epigeal species are sown or when the seeds are too small to carry sufficient peat inoculant (Brockwell 1977). Schiffman and Alper (1968) preferred soil application of a peat inoculant in water suspension when planting fungicide-treated peanut seeds. Granular inoculants have shown promise in soybean plantings in U.S. (Carlson 1976). This paper reports an experiment comparing soil application of particulate solid inoculants and liquid injection as alternatives to seed inoculation of soybeans.

II. MATERIALS AND METHODS

All inoculation methods were calculated to apply similar numbers of rhizobia, on a planted area basis irrespective of mode of application. A peat culture of soybean strain CB 1809 with a count of $1{\cdot}2 \times 10^9$ viable rhizobia per g of peat was used. The slurry inoculation method was used as the standard, applying 2 g of peat inoculum per kg of seed using a 20% gum arabic solution as the adhesive. The same inoculum was applied to 3-mm diameter alkythene granules. Seeds were sown by tine planter and granules were delivered through the same tine from the fertilizer box. The sowing rate was adjusted to apply approximately four granules to each seed.

For soil injection a peat culture in a water suspension was applied at three rates of application of 500, 250 and 80 *l* ha^{-1}. Suspensions were made in 40-*l* lots and agitated by the by-pass flow. Soil application was made through disc type nozzles giving a hollow cone pattern, attached to the rear of the planting tine. The sides and bottom of the planting furrows and possibly the seed were moistened, followed by immediate covering with soil. Uninoculated checks were included at all three sites. The three black soil sites were at Mt. Tyson, Linthorpe and Brookstead. The treatments were replicated four times in randomised blocks at each site. Bragg cultivar soybeans were machine sown in December 1974 in 10-m plots with two datum and two guard rows at 760-mm spacing. The soil moisture at 0 to 15 cm at the time of planting was good at Mt. Tyson (36%) and Brookstead (35%) but marginal at Linthorpe (23%). Prompt germination occurred at the first two sites but at Linthorpe, the planting was irrigated after the fifth day to ensure even emergence.

Twenty plants were dug from each plot for nodulation assessment 8 weeks after planting. Because of locust damage at all three sites, further data were collected only from Mt. Tyson where damage was least. Dry weights of tops and finally grain weights from 20 plants sampled at maturity, were recorded.

III. RESULTS AND DISCUSSION

Under conditions of minimal interference from soil-borne rhizobia at all sites, the success of inoculation could be judged simply from the proportion of nodulated plants (table 1). At the sites of good planting moisture there was little difference between injection application of inoculum and seed inoculation in the number of nodulated plants. However, at Linthorpe where the planting moisture was marginal (although sufficient to initiate seed germination) of the three injection rates only that at 500 *l* ha^{-1} was successful. "Inoculated" alkythene granules resulted in a consistent low level of about 50% nodulated plants at all sites.

TABLE 1

THE NODULATION AND YIELD RESPONSES OF SOYBEANS TO FIVE INOCULATION TECHNIQUES AT 3 SITES

Treatment	% Nodulated Plants			Grain Yield (g/20 Plants) Mt. Tyson
	Linthorpe	Brookstead	Mt. Tyson	
Seed inoculation	70·0 a*	68·75 a	78·75 b	375·25 a
Soil injection 500 *l* ha^{-1} ..	63·75 a	88·75 a	81·25 a	336·50 ab
Soil injection 250 *l* ha^{-1} ..	21·25 b	75·00 a	95·00 a	334·00 ab
Soil injection 80 *l* ha^{-1}	22·50 b	83·75 a	93·75 a	331·00 abc
Inoculated granules	43·75 a	46·25 b	50·00 c	279·25 c
Uninoculated Control	8·4 c	7·5 c	0 d	295·75 bc
L.S.D. 5%	39·24	21·46	13·94	53·8
1%	55·02	30·09	19·54	74·4

* Means not followed by the same letter differ significantly (P=0·05)

Leaf colour differences which appeared at Mt. Tyson although related to inoculum treatments and nodulation did not eventually correlate with dry weights of tops or grain yields.

The success of seed inoculation was less affected by varying soil moisture levels than were the soil injection methods. Under low planting moisture, the amount of water injected into the furrow determined success with levels of 250 and 80 l ha^{-1} being suboptimal. Peat cultures are known to be remarkably resistant to low soil moisture (Brockwell and Phillips 1965) and is evident in the high level of nodulation obtained with seed inoculation at Linthorpe. However, when peat is mixed with water and applied to soil some of this resilience is lost as evident in the 250 and 80-l ha^{-1} treatments. It is likely that the nodule bacteria separate from the peat particles and become free living cells to be injected into the soil separate from their protective peat particle.

The consistent, though low level of nodulation achieved by "inoculated" alkythene granules irrespective of moisture levels suggests that the number of inoculum loci determined the extent of subsequent nodulation. The experimental application rate of four granules per seed requires considerable migration of the bacteria to invade emerging roots. The efficiency of this method probably could be improved by reducing the size of individual granules thus increasing the number of inoculum loci.

Under seemingly ideal planting conditions at Mt. Tyson, 100% nodulation was not achieved by any treatment. This is consistent with previous results on black soil (Diatloff 1970) and seems to be a peculiarity of this heavier soil type in contrast to lighter texture soils (Diatloff, unpublished data).

The experiment has established that furrow injection of a simple water suspension of peat inoculum is a satisfactory alternative to seed inoculation of soybean, taking cognizance of planting moisture.

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REFERENCES

BROCKWELL, J. (1977).—Application of legume seed inoculants. *In* R. W. F. Hardy and A. H. Gibson (Eds.) 'A Treatise on Dinitrogen Fixation'. (John Wiley & Sons, New York) pp. 277-310.

BROCKWELL, J. AND PHILLIPS, L. J. (1965).—Survival at high temperatures of *Rhizobium meliloti* in peat inoculant on lucerne seed. *Australian Journal of Science* 27: 332-333.

CARLSON, J. (1976).—Soil inoculation—good insurance. *Soybean Digest* 36: 12-13.

DIATLOFF, A. (1970).—Relationship of soil moisture, temperature and alkalinity to a soybean nodulation failure. *Queensland Journal of Agricultural and Animal Sciences* 27: 279-293.

SCHIFFMANN, J. AND ALPER, Y. (1968).—Inoculation of peanuts by application of *Rhizobium* suspension into the planting furrows. *Experimental Agriculture* 4: 219-226.

WILLIAMSON, A. J. P. (1971).—Soybean is an expanding crop. *Queensland Agricultural Journal* 97: 571-581.

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