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MEMORIAS

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PROCEEDINGS

Caribbean Food Crops Society

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SANTO DOMINGO, REPUBLICA DOMINICANA

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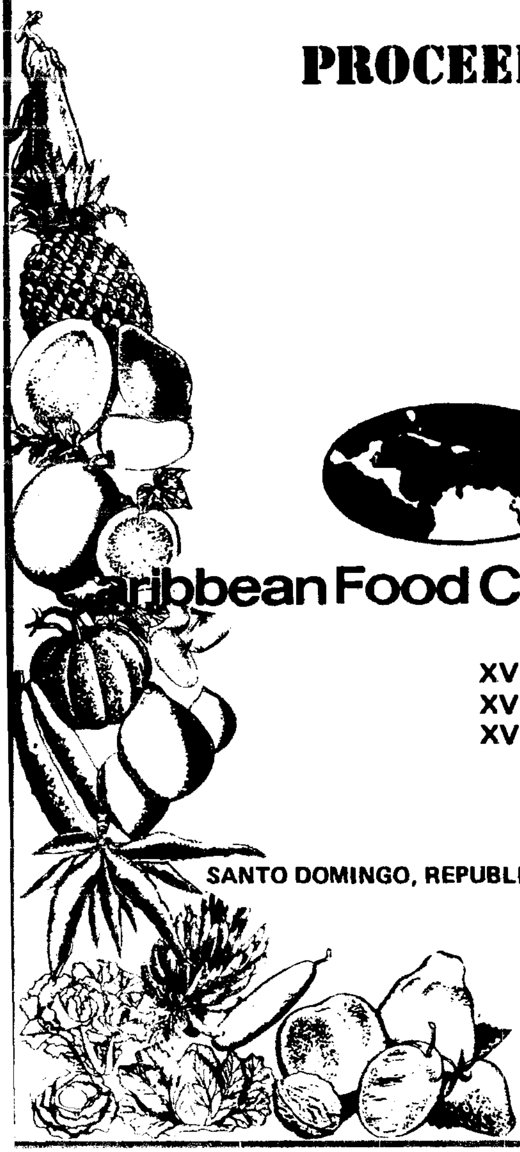

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THE EFECT OF *RHIZOBIUM* INOCULATION AND FERTILIZER NITROGEN APPLICATION ON NITROGEN UPTAKE AND COWPEA AND SOYBEAN GRAIN YIELDS ON AN ULTISOL IN TRINIDAD

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INTRODUCCION:

Production and consumption of fertilizer nitrogen has increased tenfold in the past twenty years, and the requirements for fixed are expected to increase even more over the next twenty-five years (Hardy and Havelka, 1975). Even where nitrogen fertilizers are available, their costs and difficulties in distribution render them impractical for farmers in many areas of the world. Lately after the oil crises of 1973, the situation has been accentuated by the high energy costs. In view of these facts, the *Rhizobium* legume based symbiosis offers an alternative for increasing nitrogen input to food production.

Grain legumes such as cowpeas *(Vigna unguiculata)* and soybeans (Glycine) are important components in many crop production systems. They are expected to receive most of their N supply from symbiotic N_2 fixation. Optimal symbiotic N_2 fixation requires that the ***Rhizobium*** strain is compatible with the host plant and that edaphic and climatic factors are suitable for survival and growth of the host plant and ***Rhizobium.*** Where these conditions are fulfilled, a ***Rhizobium*** legume association can supply by fixation most of the N required for high yields. Thus, legumes generally conserve what soil N is available and add to it in direct proportion to the size of the "sink" created by the yield potential of the crop.

Thus, in planning a fertilizer experiment with grain legumes, it is necessary to secure a ***Rhizobium*** strain that is both infective and effective. There is also a need to investigate whether the selected strain will survive in the soil saprophytically in the absence of the host plant. An examination of grain legume production in various parts of the world illustrates that fertilizer N is recommended (Bazan, 1975) and in experimental plots, responses to fertilizer N are common. Thus, the best means of realizing some of the potentials of grain legumes is through increasing yields and provision of effective rhizobia. Currently, the yields of grain legumes in tropical regions are low even if they are important sources of dietary protein.

There is limited data on the effect of fertilizer N application and/or inoculation of soybeans or cowpeas on the symbiotic N_2 fixation or grain yields in Trinidad. It has been shown that on some soils in Trinidad fertilizer N increase soybean yields (Brathwaite, 1974). In the present study, the purpose of the investigation is to observe the effect of fertilizer N and/or ***Rhizobium*** inocultants on symbiotic N_2 fixation and grain yields of soybeans and cowpeas on an Ultisol.

1977 Cowpea and Soybean Inoculation Experiment:

A study was undertaken to determine the offect of introduced strains of ***Rhizobium*** on the cowpeas and soybans. Strains 97C (Rh2) and 13B (Rh3) isolated from a Princes Town clay and Piarco fine sand respectively were inoculated onto cowpeas and strains 31-1b-138 (Rh2) and SOY 13B (Rh3) imported from U.S.A were inoculated onto soyban. The purpose of this preliminary experiment was to assess the need for and efectiveness of inoculation compared with fertilizer N at, 0.60, and 120 kg/ha applied as urea. This experiment was conducted on a Piarco fine sand, a highly weathered and leached acid Ultisol (Tables 1 and 2). This is a member of the fine sand, clay, kaolinitic, isohyperthermic family of aquoxic Tropoudults. The surface o-15 cm had a pH of about 4.8-5.0 while the 15-30 cm had a pH of 4.7-4.8 in KCl. The KCl extractable aluminium saturation varied from 40-80% in the top soil and 63-84% in the subsoil.

Preliminary results show that the uninoculated soybeans picked up an "indigenous" cowpea-type ***Rhizobium*** strain. Generally, it is reported that ***R. japonicum*** is not always present where soybeans have never grown previously. Inoculation greatly increased nodulation throughout the growth period. The uninoculated plots had a slow start, and nodulation greatly increased with time (Figure 1). Nodule count in cowpeas was already high at 33 days (Figure 2) and that there was no significant differences between treatments. At 42 days a lot of nodules had decayed, and this is because cowpeas are fast nodulators and are also short season crops.

A summary of the N accumulation data is presented in Table 3. The rates of N accumulation were slow early in the season in soybean plants whereas it was fairly fast in the cowpea plants, and this again is attributed to the fact that cowpeas are fast growers and nodulators. Analysis of variance indicates that a highly significant (P 0.01) difference is found among effects of nitrogen treatments in soybeans at 42 and 75 days and at harvest. In all cases there was no significant difference caused by ***Rhizobium*** treatments.

The grain yields of both the soybeans and cowpeas showed greatest responses to first increments of fertilizer N (60 kg/ha) at all rhizobial treatments (Figure 3), and N application over and above 60 kg/ha reduced grain yields. This may be due to reduced efficiency of the rhizobia to fix atmospheric N_2 in the presence of high levels of combined N (Summerfield **et al**, 1977). Cowpea strain Rh3 isolated from an Ultisol gave slightly higher yields than non-inoculated or Rh2 plots. On the other hand, uninoculated plots which picked up an "indigenous" ***Rhizobium*** strain gave almost 50% more grain yields than when inoculated with either of the strains imported from the USA

N/ha was required to obtain maximun grain yield in the uninoculated plants. The present results show that the grain yields in the inoculated plots are higher than in the uninoculated plots. In fact the grain yields in the uninoculated plots at 60 kg N/ha. This is similar to the results of 1977 whereby inoculation was just as good as fertilizer N.

From the present experiment, one may conclude that it is better to inoculate the seeds even where the ***Rhizobium*** strain was established. It may be that the ***Rhizobium*** that was used in the first season had lost its effectiveness after one year without the cowpea as the host plant. This raises the question as to whether the seeds should be inoculated every time a new crop is planted, although the general belief is that if the "appropriate" rhizobia were widespread, there is no need for re-inoculation. On the other hand, if there is a lack of an "appropriate" host crop over a period of time, the numbers of rhizobia may be reduced to low levels. Under such circumstances, response to inoculation may be obtained.

There was a short dry spell in September/October, 1978 and as a result the soil was so desicated that destructive sampling was impractical. To date only the N content and the grain yields of the soybeans are reported. Results in Table 7 show that there were no signiticant differences in the percentage N in the plant tops between N and/or ***Rhizobium*** treatments. Generally, inoculated plants showed highner N contents than the uninoculated plants.

Fertilizer N almost increased the soybean grain yields linearly in both inoculated and uninoculated plants. There was an indication that 60 kg N/ha rate was not adequate to sustain maximun grain yields in both rhizobial treatments (Table 7). This is because soybeans have inoculation did not have any beneficial effects over uninoculated plots except when no N was applied. One may argue that re-inoculation of soybeans is not necessary when the ***R. japonicum*** is estabilished (Freire, 1976).

Under suitable conditions most of or all of the nitrogen requirements of the grain legumes can be provided by the ***Rhizobium***. In the absence of an appropriate rhizobial population, the legumes will fail to develop effective nodules. In the present study these conditions were not met and the soybean crop depended on fertilizer N. On the other hand, fertilizer N gave no higher yields than a wellnodulated cowpea crop without it. Thus one may conclude that the contribution of fixed N to the growth and yield of grain legumes would depend on the existence of effective and efficient inoculant, given optimum edaphic and climatic factors. Future studies, then, would include a correlation of nodulation and N_2 fixation characteristics with plant properties. A determination of thenumber,size and distribution, weight and color of the nodules and also the N uptake of the soil N and atmospheric N_2 is essential.;

References:

Bazan, R. 1975. Nitrogen fertilization and management of grain legumes in Central America. In E. Bernemisza and A. Alvarado (ed.), Soil Management in Tropical America, North Carolina State University, Raleigh, N.C.

Brathwaite, R.A.I., Jammerton, J.L. and Tai, E.A. 1974. Effects of fertilizer on yield, seed quality and plant characteristics of soybean (Glycine max. (L) Merrill). Twelfth Ann. Mtg. of the CFCS Jamaica, June 30 - July 6, 1974.

Ezedinma, F.O.C. 1964. Effects of inoculation with local isolates of cowpea Rhizobium and application of nitrate-nitrogen on the development of cowpeas. Trop. Agric. (Trin.) 41: 243-249.

Freire, J.R. 1976. Inoculation of soybeans. In Exploiting the legume-Rhizobium symbiosis in Tropical Agriculture. Proceedings of Workshop, Kahului, Maui, Hawaii, August 23-28, 1976.

Godfrey-Sam-Aggrey, W. 1973. Effects of fertilizers on harvest time and yield of cowpeas (Vigna unguiculata) in Sierra Leone. Expl. Agric. 9: 315-320.

Hardy, R.W.F. and Havelka, U.D. 1975. Nitrogen fixation research: A key to world food. In P.H. Abelson (ed.) Food: Politics, economics, nutrition and research. Amer. Assoc. Adv. Sci. pp. 178-188.

Summerfields, R.J., Dart, P.J., Huxley, P.A. Eagiesham, A.R. J., Minchin, F.R. and Day, J.M. Nitrogen nutrition of cowpea (Vigna unguiculata). I Effects of aplied nitrogen and symbiotic nitrogen fixation on growth and seed yield. Expl. Agric. 13: 129-142.

Table 1: Estimations of aluminium saturation in KCl - estracts Of the Ultisol at Wallerfield

Sample[1]	pH	Ca	Mg	Al	Cations	o/oAl
		me/100 g				
0.15 N	5.0	1.60	0.61	1.50	3.71	40
15-30 N	4.8	1.00	0.42	2.44	3.86	63
0 15 S	4.6	0.40	0.19	2.37	2.96	80
15-30 S	4.7	0.35	0.17	2.69	3.21	84

Table 2. Some chemical analyses of the soil samples from Wallerfield[2/]

Sample[1/]	P	Ca	Mg	K	Zn	o/o 0.M	o/o N
			ppm				
0-15 N	2.0	275	70	30	1.5	3.4	0.22
15-30 N	1.5	175	55	35	1.0	2.2	0.15
0 15 S	1.0	75	30	15	1.5	2.2	0.14
15-30 S	1.0	50	25	15	1.0	1.6	0.06

1/ 0-15 cm and 15-30 is depth in cm
H and S designates north and south respectively to show the grandient in nutrient levels as related to proximity to the pig pen which is N of the experimental site.

2/ NH_4 OAc - extracteble cations.

Table 3: Accumulation of N by Soybean and cowpea plants at different Sampling periods as influenced by fertilizer nitrogen and inoculation (Kg/ha)

Treat/ Period 1/	Soybens 29	42	75	Harvest 2/	Cowpeas 33	42	Harvest2/
Rh_1 N_1	6.1	9.5	61.8	39.8	17.5	20.4	6.6
Rh_1 N_2	9.2	28.5	76.7	79.4	19.8	25.0	16.1
Rh_1 N_3	6.4	38.1	89.0	71.4	16.7	18.1	16.1
Rh_2 N_1	7.2	17.6	55.4	27.1	14.0	15.8	6.1
Rh_2 N_2	11.7	30.1	91.1	50.8	17.4	20.5	16.0
Rh_2 N3	10.3	29.4	102.6	43.9	12.7	13.9	12.5
Rh_3 N_1	7.7	23.7	57.9	39.1	10.0	15.8	11.4
Rh_3 N_2	8.9	26.3	7.1	46.2	15.8	30.6	20.4
Rh_3 N_3	8.6	24.1	61.8	48.1	17.1	18.4	19.6

1/ Days from planting
2/ Harvest – N harvested in grain.

Table 4: The effect of Rhizobium inoculation and fertilizer N application on the nodule count in cowpeas

Treat/ Rep.	I	II	III	IV	V	VI	Mean
Rh_1 N_1	71	23	74	50	29	21	47.2
Rh_1 N2	41	270	91	48	22	39	85.2
Rh_1 N3	107	110	56	23	38	85	69.8
Rh_2 N_1	15	88	72	133	304	126	123.0
Rh_2 N_2	105	107	8	59	31	12	53.7
Rh_2 N_3	98	104	78	3	37	71	65.2

Table 5: The effect of Rhizobium inoculation and fertilizer N application on the uptake of N in cowpeas (g/3 plants) plants sampled at flowering

Treat/ Rep.	I	II	III	IV	V	VI	Mean
Rh_1 N_1	0.85	1.08	1.30	0.94	0.56	0.33	0.85
Rh_1 N_2	1.31	1.06	1.44	1.00	0.29	0.29	0.89
Rh_1 N_3	1.34	1.34	1.83	0.49	0.48	0.20	0.94
Rh_2 N_1	0.99	1.38	1.05	0.60	0.89	0.67	0.88
Rh_2 N_2	1.54	1.17	1.51	1.35	0.32	0.33	1.04
Rh_2 N_3	1.31	1.17	1.37	0.64	0.69	0.24	0.98

Table 6: The effect of Rhizobium inoculation and fertilizer N application on the cowpea grain yield kg/ha

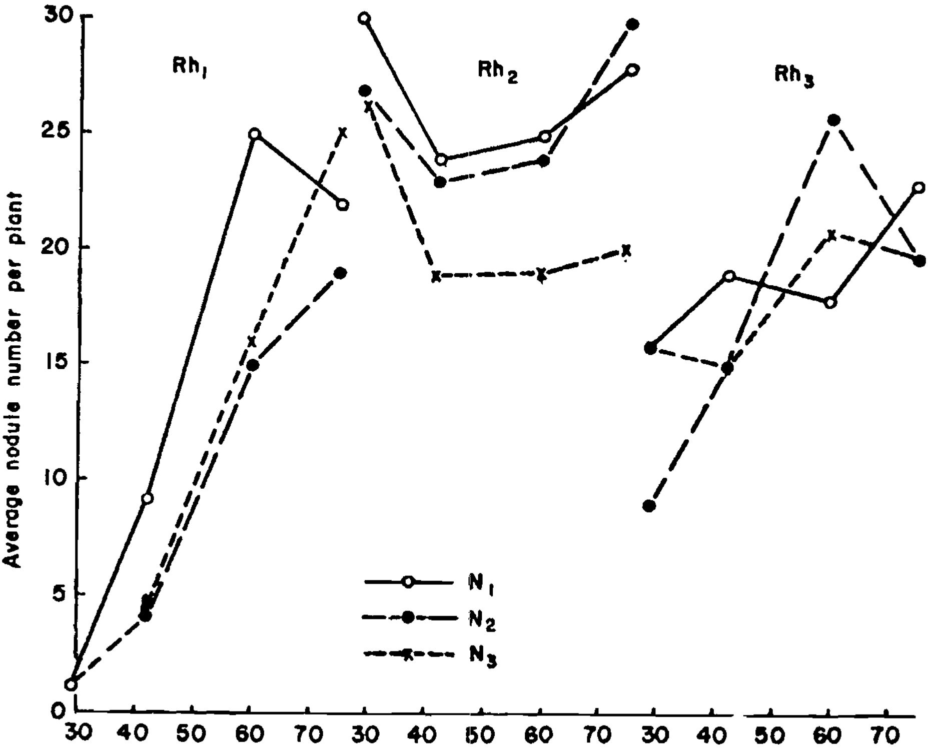
Treat/ Rep.	I	II	III	IV	V	VI	Mean
Rh_1 N_1	856	1643	985	904	662	554	934
Rh_1 N_2	1858	1389	1237	933	434	229	1013
Rh_1 N_3	1573	1910	1487	367	1074	318	1122
Rh_2 N_1	1456	1482	1890	412	1097	613	1158
Rh_2 N_2	1909	1267	1462	1179	387	418	1104
Rh_2 N_3	1694	1872	1490	360	892	392	1117

Table 7: The effect of Rhizobium inoculation and fertilizer N apllication on the N content of the soybean plant tops (% N)

Treat/ Rep.	I	II	III	IV	V	VI	Mean
Rh_1 N_1	1.80	3.10	3.45	3.35	1.75	2.15	2.60
Rh_1 N_2	2.15	2.10	2.95	2.25	1.95	2.10	2.25
Rh_1 N_3	2.55	2.50	2.15	2.40	3.15	2.70	2.58
Rh_2 N_1	2.50	2.85	3.45	2.40	3.60	1.80	2.76
Rh_2 N_2	1.90	2.60	2.85	2.60	2.75	4.25	2.82
Rh_2 N_3	2.50	2.75	2.60	1.80	2.45	2.40	2.42

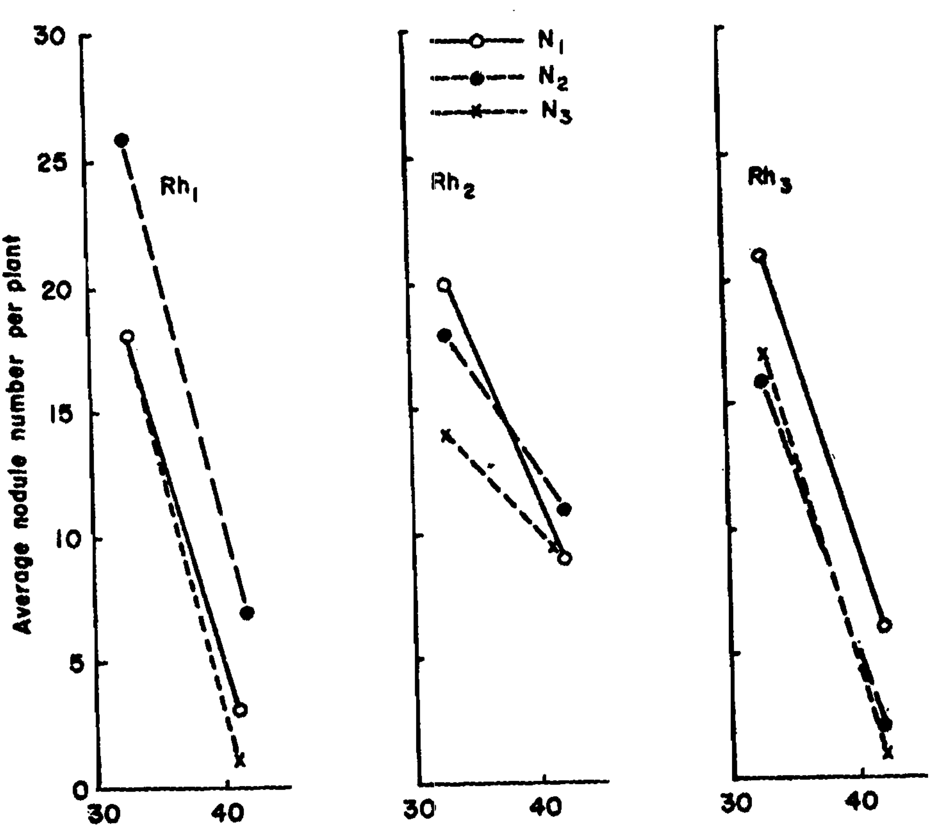
Table 8: The effect of Rhizobium inoculation and fertilizer N application on the soybean grain yields kg/ha

Treat/ Rep.	I	II	III	IV	V	VI	Mean
Rh_1 N_1	810	1288	1104	612	450	862	855
Rh_1 N_2	1084	1814	1114	796	788	612	1065
Rh_1 N_3	1866	1854	1278	890	1128	384	1266
Rh_2 N_1	1840	908	868	798	474	482	899
Rh_2 N_2	1798	1456	1296	630	687	388	1059
Rh_2 N_3	1036	1652	2186	664	908	388	1166



Number of days after planting

Figure 1. Change in nodule count in soybeans with time



Number of days after planting

Figure 2. Change in nodule count on cowpeas with time

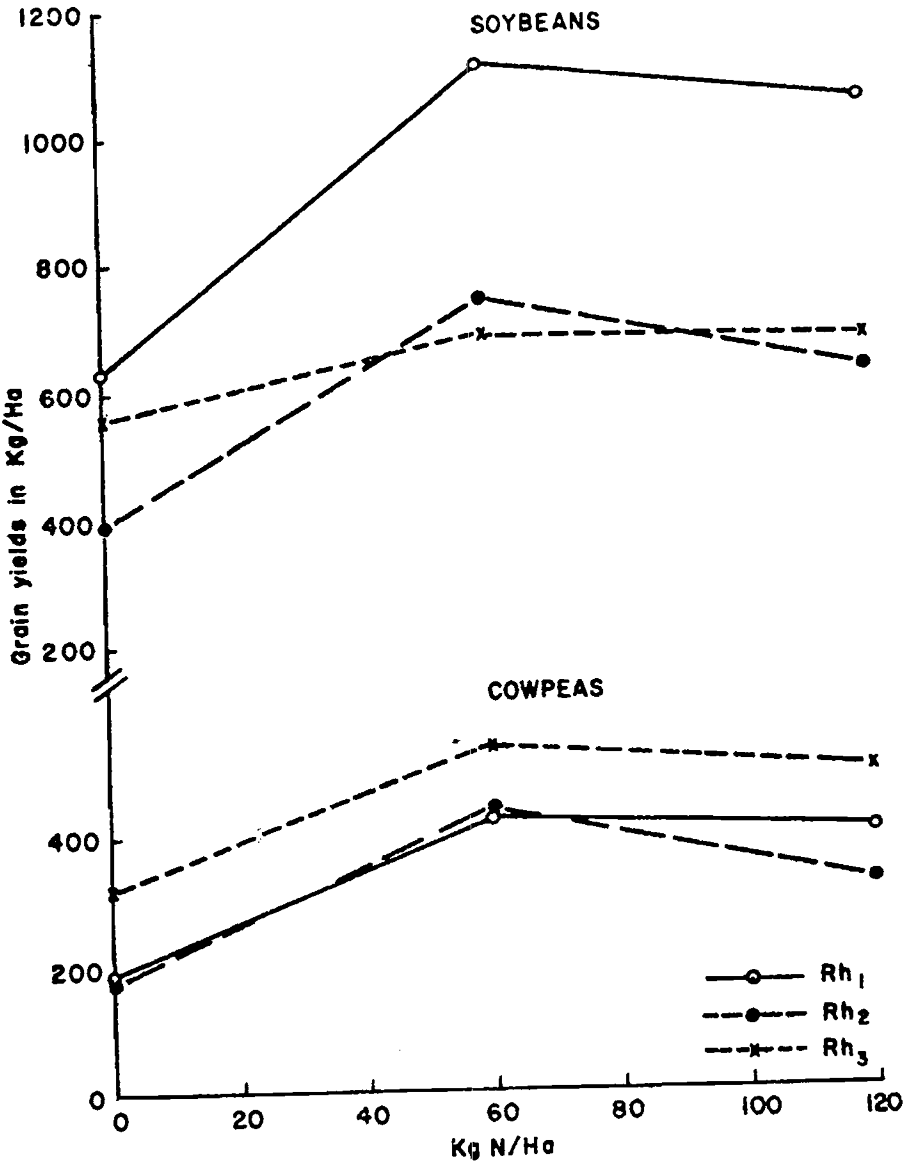


Figure 3. The effect of Nitrogen and Rhizobial inoculation on the grain yield of the soybeans (Glycine max) and the cowpeas (Vigna unguiculata).-

(Rh2 and Rh3). This is attributed to the fact that ***Rhizobium*** from this Ultisol is presumably more adapted to the adverse soil conditions prevailing.

1978 Cowpea and Soybeans Re-inoculation Experiment:

Materials and Methids.:

For the cowpeas, the plots were laid on the site that had previously been cultivated to cowpeas in the major rainy season of 1977 and to sorghum in the 1977/78 minor season. In case of soybeans, the plots were laid on the site that was grown to soybeans in both the major and minor seasons.

Treatments consisted of a factorial combination of fertilizer N as urea at the rates of 0,30, and 60 kg N/ha banded and rhizobia strains 13B and SN2 for Rh2 plots for cowpeas and soybeans respectively, and Rh1 as the check plots. Basal treatments included triple superphosphate, muriate of potash, zinc sulfate, magnesium sulfate at the rates of 40 kg P/ha, 5 kg Zn/ha, and 60 kg/ha Mg SO_4 respectively.

The plots were seeded to cowpeas, California 5 variety on June 20, 1978 at 4 seeds per stand 15 cm apart within the row which were spaced at 50 cm apart. The seeds were inoculated with cowpea *Rhizobium* strain 13B or blank the night before planting. The seedlings were thinned to one per stand on July 11, 1978. Soybeans were planted the same way on August 10, 1978, but since germination was poor, the seedlings were uprooted and the plots reseedes on August 24. The seeds were inoculated with SN_2 Rh2 and blank for the Rh1.

Destructive sampling of the cowpea seedlings was done on August 7 to determine the nodule number, plant weight and N content of the tops. It was difficult to uproot the seedlings in the soybean plots in September/October because the land was dry, and as such nodule count was not done.

Results aud Discussion

In the non-inoculated plants there was an increase in nodule count with increased N application, and that 30 kg N/ha had the highest nodule count (Table 4). It may be argued that a starter application of fertilizer N is necessary to best seedling growth before the plants nitrogen-fixing process begins (Ezedinma, 1964). On the other hand, the highest nodule count in the uninoculated plots resulted at the o kg N/ha. The theory behind this may be that N application at the time o planting reduces infectiveness since the *Rhizobium* is near the fertilizer

There was almost a linear increase in N uptake with fertilizer N application in the uninoculated plots (Table 5). The N uptake in the inoculated plots increased at the first increment of N and slightly decreased at the highest N rate, although it was still higher than the 0 kg N/ha.

Results in Table 5 clearly show that fertilizer N increases grain yields when *Rhizobium* strain 13B is not used, and the trend is almost linear. Similar results were reported by Godfrey, 1973. He found that in nitrogen-depleted low pH (5.2) ferralitic soils of Sierra Leone where the cowpea roots had non-functional nodules, as much as 165 kg