

Influence of Soybean Genotype and Rhizobial Inoculation on Soybean Nodulation, Yield and Yield Component in Minna, Southern Guinea Savanna of Nigeria

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ABSTRACT

Promiscuous Soybean (*Glycine max*) varieties of the TGx types are known to nodulate and fix nitrogen with indigenous rhizobial populations in soils of most parts of Nigeria. The response of these varieties to rhizobial inoculation is, however, unclear. Therefore, a field study was conducted to assess the response of five genotypes of TGx soybean to inoculation. The experiment was a 2 x 5 factorial replicated three times and fitted into a Complete Randomized Block Design (RCBD), comprising five genotypes (varieties) (TGx1448-2E, TGx1904-6F, TGx1955-4F, TGx1935-3F and TGx1951-3F), two levels of inoculation (Inoculated and Uninoculated). Inoculation significantly increased nodule number, shoot biomass, and grain yield, but delayed pod production. An increase of 26.6% in nodule number, 20.7% in grain yield and 19.4% in shoot biomass due to rhizobial inoculation was evidenced. Among genotypes, TGx1955-4F had the most numerous nodules, while TGx1448-2E and TGx1951-3F had the fewest. TGx1951-3F and TGx1955-4F produced pods earlier than TGx1935-3F with TGx1904-6F, taking longest time to pod. However, TGx1935-3F, along with TGx1951-3F, produced the heaviest grains. There were no significant interactions between variety and inoculation in all the parameters measured suggesting the possibility of soybean response to inoculation irrespective of genotype.

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INTRODUCTION

Biological Nitrogen fixation (BNF) is an effective and efficient source of nitrogen supply to leguminous plants under favourable atmospheric and environmental conditions (Hungaria and Vargas, 2000; Chen *et al.*, 2002). The capacity for BNF is better enhanced by the presence of effective indigenous rhizobial populations or by the application of appropriate rhizobial inoculants (Giller and Cadisch, 1995; Tahir, *et al.*, 2009).

Inoculation is an effective technology used to establish large rhizobial populations in the rhizosphere that leads to improved N₂ –fixation and crop productivity (Keyser and Li, 1992; Peoples *et al.*, 1995; Tahir *et al.*, 2009). Soybean response to inoculation is affected by, among many factors, the crop genotype and the size of the native rhizobial populations (Abaidoo *et al.*, 2000).

The Tropical *Glycine* Cross (TGx) varieties of soybean, developed to nodulate with rhizobial populations indigenous to African soils (Pulver *et al.*, 1985; Abaidoo *et al.*, 2000) are widely cultivated by farmers in Nigeria (Bala *et al.*, 2003). Previous studies have shown that the TGx varieties develop nitrogen deficiency symptoms in some locations (Okereke and Eaglesham, 1992; Abaidoo *et al.*, 2000) or exhibit increase in some yield

parameters when inoculated thus suggesting that the TGx soybean genotypes could benefit from rhizobial inoculation for improved crop productivity. This study is, therefore, designed to assess the response of five TGx soybean varieties to rhizobial inoculation in Minna, in the Southern Guinea savanna of Nigeria.

MATERIALS AND METHODS

Study Site

The field trial was conducted during the 2012 cropping season on a farmer's field at Gidan Kwano within Lat. 09° 32.738' N and 006° 27.189' E in an Alfisol of Minna, Southern Guinea Savanna of Nigeria. The soil at the site is Typic Haplustalf underlain by Basement complex rocks that are mainly made of granites (Bennett *et al.*, 1979; Ojanuga, 2006). The climate of Minna is sub-humid with mean annual rainfall of 1284 mm and a distinct dry season of about 5 months duration occurring from November to March (Ojanuga, 2006). The mean maximum temperature remains high throughout, about 32 °C, particularly in March and June. Prior to the 2012 cropping season, the sites has been left fallow for about five years with the surrounding area being planted to yam,

Sorghum, Millet, maize, rice and some legumes as Groundnut and Soyabean.

Treatment and Experimental Design

The field trial was a factorial experiment consisting of five TGx soybean varieties (TGx1448-2E, TGx1904-6F, TGx1955-4F, TGx1935-3F and TGx1951-3F) and two levels of inoculation (Inoculated and Uninoculated) in three replicates fitted into a Randomized Complete Block Design (RCBD).

Agronomic Practices

The site was cleared manually, dis-ploughed and harrowed by tractor. Planting of the different varieties were done on flat in a 3 m x 3 m plots replicated three times. Each plot had six rows spaced at 50 cm apart, with a net plot of 4 m² and a peak biomass sampling area of 0.5 m². The TGx soybean varieties used were source from the Kano station of the International Institute of Tropical Agriculture (IITA), and planted on 10th August, 2012. Rhizobial inoculant (Legume Fix) obtained from Legume Technology, UK, was used to inoculate the soybean seeds as recommended by the manufacturer before planting. The uninoculated soybean treatments were first planted to avoid contamination by the inoculated ones. Soybean seeds were drilled in to open grooves and covered slightly with soil. The seedlings were thinned to three per hill at 10 cm within row spacing two weeks after planting (WAP). Phosphorus fertilizer (SSP at 20 Kg P₂O₅ ha⁻¹) was applied at planting in furrow (2 cm deep) dug 5 cm away from the planting lines and covered with the soil. Manual weeding was carried out at 4 and 7 WAP respectively.

Soil Sampling and Analysis

Soil was sampled randomly at 0-20 cm depth from 10 positions and thoroughly mixed together to get a composite. The air-dried and sieved soil sample was subjected to routine physico-chemical analysis (IITA, 1989)

Growth, Phenology and Nodulation Analysis

The phenological data recorded were days to 50 % flowering and podding. At mid-

podding, above ground biomass of all the plants within the peak biomass sampling area (0.5 m²) were cut at the soil line, the shoots were weighed and later transferred for oven drying at 75 °C to obtain the oven-dried shoot biomass. The roots of the same plants harvested for biomass assessment were carefully pulled out of the soil with spade into polythene bags and brought to the Laboratory. The roots were washed under tap water to remove the adhering soil and the nodules on the roots harvested for nodule counts and counted with the picked ones to obtain nodule number per plant. The nodules were enveloped and oven dried at 75 °C to obtain nodule dry weight per plant. Nodule activity was assessed by randomly selecting 5 nodules, cutting them into two and recording the percentage of those with pink colour inside.

Yield and Yield Components Analysis

Sampling for yield and yield components analysis was carried out in the net plot of 4 m². At maturity, number of pods per plants were recorded as Pod load, distance between the ground level and the first pod was recorded as the Pod clearance. The total pods within the net plot were harvested, weighed and recorded and sub sample of known weight taken. The sub samples were oven dried at 75 °C to a constant weight and their weight determined, this was later threshed manually and the grain yield recorded. A sub-sample of the harvested haulms was oven-dried to get a haulm yield. 100 seeds were randomly selected, weighed and converted to 1000 seed weight.

Statistical Analysis

All the data were subjected to analysis of variance where significant means were separated using Least Significant Difference (LSD). This was done using GLM proc of SAS (SAS Inst., 2002).

RESULTS AND DISCUSSION

Soil Physical and Chemical Properties

Results of Soil physical and chemical analysis (Table1) showed that, the soil at the study site is Loamy sand in texture, slightly acidic in reaction and generally low in available nutrients.

Table 1: Physical and chemical properties of Soil (0-15 cm).

Parameter	Value
Sand (g kg ⁻¹)	800
Clay (g kg ⁻¹)	110
Silt (g kg ⁻¹)	90
Textural class	Loamy sand

Parameter	Value
pH (CaCl ₂)	6.2
OC (g kg ⁻¹)	4.52
TN (g kg ⁻¹)	0.45
Available P (mg kg ⁻¹)	9.51
Na (cmol kg ⁻¹)	2.00
K (cmol kg ⁻¹)	1.50
Ca ²⁺ (cmol kg ⁻¹)	3.20
Mg ²⁺ (cmol kg ⁻¹)	1.20
Exch. Acidity (cmol kg ⁻¹)	0.18

Shoot Biomass

The effects of crop genotype and rhizobial Inoculation on Shoot biomass are shown in Table 2. There was no significant difference among the soybean varieties in shoot biomass, whereas, Inoculation treatments significantly ($P < 0.05$) increased the shoot biomass in the inoculated plots above those of uninoculated. Rhizobial Inoculation alone increased shoot biomass from 257.20 g in the uninoculated plots to 318.93 g (19.4% increases) in the inoculated treatment plots. There were no significant interaction between crop genotype and inoculation on the shoot biomass. These results are similar to the report of Muhammad, (2010) and also fall within 7 – 23% reported by Egamberdiyeva *et al.*, (2004). An increase (11%) in shoot biomass has also been reported in TGx 1448 when inoculated with Bradyrhizobium (Okogun *et al.*, 2004).

Days to 50% Flowering and Podding

The effects of crop genotype and rhizobial Inoculation on days to 50% flowering and podding are shown in Table 2. Both the single effect of crop genotype, rhizobial inoculation and their interaction did not affect the number of days to 50% flowering. The influence of crop genotype and inoculation treatments (main effect only) on the number of days to 50 % podding was significant ($P < 0.05$). The genotype TGx1955-4F and TGx1951-3F podded significantly earlier than TGx1935-3F which was earlier than TGx1448-2E, while TGx 1904-6F delayed podding compared to the others. Inoculation significantly delayed podding by one day in the inoculated plots compared to the

uninoculated, whereas, there were no significant interaction between crop genotype and inoculation treatments regarding days to 50% podding.

Nodulation

The effects of crop genotype and rhizobial inoculation on nodule weight, number and activity, are shown in Table 2. Although, there was no significant difference among the crop genotypes and inoculation treatments in nodule weight and Nodule activity, both the variety and inoculation influenced the nodule number formed per plant. Among the five genotypes, TGx1955-4F had most numerous nodules which were not significantly different from TGx 1935-3F, whereas, TGx1448-2E and TGx1951-3F had the fewest. Also, Inoculation significantly ($P < 0.05$) increased nodule number from 58 nodule plant⁻¹ in the uninoculated plots to 79 nodule plant⁻¹ in the inoculated leading to a 26.6% increase in nodule number per plant. There were no significant interaction among the crop genotypes and the inoculation treatments. Nodule count reflects the efficiency of rhizobial used, thus suggesting that the native rhizobial alone do not affect the observed differences in inoculated and uninoculated plots. However, numerous of nodules formed due to inoculation suggested that, there is better combining and symbiotic relationship between introduced rhizobial and soybean (Tahir *et al.*, 2009). Higher nodule number due to rhizobial inoculation has also being reported else where (Zhang-Feng *et al.*, 1997 and Oad *et al.*, 2004).

Table 2: Effects crop genotype and Inoculation on soybean growth, phenology, and nodulation

Treatment	Days to 50% flowering	Days to 50%podding	Shoot Biomass (g)	Nodule number (Plant ⁻¹)	Nodule weight (g Plant ⁻¹)	Nodule Activity (%)
Genotype (G)						
TGx1448-2E	44.00	55.00	270.00	53.00	0.42	78.00
TGx1904-6F	45.00	56.00	279.67	63.00	0.33	80.00
TGx1955-4F	44.00	53.00	280.67	92.00	0.42	70.00
TGx1935-3F	45.00	54.00	296.33	82.00	0.44	70.00
TGx1951-3F	44.00	53.00	313.00	52.00	0.33	58.00
SE±	0.39	0.22	32.00	8.83	0.07	7.45
LSD (P < 0.05)	NS	0.66	NS	26.03	NS	NS
Inoculation (I)						
Inoculated	45.00	54.00	318.93	79.00	0.39	71.00
Uninoculated	44.00	53.00	257.20	58.00	0.38	71.00
SE±	0.25	0.14	20.24	5.58	0.04	4.71
LSD (P < 0.05)	NS	0.42	59.72	16.46	NS	NS
Interaction						
G x I	NS	NS	NS	NS	NS	NS

Yield and Yield Components

The effects of crop genotype and rhizobial inoculation on yield and yield components which includes Pod load (plant⁻¹), Pod clearance (cm plant⁻¹), 1000 seed weight (g), Grain and haulm yield (Kg ha⁻¹) are shown in Table 3. There were no significant soybean response to due to crop genotypic variation, Inoculation and their interaction in the Pod load, and pod clearance, whereas, 1000 seed weight was influenced by variety. TGx1951-3F and TGx1935-3F produced significantly heavier grains compared to the others. No significant interaction was observed between crop genotype and inoculation treatments on 1000 seed weight. There was no significant response of soybean grain yield to crop genotype, but inoculation significantly increased grain yield from 881.07 Kg ha⁻¹ in uninoculated plots to 1110.52 Kg ha⁻¹ in inoculated plots leading

to a 20.7% yield increase. Haulm yield did not respond significantly to crop genotype and inoculation treatments, even though there was an insignificant increase in haulm when soybean is being inoculated.

Symbiosis between soybean and Rhizobium could be the possible explanation to the increase in grain yield. This is because, increased nodulation resulted in more N₂-fixation that leads to increased yield components. The 20.7% increase in grain yield due to Inoculation was greater than 6 and 10% reported by Tien *et al.*, (2002), but within the range of 14 – 100% reported by Okereke *et al.*, (2004). Similarly, Ashraf *et al.*, (2002) and Abbasi *et al.*, (2008) in Pakistan reported increase in grain yield due to Rhizobium inoculation suggesting that Rhizobium inoculation is still effective in legume cropping systems to realize the yield potential of crop.

Table 3: Effects crop genotype and Inoculation on soybean yield and yield components

Treatment	Pod Load (No. Plant ⁻¹)	Pod Clearance (cm Plant ⁻¹)	1000 Seed weight (g)	Grain yield (Kg ha ⁻¹)	Haulm yield (Kg ha ⁻¹)
Genotype (G)					
TGx1448-2E	42.00	10.92	78.37	986.80	1328.80
TGx1904-6F	36.00	9.83	79.38	948.20	1300.10
TGx1955-4F	35.00	9.57	87.23	1001.90	1156.70

Treatment	Pod Load (No. Plant ⁻¹)	Pod Clearance (cm Plant ⁻¹)	1000 Seed weight (g)	Grain yield (Kg ha ⁻¹)	Haulm yield (Kg ha ⁻¹)
TGx1935-3F	45.00	10.83	97.02	1044.90	1392.30
TGx1951-3F	38.00	9.17	100.75	997.20	1273.30
SE±	3.74	1.06	3.09	109.31	92.55
LSD (P < 0.05)	NS	NS	9.11	NS	NS
Inoculation (I)					
Inoculated	41.00	10.03	89.61	1110.52	1347.46
Uninoculated	37.00	10.10	87.48	881.07	1233.03
SE±	2.37	0.67	1.95	69.13	58.53
LSD (P < 0.05)	NS	NS	NS	203.94	NS
Interaction					
G x I	NS	NS	NS	NS	NS

CONCLUSION

The result of this experiment has shown that Promiscuous soybean irrespective of the genotype variety requires rhizobial Inoculation for high grain yield production in the area. Promiscuous soybean developed to nodulate with rhizobial populations indigenous to African soils had shown a positive response to Rhizobial inoculation in terms of nodulation, shoot biomass and yield when Phosphorus limitation is removed through application of 20 Kg P ha⁻¹ without starter N application. The single effect of the crop genotype was only inconsistent from the result of this study and there were no significant interactions between variety and inoculation in all the parameters measured.

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