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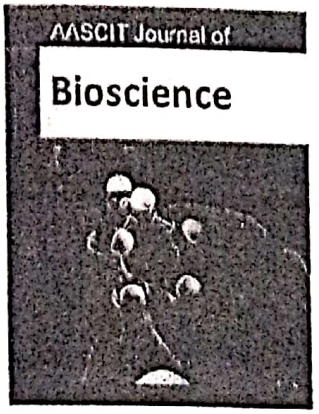

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Effects of Rhizobium Inoculation and Variety on the Productivity of Soybean in Minna, Southern Guinea Savanna

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Abstract
Crop genotype as well as the effectiveness of rhizobium inoculants affect productivity of legumes especially soybeans. A field experiment was conducted at the Teaching and Research farm, Federal University of Technology, Minna. The aim of the research was to quantify the contribution of elite strains of rhizobium to the growth and yield of promiscuous soybean varieties and to ascertain if there will be need for inoculation with these elite strains. The experimental design was a 3 x 5 x 4 factorial experiment fitted to Completely Randomized Design. The treatments were three N levels (0 Kg N ha^{-1}, Peat inoculant, Total Nitro liquid inoculant) and five soybean varieties (TGX 1448-2E, TGX 1951-3F, TGX 1945-1F, TGX 1835-10F and local check). All treatments were replicated 4 times. Plots of size 3.5 x 4m were marked out with an inter-plot spacing of 1m and inter-rep spacing of 2m. Seeds were sown at the rate of 4 seeds per hole and thinned to 2 seedlings at one week after sowing, prior to basal application of 20 Kg N and 30 Kg P_2O_5 ha^{-1}. Inoculation was done at the rate of 5g of peat per Kg of seeds and 28 mls of TotalNitro per Kg of seeds. Results revealed that inoculation and variety significantly affected shoot biomass and nodule weight of soybeans demonstrating that some benefits can be derived from inoculation of promiscuous soybean. Yield was not significantly affected by inoculation, suggesting that the indigenous strains were probably more competitive than the introduced rhizobia. Given the mixed results obtained from this preliminary field work, it is necessary to conduct a need-to-inoculate of soils across the Nigerian savanna to establish the frequency and magnitude of response to inoculation.

1. Introduction

The soybean (U.S) or Soyabeans (U.K) (*Glycine max (L) merr*) (Encyclopedia of Life, 2012), is a leguminous vegetable of the pea family that grows in tropical, subtropical and temperate climate and are native to East Asia (Multilingual Multiscript Plant Name Database, 2012). It is the richest source of plant protein known to man (Odusanya, 2002), the cheapest and the readily available source of protein, especially in developing countries; it is therefore very important in rectifying the protein deficiency which is very common in diet of people in rural areas. Soybean has the capacity to improve soil fertility by fixing nitrogen into the soil through nitrogen fixing bacteria resident in the

the 5th of September 2011 while the inoculated seeds were planted on the 6th and 7th of September, 2011 at the rate of 4 seeds per hole. The rate of Inoculation with peat was 5 g per kg of seeds while inoculation with TotalNitro liquid inoculants was at the rate of 28 mls per kg of seeds. Seedlings were later thinned to 2 seedlings at one week after planting prior to the application of basal N at the rateof 20 kg N ha^{-1} to give a starter N effect. This is equivalent to 43.5 Kg of urea per hectare ie 59g of urea per plot size of 13.5m^2. Plots were constantly kept weed-free manually.

2.6. Tissue Sampling and Harvesting

Shoot biomass of soybean was sampled at 50% podding to asses Biological Nitrogen Fixation (BNF) and nodulation ie the two inner ridges were destructively sampled by selecting eight plants at random. Harvesting was done at physiological maturity by hand pulling and threshing.

2.7. Statistical Analysis

Yield, growth and nodulationdata weresubjected to two way analysis of variance (ANOVA) using statistical package SAS inc.(2002) to determine treatment effect at 5% level of significance. LSD was used to separate means.

3. Results and Discussions

Physicochemical Properties of Soil

The results of the physical and chemical properties of the soil at 0-20cm depth are shown in Table 1. The soil was classified as sandy clay loam. The pH of soil was slightly acidic (pH in H_2O and $CaCl_2$ of 6.9 and 6.41 respectively). According to Esu 1995 rating, organic carbon was low (6.50 g kg^{-1}). Available phosphorus was medium (16.1 mg kg^{-1}), Total Nitrogen was high (>0.2). The exchangeable Ca of 3.10 C mol Kg^{-1} was medium, exchangeable Mg of 1.00 C mol Kg^{-1} was medium and exchangeable K of 0.48 Cmol Kg^{-1} was high. Exchangeable Na of 0.299 Cmol Kg^{-1} was medium. Exchangeable acidity was 1.38 C mol Kg^{-1}

Table 1. Some Physicochemical Properties of the Soil at the experimental farm prior to planting of soybean (Varietal Trial) 2011.

Parameter	Value
Sand (g kg^{-1})	758.8
Silt (g kg^{-1})	7.00
Clay (g kg^{-1})	234.2
Textural class	Sandy clay loam
pH in $CaCl_2$	6.41
pH in H_2O (1:2.5)	6.41
Available P (mg kg^{-1})	9.00
Total N (g kg^{-1})	0.28
Organic C (g kg^{-1})	6.5
Exchangeable cation (cmol kg^{-1})	
Mg^{2+}	1.00
Ca^{2+}	3.10
K^+	0.48
Na^+	0.29
Exchangeable acidity (cmol kg^{-1})	
$Al^{3+}+H^+$	1.38
ECEC	6.25
Indigenous rhizobia population (cells g^{-1} soil)	2,422

Table 2. Growth, Nodulation and Yield Parameters of Soybean Varieties as affected by Inoculation Treatment.

	Plant Height (cm)	Shoot Biomass (g)	Leaf No	Nodule No	Nodule weight g/plt^{-1}	Pod No	Pod weight g plt^{-1}	Yield Kg ha^{-1}
INOCULATION (I)								
Control	48.3	12.0	32	29	0.41	18	2.3	749.6
Inoculated with peat	49.8	13.7	33	27	0.28	22	2.6	740.6
Inoculated with liquid	44.9	14.7	38	27	0.32	33	4.5	580.7
LSD < 0.05	NS	NS	NS	NS	NS	10	1.6	NS
VARIETY (V)								
TGX 1448 – 2E	51.6	12.2	35	30	0.37	17	2.4	801.8
TGX 1951 – 3F	51.1	14.6	42	26	0.40	24	2.8	591.8
TGX 1945 – 1F	44.1	16.0	29	21	0.20	36	3.8	765.8
TGX 1835 – 10F	46.9	12.2	27	31	0.34	20	3.1	623.7
Local Variety	44.7	12.4	38	31	0.37	24	3.5	668.3
LSD < 0.05	NS	NS	10	NS	NS	13	NS	NS
Vx I	NS	3.8	NS	NS	0.15	NS	NS	NS

NSNot significant at 5%LSD least Significant Difference

Soybean breeders at the IITA, Nigeria developed new soybean genotypes for Africa in order to avoid the need for inoculation. These genotypes known as tropical glycine cross (TGx), nodulate with bradyrhizobium sp. populations indigenous to African soils (Abaidoo *et al.*, 2000, Osunde *et al* 2003). This result has demonstrated that inoculation with bradyrhizobium sources (peat and total nitro liquid) significantly affected podding (Table 2). Averagely, inoculation improved podding characteristics of the soybean varieties but improvement did not translate to better yields. This may indicate that assimilate partitioning and translocation was in favor of podding than seed yield. It may also suggest that the pods were more active sinks than the seeds. This is consistent with the work of Ali *et al.*(2000) who reported that Rhizobium culture significantly affected pod number per plant. Varietal treatment significantly affected pod number of soybeans. The pod number of the local check was only inferior to the pod number of TGx1945-1F and may suggest why the yield of the local check (668.3kgha^{-1}) was inferior to the yield of TGx1945-1F (765.8kgha^{-1}).

Inoculation did not significantly affect (P>0.05) yield

suggesting that the indigenous bradyrhizobium strains were averagely more competitive than the 532c strain contained in the peat and the SEMIA 5079 and SEMIA 5080 strains contained in TotalNitro liquid inoculant. The peat inoculant however produced seed yield (740.6kgha^{-1}) that was superior to that produced by liquid inoculant (580.7kgha^{-1}). The peat probably improved adherence of inoculant to the seeds and provided a lasting energy source for the associating *bradyrhizobium strains*. Varietal treatment did not significantly affect (P>0.05) yield of soybeans suggesting that the yield of the local variety (668.3 kg ha^{-1}) that was not statistically different from the yields of the TGX was comparable. The highest yield of 801.8kg ha^{-1} produced by TGX 1448-2E was probably a reflection of the level of genetic stability. Although the nodule values of the local check were similar to those of TGx1448-2E and better than those of TGx1945-1F, they only translated to better pod values.

Table 3. Shoot Biomass (g plant^{-1}) of Soybean Varieties as affected by Inoculation Treatment.

Variety	Control	Peat inoculants	Total Nitro liquid inoculant
TGx 1448-2E	12.4	12.8	11.5
TGx 1951-3F	16.6	8.3	18.8
TGx 1945-1F	11.8	13.8	22.4
TGx 1835-10F	9.7	16.0	10.9
Local check	9.7	17.3	10.1
LSD <0.05	3.9		

Interaction between inoculation and variety significantly affected shoot biomass (Table 3) and nodule weight (Table 4) of soybeans confirming the report of Triplett, (1990) that response to inoculation is a complex system involving interactions between bacteria genomes, host genomes and the environment. Shoot biomass was highest when TGX 1945-1F was inoculated with liquid inoculant and lowest when TGX 1951-3F was inoculated with peat inoculant (Table 3) indicating a host x strain interaction (Sanginga *et al.*, 2000). Nodule weight was highest when TGX 1951-3F was associating with the natural rhizobia in the control treatment and lowest when TGX1945-1F was inoculated with peat signifying that the natural rhizobia were more competitive than the 523c strains in the peat inoculant (Sanginga *et al.*, 2000). Growth response to indigenous Bradyrhizobium populations suggests that biological nitrogen fixation was enhanced (Graham, 2003). Several authors have reported that 75% of the nitrogen needed by soybean is supplied biologically (Adjei *et al.*, 2002).

Table 4. Nodule Weight (g plant^{-1}) of Soybean Varieties as affected by Inoculation Treatment.

Varieties	Control	Peat inoculant	Total Nitro liquid inoculant
TGx 1448-2E	0.40	0.16	0.56
TGx 1951-3F	0.73	0.27	0.18
TGx 1945-1F	0.24	0.13	0.23
TGx 1835-10F	0.29	0.41	0.30
Local check	0.39	0.40	0.32
LSD < 0.05	0.16		

Inoculation averagely depressed nodulation (Table 4). Nodulation of TGx 1951-3F was significantly depressed by inoculation while that of TGX 1448-2E was significantly improved by inoculation with liquid inoculant indicating that this variety can benefit from rhizobial inoculation. The other varieties were not significantly affected by either peat inoculant or liquid inoculant confirming that theycan effectively associate with the indigenous strains of rhizobium and have prospects in the low-inputs cropping system of the Guinea Savanna.

4. Conclusion

In conclusion, interaction between inoculation and variety significantly affected shoot biomass and nodule weight of soybeans demonstrating that some benefits can be derived from inoculation of soybeans at Gidan Kwano. Averagely, yield was not improved by inoculation suggesting that the indigenous strain population of 2,422 cells g^{-1} of soil (table 1) was probably more competitive than the introduced rhizobia strains. Secondly, high total nitrogen content of > 0.2 g Kg (table 1) probably affected response to inoculation. Given the mixed results obtained from this preliminary field work, it is necessary to conduct a need-to-inoculate study of soils across the Nigerian savanna to establish and justify the frequency and magnitude of response to inoculation.

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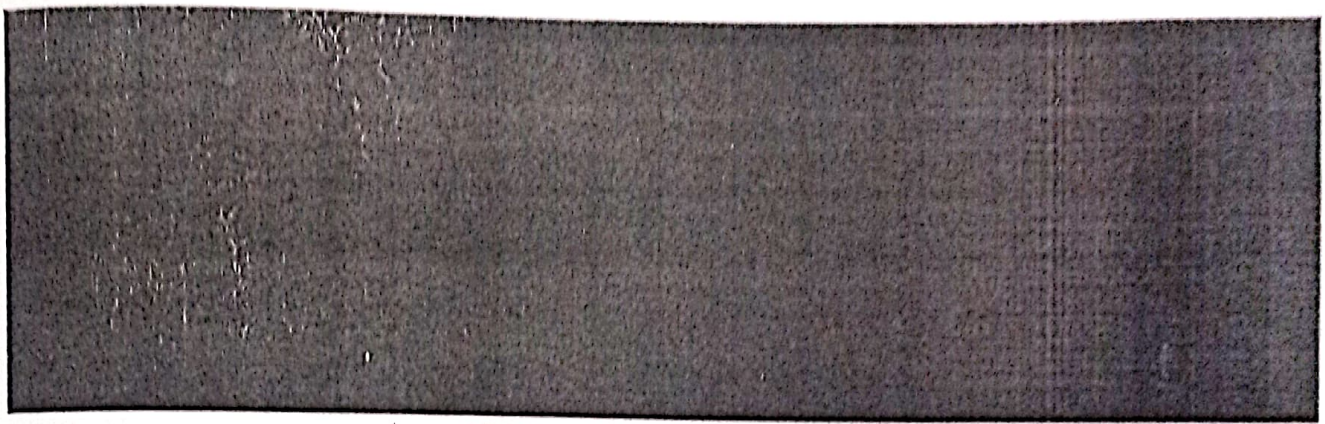

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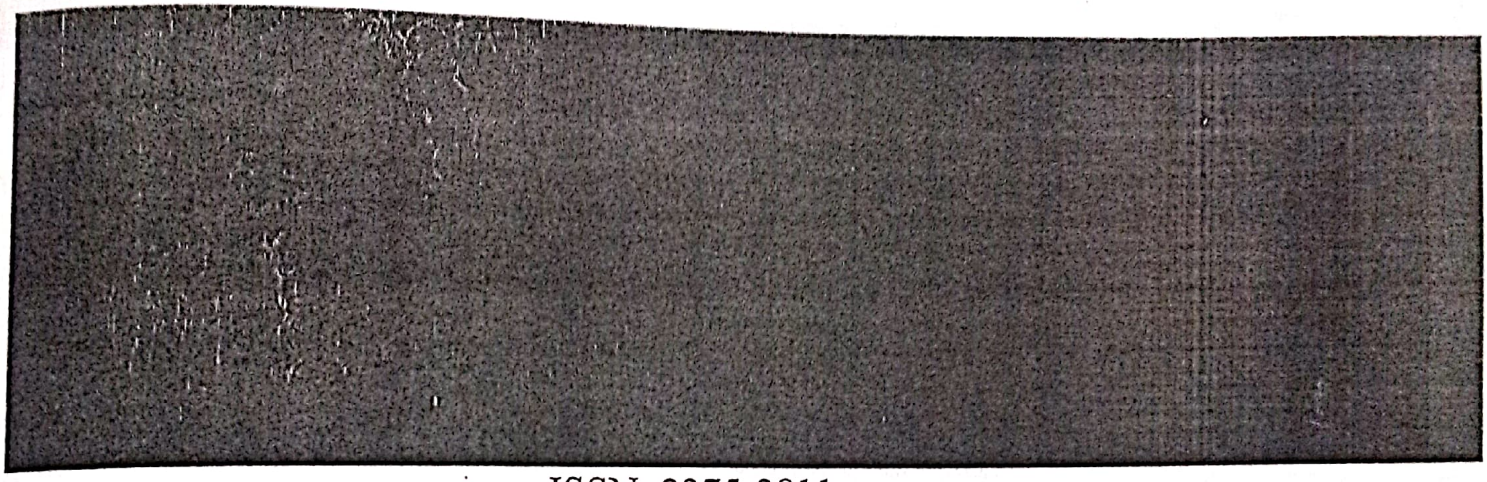

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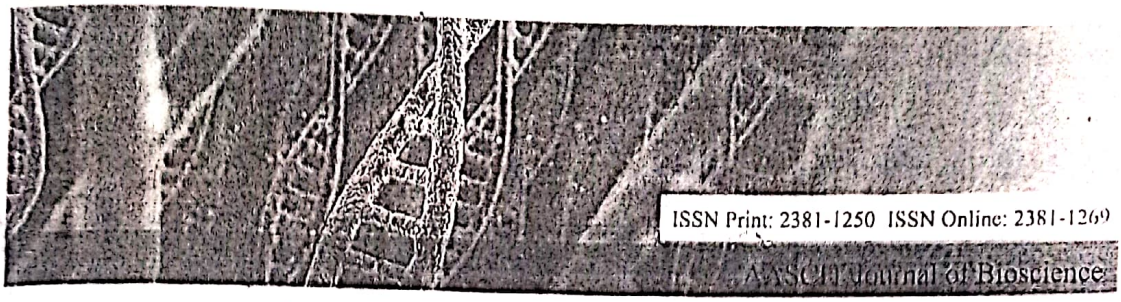

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