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Response of a Promiscuous Soybean Cultivar to Rhizobial Inoculation and Phosphorus in Nigeria's Southern Guinea Savanna Alfisol

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ABSTRACT: An experiment was carried out at the Federal University of Technology (F. U. T.) Farm, Minna during the 2008 cropping season to investigate the number of nodules, dry shoot biomass, grain yield and, grain N and haulm N contents. An early maturing (75 days) promiscuous soybean cultivar (TGX 1485) was used. The experiment was laid out in a randomized complete block design with six N sources (Uninoculated, inoculated with four rhizobial types {R25B, IRj 2180A, IRc 461 and IRc 291} and 60 kg N ha^{-1} as urea) and three P – levels (0 kg P_2O_5 ha $^{-1}$, 25 kg P_2O_5 ha $^{-1}$ and 50 kg P_2O_5 ha $^{-1}$) as treatments. These treatments were replicated four times. The four rhizobial inoculants were found to increase the parameters investigated over those of the control. Except for the nodule number that was significantly ($P \leq 0.05$) depressed by N fertilization among treatments, the IRj 2180A rhizobial strain produced yields that were comparable with those of the plots supplied with 60 kg N ha $^{-1}$. On the other hand, as P- rates increased the parameters investigated also increased.
Key words: Rhizobial inoculation, phosphorus and promiscuous soybean cultivar.

INTRODUCTION

Soybean is the most important and most widely grown of the grain legumes worldwide (Giller and Wilson, 1991),but, in the recent times it is cultivated in Nigeria and other parts of Africa, and is gaining popularity as a consequence of the increasing needs for protein from food and fodder. It also has the capability for soil fertility improvement in cereal based cropping systems in the Guinea savanna (Carsky *et al*., 1996 and Yusuf *et al.,* 2006), since they are able to fix about 300 kg N ha^{-1} atmospheric nitrogen (Keyser and Li, 1992). Soybean residues (haulms) so obtained improve the soil condition, and on decay it supplies organic nutrients to subsequent crops.

The greatest success interms of modified agricultural practices arising from scientific research in Biological Nitrogen Fixation (BNF) has been the development of rhizobial inoculants (Giller and Cadisch, 1995). This has allowed the successful introduction of legumes to new farming systems where compatible rhizobia are absent from soils. Soybean is, however, highly specific in its rhizobial requirements (Sanginga *et al*., 1997). Sanginga *et al*. (1995) reported that many tropical soils are deficient in P. this deficiency is known to limit nodulation, nitrogen fixation and the growth of legumes.

Recently scientists at the International Institute of Tropical Agriculture (IITA), Ibadan have bred promiscuous soybean varieties which can nodulate freely and effectively with indigenous bradyrhizobial populations in Nigerian soils. These soybean varieties were reported to have an increased potential to fix N over most other lines (I I T A, 1996).

The present study was conducted to asses:

(i) The response of an early maturing promiscuous soybean cultivar (TGX 1485) released by I I T A to four rhizobial inoculants and

(ii) The influence of increasing P-rates on growth and yield of TGX 1485.

MATERIALS AND METHODS

Site Description: The experiment was conducted in the field during the 2008 rainy season at Federal University of Technology Minna Farm. Minna (9^0 40' N; $6^0$30' E) is located in the Southern Guinea savanna zone of Nigeria with about 1200 mm mean annual rainfall and average wet season temperature of about 29^0 C. The soil type is Alfisol derived from Basement Complex rocks (Muhammad, 2005).

Soil sampling and analysis: Before the commencement of the experiment, twenty (20) core samples from the surface 0 – 15 cm were taken at random and bulked to give composite samples. A sub-sample of the composite soil was air dried, sieved using 2 mm screen and subjected to routine physico – chemical analysis using the procedures described by Juo (1979).

Treatment and experimental design: The experiment was laid out in a randomized complete block design. The plots were randomly replicated four times.

An early maturing promiscuous cultivar (TGX 1485) released by I I T A was used in this experiment. The experiment had six N sources and three P rates. The N sources were inoculation using one of four rhizobial strains (R25B, IRj 2180A, IRc 461 and IRc 291), an uninoculated control and a 60 kg N ha^{-1} control as urea. The P rates were 0, 25 and 50 kg P_2O_5 ha^{-1} applied as single super phosphate.

Inoculation: Inoculation was done using peat carrier inoculum at a population density of approximately 10^7 cells of viable rhizobial per gram. Five (5) grammes of peat inoculum was mixed with 15 ml of 5% sugar solution in a plastic bowl to obtain a fluid paste. The inoculum was then poured over 1 kg seeds of promiscuous soybean in another bowl, mixed carefully until seeds were coated with black film of inoculants and allowed to dry for a few minutes after which they were quickly handrilled on the ridges.

Thinning was done at two weeks after planting to 10 cm between stands. Nitrogen and Phosphorus fertilizers were applied as single application immediately after thinning.

Plant sampling and analysis: The shoot was used for shoot biomass (dry) and haulm N content determination. This was done after oven drying at 70^0C to a constant weight. The physiologically matured grains were harvested, threshed and winnowed manually. Clean grains were collected, oven dried at 70^0C and weighed (for grain yield). Oven dried sub-samples of soybean grains and haulms were ground to pass through 18 mm mesh sieve for grain N and haulm N contents determination using the automated analyzer following wet digestion at I. I. T. A., Ibadan.

Statistical analysis: The data collected were subjected to statistical analysis using Statistical Analysis System Instruction Inc. (1989). Comparism of treatment levels was done using the Duncan New Multiple Range Test at 5% level of significance.

RESULTS AND DISCUSSION

Soil characteristics: The soil at the site is loamy sand in texture. The soil is acidic with generally low total N, available P, organic C and exchangeable cations (Table 1). These showed that the soil had low fertility status which is a characteristic of most soils in the savanna. This is consistent with the findings of Uyovbisere *et al*., (1990).

Table 1: Some selected physico-chemical properties of the soil before the commencement of the experiment

Parameters	
Sand (%)	79
Silt (%)	17
Clay (%)	4
pH (KCl)	4.83
Organic C (%)	0.83
Total N (%)	0.38
Extractable P (µgg^{-1} soil)	7.08
Exchangeable bases (cmol kg^{-1})	
K	0.1
Na	0.2
Ca	1.0
Mg	0.2
Exchangeable acidity (cmol kg^{-1})	0.1
Effective CEC (cmol kg^{-1})	1.5

Number of nodules: There was no significant difference (P>0.05) in number of nodules among inoculations. However, both inoculated and uninoculated control plots had significantly (P≤0.05) higher number of nodules compared with the 60 kg N ha^{-1} treatment plots (Table 2). As P- rates increased from P_0 to P_{50} the nodule number also increased significantly (Table 3).

Shoot biomass: Inoculation and 60 kg N ha^{-1} treatments significantly (P≤0.05) increased the shoot biomass over those of the control. Although IRj 2180A rhizobial strain produced significantly (P≤0.05) the largest shoot biomass among treatments, this was not significantly different (P>0.05) from the 60 kg N ha^{-1} fertilizer treatment (Table 2). Generally, as P-rates increased, shoot biomass also increased, but only the 50 kg P_2O_5 ha^{-1} treated plots significantly (P≤0.05) increased shoot biomass over those of the control (Table 3).

Grain yield: Treatment IRc 291 had the lowest grain yield among inoculation treatments, but this was not significantly (P>0.05) different from R25B, IRc 461, 60 kg N $ha^{-1}$and the control (Table 2). Treatment IRj 2180A had the largest yield, but this was comparable with yields of treatments R25B, IRc 461 and 60 kg N ha^{-1} (Table 2). Only the 50 kg P_2O_5 ha^{-1} treated plots had significantly ($P\leq0.05$) larger grain yield than the control (Table 3).

Grain nitrogen content: Except for treatment IRj 2180A, neither the inoculation nor N fertilizer treatments had more grain N content than the control (Table 2). As P- level increased, grain N content also increased. However, the increase in 50 kg P_2O_5 ha^{-1} treated plots was significant ($P\leq0.05$) over those of the control (Table 3).

Haulm nitrogen content: Treatment IRj 2180A had significantly higher ($P\leq0.05$) haulm N content than those of the other inoculation treatments and the control, this was however, not significant ($P>0.05$) from the 60 kg N ha^{-1} treatment plots (Table 2). Phosphorus effect on haulm N content was not significant ($P>0.05$), but the largest haulm N content was in 50 kg P_2O_5 ha^{-1} treated plots (Table 3).

Table 2: Nodule number (no. $plant^{-1}$), dry shoot biomass (g $plant^{-1}$), grain yield (t ha^{-1}), grain N (kg ha^{-1}), and haulm N (kg ha^{-1}) of promiscuous soybean (TGX 1485) as affected by inoculation.

Treatment	**Nodule Number (no. $plant^{-1}$)**	**Dry shoot biomass (g $plant^{-1}$)**	**Grain yield (t ha^{-1})**	**Grain nitrogen (kg ha^{-1})**	**Haulm nitrogen (kg ha^{-1})**
Uninoculated	23b	6.14c	0.91b	56.69b	23.58b
R25B	33a	7.14b	1.18ab	74.58ab	29.85b
IRj 2180A	36a	9.54a	1.46a	95.19a	38.35a
IRc 461	31a	6.91b	1.12ab	69.66ab	27.07b
IRc 291	30a	7.05b	1.09b	68.34b	26.33b
60 kg N ha^{-1}	15c	7.63ab	1.17ab	78.18ab	29.78ab

Values within a column followed by the same alphabet are not significantly different at P>0.05.

Table 3: Nodule number (no. $plant^{-1}$), dry shoot biomass (g $plant^{-1}$), grain yield (t ha^{-1}), grain N (kg ha^{-1}), and haulm N (kg ha^{-1}) of promiscuous soybean (TGX 1485) as affected by phosphorus.

Treatment	Nodule Number (no. plant-1)	Dry shoot biomass (g plant-1)	Grain yield (t ha-1)	Grain nitrogen (kg ha-1)	Haulm nitrogen (kg ha-1)
0 kg P2O5 ha-1 (P0)	22c	6.61b	1.04b	65.52a	25.58a
25 kg P2O5 ha-1 (P0)	37b	7.60ab	1.15ab	72.57a	29.41a
50 kg P2O5 ha-1 (P0)	43a	7.91a	1.27a	80.52a	31.16a

Values within a column followed by the same alphabet are not significantly different at P>0.05.

Nitrogen fertilizer severely depressed nodulation in this cultivar. This is however consistent with the work of Eaglesham (1989) who reported that the increasing levels of mineral N in the rhizosphere inhibits soybean nodule formation and functioning. The large nodulation on inoculated plots agrees with the findings of Sanginga *et al*., (1997). They reported that inoculant strains induced on average 25 % of nodules formed by soybeans.

The effectiveness and efficiency of N_2 fixation by rhizobial strains used and the N applied resulted in the higher shoot biomass over those of the control. The largest shoot biomass produced by IRj 2180A among inoculations could be that the rhizobial strain was most compatible to host strain, best competitor for nodule occupancy and most efficient in N_2 fixation. These probably explained why TGX 1485 cultivar inoculated with IRj 2180A had N contents even larger than those plots fertilized with 60 kg N ha^{-1}.

Inoculation and N fertilization also resulted in an increased grain yield and, grain and haulm N contents. These results could have been attributed to the competiveness and luxuriant N fertilization respectively (Sanginga *et al.* 1997 and Ajakaiye, 1980).

The results of these work also showed that as P- fertilization increased, growth and yields of the promiscuous soybean cultivar increased. This findings was consistent with the work of

El-Ghandour *et al*., (1996). They reported that fertilization with phosphorus increased nodulation, growth, grain yield and N contents in Faba-bean compared with the control.

Conclusion and Recommendation: The results of this experiment showed that inoculation and phosphorus treatments generally increased soybean growth and yields above those of the control (uninoculated). Except for the nodule number that was depressed significantly by N fertilization among treatments, the IRj 2180A rhizobial strain produced growth and yields that were comparable with those that were supplied with 60 kg N ha^{-1} . On the other hand, increased phosphorus levels correspondingly increased the parameters Investigated in this work over those of the control.

Based on the findings of this study, it is recommended that

(i) The TGX 1485 cultivar be made available to farmers in the study area.

(ii) The TGX 1485 cultivar be inoculated with any of the rhizobial strain used in this work but preferably the IRj 2180A inoculum, and

(iii) The 25 kg P_2O_5 ha^{-1} phosphorus fertilization levels be used.

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