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Performance of Soybeans (Glycine max (L.) Merrill CV 'Jupiter') in Guyana as Affected by Inoculum (Rhizobium japonicum) and Nitrogen

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INTRODUCTION

Soybeans (Glycine max (L.) Merrill is a relatively new crop for tropical countries, especially those like Guyana (Latitude 5°N) that are relatively near to the Equator. As such there is very little information as to the factors influencing its performance in these areas. In the southern United States inoculation of soybean seeds with cultures of the bacterium Rhizobium japonicum has caused increases in yield (Caldwell and Vest (1970), Abel and Erdman (1964), percentage protein in the seed, root nodulation and fresh plant weight and a decrease in percentage oil in the seed (Abel and Erdman, 1964). Jacob and von Uexküll (1963) have stated that a light dressing of N at planting produces increased yields.

The study reported here was designed to obtain preliminary indications on the effect of seed inoculation, nitrogen fertilization and their interaction on the performance of soybeans Var. 'Jupiter' on two soil types in Guyana.

MATERIALS AND METHODS

Soils

The experiments were located at the Central Agricultural Station, Mon Repos, in the coastal region and the Matthews' Ridge Sub-station in the North West region of Guyana. The soil types at Mon Repos and Matthews' Ridge were Onverwagt clay, sandy substratum--a low humic gley (Typic

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Ochraqualfs), and Arakaka clay loam--a red yellow podzol, Oxic Normudult-- respectively (Ramdin, 1966; Ramdin, 1969). Some chemical and physical characteristics of the top 15 cm of these soils are presented in Table 1.

Table 1. Some Chemical and Physical Properties of the Top 15 cm of Arakaka Silt Loam and Onverwagt Clay (sandy substratum).

Soil	pH	% Organic matter	% Total N	Fruog P(ppm) P_2O_5	PBS*	m.e./100 g.				Particle size Distribution (%)		
						CEC#	Ca	Mg	K	Sand	Silt	Clay
Arakaka silt Loam	4.6	4.1	0.2	1	81	2.7	0.5	0.5	0.4	35	37	28
Onverwagt clay, (Sandy substratum)	5.0	2.1	0.1	10	98	22.1	3.6	17.9	0.4	1	51	48

* PBS = Percent Base Saturation

CEC = Cation Exchange Capacity

Experimental Design and Field Procedures

The experiment was of a split-plot design with rates of N as the whole units and rates of inoculum as the subunits. The whole units were arranged in a randomized block design and the subunits randomized within the whole units. Sub-plot size was 7.2 x 3.6 m at Matthews' Ridge and 5.7 x 4.5 m at Mon Repos.

The levels of N (n_0 , n_1 , n_2 and n_3) were 0, 16, 32 and 48 kg N per ha, respectively. The levels of inocula (i_0 , i_1 and i_2) were 0, 224 and 448 g. per kg of seed, respectively; i_1 represents the recommended commercial rate. All plots received the equivalent of 88 kg/ha of P_2O_5 and K_2O each. At Matthews' Ridge, the plots were limed at 2,200 kg/ha with dolomitic limestone to bring soil pH to approximately 6.5; liming was not done at Mon Repos as the soil pH was already 6.0. The fertilizer sources used were ammonium sulphate, triple

superphosphate and muriate of potash for N, P and K, respectively. The inoculant used was commercial type 'Nitragin' which is an 'S' culture of a mixture of strains of R. japonicum in a peatbase medium.

At both sites, soybeans were never planted before and at Matthews' Ridge the land was previously forested. Inoculated seeds (two per hole) were planted by hand at a spacing of 45 cm between rows and 15 cm within the row. Inoculation of the seeds was done by sprinkling the relevant weights of inocula on seed which were previously moistened with a weak sugar solution. The inocula were then distributed thoroughly among the seeds by rotating the container. Seeds were planted immediately after. All of the fertilizer was applied at planting 5 cm to the side and below the seed.

At planting the soil was treated with the pre-emergent weedicide 'Dacthal' at 5.4 kg/ha. Control of insects was done as required using 'Sevin'.

At about one month before harvest, 10 plants from each plot were carefully uprooted and the number of effective nodules counted. At harvest the yield of dry clean soybean seeds per plot was recorded. Results were statistically analyzed (Steel and Torrie, 1960).

At Matthews' Ridge, the experiment was first planted in November, 1969 and replanted on the same site in May and November, 1970. At Mon Repos, the experiment was planted in November, 1970.

RESULTS

Yield

The yield results are presented in Tables 2 - 5. At no time was the effect of N significant. Inoculum had a significant effect ($P < 0.05$) only at the May, 1970 planting at Matthews' Ridge, where yields at the i_2 level were higher than those at the i_0 and i_1 levels. In November, 1970 planting

at Matthews Ridge the NI interaction was significant ($P < 0.05$). Examination of this interaction showed that within the n_3 level, yields at the i_1 level were significantly lower than those at the i_0 level.

Table 2. Effect of varying levels of N and Inoculum on Soybeans Yields (kg/ha). Planted November, 1969 at Matthews' Ridge.

Nitrogen (kg/ha)	Inocula (g/kg seed)			Means
	0	224	448	
		kg/ha		
0	1500	1400	1882	1594
16	1706	1975	1562	1747
32	1986	1946	1768	1906
48	2042	1926	1966	1981
Means	1808	1814	1799	

S.E.:	N means	= 159
	I means	= 137
	I level means within the same N level	= 276

Table 3. Effect of varying levels of N and inoculum on soybean yields (kg/ha). Planted May, 1970, at Matthews' Ridge

Nitrogen (kg/ha)	Inocula (g/kg seed)			Means
	0	224	448	
		kg/ha		
0	2255	2162	2371	2263
16	2238	2277	2451	2322
32	2158	1980	2555	2231
48	1841	2288	2606	2245
Means	2123	2177	2496	

S.E.: N means = 126
I means = 109
I level means
within the
same N level = 218

Table 4. Effect of varying levels of N and inoculum on soybean yields (kg/ha). Planted November, 1970 at Matthews' Ridge.

Nitrogen (kg/ha)	Inocula (g/kg seed)			Means
	0	224	448	
		kg/ha		
0	3655	3812	3687	3718
16	3972	3678	3889	3846
32	3551	3573	3592	3572
48	3895	3973	3555	3741
Means	3781	3759	3631	

S.E.: N means = 205
N means = 89
I levels means
within the
same N level = 173

Table 5. Effect of varying levels of N and inoculum on yields (kg/ha) of soybeans. Planted November, 1970 at Mon Repos.

Nitrogen (kg/ha)	Inocula (g/kg seed)			Means
	0	224	448	
		kg/ha		
0	4058	4105	4043	4068
16	4355	4135	4307	4266
32	4197	4043	4058	4098
48	4245	3723	4095	4020
Means	4212	4003	4122	

S.E.: N means = 171

I means = 164

I level means within
the same N level 330

Leaf colour was not markedly affected by the treatments at any of the plantings.

Nodulation

The results on nodulation for the May, 1970 Matthews' Ridge and November, 1970 Mon Repos plantings presented in Tables 6 and 7, respectively, show that the number of nodules was not affected by either N or inoculum. At the latter planting, examination of the N x I interaction which was significant (P 0.05) showed that at the N_0 level, the number of nodules at the i_1 level was greater than that of the check. Although actual nodule weights were not recorded, the nodules from all plots were approximately the same size and thus nodule numbers give a good assessment of treatment effects. It should be mentioned here that

Table 6. Effect of varying levels of N and inoculum on nodules (No. plant) of soybeans. Planted May, 1970 at Matthews' Ridge.

Nitrogen (kg/ha)	Inocula (g/kg seed)			Means
	0	224	448	
		Av. No./ plant		
0	56	49	52	52
16	43	43	50	46
32	62	65	51	60
48	30	56	51	46
Means	48	53	51	

S.E.: N means = 6.0
I means = 5.2
I level means within
the same N level = 10.4

Table 7. Effect of varying levels of N and inoculum on Av. No. of nodules per plant. Planted November, 1970 at Mon Repos.

Nitrogen (kg/ha)	Inocula (g/kg seed)			Means
	0	224	448	
		Av. No./ plant		
0	15	24	21	20
16	29	23	16	23
32	14	18	20	17
48	19	21	20	20
Means	19	21	19	

S.E.: N means = 3.0
I means = 2.2
I level means within
the same N level = 4.3

DISCUSSION

Generally both N and inoculum had no effect on the performance of soybeans. The purpose of applying N is supposedly to satisfy the crop's N requirements until the crop can manufacture its own with the aid of rhizobia. Both soils has relatively high concentrations of total N (0.2 and 0.1%). Cornforth, (1971) has found that in soils in high rainfall areas (2300 mm per year), 70 ppm N can be mineralized at the start of the rainy season. These soils are both in high rainfall areas (Mon Repos, 2375 mm; Matthews' Ridge, 2500 mm) so that it could be safely assumed that there was an adequate supply of mineral N when the soybeans were planted.

Shukla (1969) and Chesney (1969) have reported similar findings with N on soybeans in Guyana.

The failure of inoculum to generally influence yield and nodulation especially at the first plantings is very noteworthy. Iswaran, Sarma and Comnaire (1970) in their review article stated that the rhizobial population in acid soils is generally considered to be low and that rhizobia do not persist in these soils. It will be safe to assume that these soils, both naturally very acid, would have very low rhizobial populations. If this assumption is correct, then it must be concluded that the commercial inoculant used was not effective. Supporting evidence for this conclusion comes from Abel and Erdman (1964) who have stated that when soybeans was first introduced into the southwestern U.S.A. the commercial inoculants used were not effective. The general increases in yield that occurred in the subsequent plantings at Matthews' Ridge may have been caused by a build up of rhizobia in the soil because of the presence of the soybean plants; this further suggests that the inoculum used was ineffective.

The significant effect of inoculum at the May, 1970 planting at Matthews' Ridge is inconsistent with the other results. Caldwell and Vest (1970) have however, found that there is a significant rhizobia strain X year interaction on yields of soybeans in the U.S.A., perhaps a similar interaction or a strain X season interaction occurs in Guyana.

The finding at the November, 1970 planting that inoculum increased nodulation only in the sence of N suggests that N may have inhibited the action of the introduced rhizobia. However, since this effect did not always occur, plus the fact that neither of the main factors were significant, much emphasis cannot be placed on this observation.

It is seen from these studies that the question of inoculation of soybeans in Guyana is not a simple one and much work needs to be done to gain a full understanding of the mechanisms involved. Some of this work will have to be done under greenhouse conditions where greater control can be achieved.

SUMMARY

The effect of nitrogen (N) and inoculum (Rhizobium japonicum) on the yield and nodulation of soybeans (Glycine max (L.) Merrill. CV 'Jupiter') was studied on two soil types of Guyana. Generally, nodulation and yield were bogh unaffected by N and inoculum. Possible reasons for these effects are discussed.

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