ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 5, Issue 9 , September 2018

Response of Soybean (*Glycine Max. l.*) Cultivars to Bradyrhizobium Inoculation in Sudan Savanna Kano Nigeria

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ABSTRACT: Field trial was conducted to study the response of soybean varieties to *Bradyrhizobium* inoculation in the Teaching and Research farm of Bayero University, Kano, Sudan savanna agro ecological zone of Nigeria. The experiment investigated the performance of ten soybean varieties (TGX 1835-10E, TGX 1904-6F, TGX 1935-3F, TGX 1951-3E, TGX 1448-2E, TGX 1955-4E, TGX 1485-1D, TGX 1987-62F, TGX 1945-3E and SC SAGA.) under two conditions (inoculation and un-inoculation). The treatments were laid out in a split plot design in four replications, with inoculation in the main plots and varieties in the sub plots. Standard agronomic practices were followed throughout the growing season. Soil samples were collected and analyzed according to standard procedures. The data collected included; Number of leaves per plant, Number of branches per plant, Shoot biomass (t ha^{-1}), 100 Seed weight per pod (g) and Grain yield per hectare (t ha^{-1}). The data was subjected to Analysis of Variance (ANOVA) using statistix 9.0. Inoculation enhanced growth and development of soybean there by increasing yield (t ha^{-1}). The varieties TGX 1935-3F, TGX 1987-62F and TGX 1835-10E performed similar and better than the other improved and local varieties in terms of grain yield.

KEYWORDS: Soil, Nitrogen, Improved, Inoculation, Savanna, Soybean,

I. INTRODUCTION

Nitrogen (N) is a major nutrient limiting crop production in the Guinea savanna of Nigeria due to the inherently poor N status of the soils. The problem is further exacerbated by the non-availability, and when available, expensive nature of inorganic N fertilizers. Nitrogen is a critical limiting element for plant growth and production. It is a major component of chlorophyll, the most important pigment needed for photosynthesis, as well as amino acids, the key building blocks of proteins. According to (Brady and Weil, 2005), plant growth in soils throughout the world is often restricted by the supply of available N and as a result, it is often the most limiting nutrient for crop production in most soils of the world. Grain yields are still very low in Sub-Saharan Africa FAO (2005). This is partly due to low N fertility of many savanna soils. (Kwari 2005, Sandabe and Bapatel, 2008).The low fertility of these soils remains one of the major constraints to production of both food and cash crops in the zone (Rayar, 1987). The International Institute of Tropical Agriculture (IITA) has developed promiscuous soybean varieties, which are capable of establishing symbiotic relationship with indigenous *bradyrhizobia,* as a practical alternative to inoculation by African farmers (Dashiell *et. al.,* 1987). Use of *rhizobium* inoculums in the establishment of legumes has been widely recognized, especially in areas where indigenous nodulation has been found to be inadequate (Bruno, *et. al*., 2003). The benefits by the use of *rhizobium* inoculants show that a quite good deal of money can be saved by marginal farmers by using quality tested inoculants on the farm. Further, it has been reported that the legumes crop enrich the fertility of the soil. Rhizobia inoculation to seeds is well studied and exploitation of this beneficial nitrogen fixing root nodule symbiosis represents a hallmark of successfully applied agricultural microbiology (Bruno, *et. al*., 2003).

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International Journal of AdvancedResearch in Science, Engineering and Technology
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There is however dearth of reliable information on response of promiscuous soybean varieties to *bradyrhizobium* inoculation in the Sudan savanna zone

II. MATERIALS AND METHODS

A) EXPERIMENTAL SITE

The experiment was conducted at Bayero University, Kano (BUK) Teaching and Research Farm (latitude $12^{0}58^{1}$N, longitude $8^{0}25^{1}$E) in the Sudan Savanna agro-ecology. The location was characterized by two seasons: a wet season (May to September) and dry season (October to April). The amount of rainfall received during the field trial was 1041.80mm. The daily minimum and maximum temperatures during the period ranged from 18 ^{0}C to 34 ^{0}Crespectively.

B) FIELD EXPERIMENT / EXPERIMENTAL DESIGN

Field trial was conducted during rainy season where nine (9) improved soybean varieties viz.: TGX 1835-10E, TGX 1904-6F, TGX 1935-3F, TGX 1951-3E, TGX 1448-2E, TGX 1955-4E, TGX 1485-1D, TGX 1987-62F, TGX 1945-3E, one (1) local variety SC SAGA, natural fallow and maize were grown under two levels of *bradyrhizobium* inoculation conditions (inoculated and un-inoculated). The treatments were laid out in a split plot design in four replications, with inoculation in the main plots and varieties in the sub plots.

C) AGRONOMIC PRACTICE

Before the establishment of the experiment, the land was ploughed and harrowed to a fine tilt and ridged at 0.75m apart. Later, the land was marked in to plots and replications. An alley of 1.5 m and 2.0 m were left between plots and replications, respectively. In the experiment the gross sub plot size consisted of 6 rows, 0.75m apart and 3m long. Each plot size measured 4.5m broad x 3.0 m long (13.5m^{2}); while net plot was 3m wide x 1.5m (4.5m^{2}). Sowing of soybean was done at 3 seeds per hole at about 0.75m apart between rows and 10cm between stands. Single Super Phosphate (SSP) was applied at a rate of 20 kg/hectare at planting. The fertilizer was banded 10cm away from the planting line, in a 2cm deep trench and covered after application. While weeds were controlled manually using hoe as often and when necessary, cases of pests and diseases were not observed throughout the trial.

D) SOIL ANALYSIS

Before the establishment of the trial, soil samples were collected randomly according to standard procedures from 0-15cm using auger for determination of physico-chemical properties.

E) GROWTH AND YIELD COMPONENTS

- Number of leaves per plant: Five plants were randomly selected and tagged. The number of leaves was determined at 6, 9 and 12 WAS and the mean taken.
- Number of branches per plant: The number of branches was determined by counting the number of branches from five tagged plants at 6, 9 and 12 WAS and the mean number taken.
- Shoot biomass (t ha^{-1}): Data was collected on Shoot biomass after harvest in kg from each sampling area of the net plot (4.5 m^{2}) at full pod. The data collected from the five tagged plants were totaled and average taken. The result was expressed in t ha^{-1}
- 100 Seed weight per pod (g): 100 seeds were randomly selected from each of the five tagged plants at harvest. The seeds weighed and the average was computed.
- Grain yield per hectare (t ha^{-1}): Grain yield was determined by harvesting the pods in each net plot dried and weighed. The yield was then expressed in t ha^{-1}

F) DATA ANALYSIS

Data obtained were subjected to statistical analysis using the analysis of variance (Harry and Steven, 1995). Means that were significantly different were separated using the Least Significant Difference (L.S.D.) as reported by Steel and Torrie (1985).

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III. RESULTS AND DISCUSSION

A) INITIAL SOIL PHYSICAL AND CHEMICAL PROPERTIES

The physico-chemical properties of the soil (0-15cm) of the trial site before establishment of the trials are presented in Table 1. The soil texture was characterized as sandy loam. The soil pH (H_2O) was slightly acidic while organic carbon, total N, available phosphorus, and Sulphur contents were all low. The cation exchange capacity (CEC) and exchangeable bases were also in the low fertility class (less than 5.0 and 50 Cmol/kg, respectively) (Eno*et al*., 2009).

Table 1: Initial physico-chemical properties of surface soil of the experimental site

Soil property		Fertility Class (Eno*et. al.*, 2009)
Particle size distribution (g kg^{-1})		
Clay	170	-
Silt	40	-
Sand	790	-
Textural class	Sandy loam	-
Exchangeable bases (Cmol kg^{-1})		
Ca	0.75	Low
Mg	0.50	Low
K	0.07	Low
Na	0.33	Low
CEC (Cmol kg^{-1})	5.00	Low
pH in H_2O (1:2.5)	6.70	Slightly acidic
Organic Carbon (g kg^{-1})	9.5	Low
Total Nitrogen (g kg^{-1})	3.6	Low
Avail. Phosphorus (g kg^{-1})	10.1	Low
Available Sulphur (µg /g)	0.43	Low

Source: Laboratory analysis

B) EFFECT OF INOCULATION AND VARIETY ON GROWTH AND DEVELOPMENT OF SOYBEAN

- Number of branches/plant: The effect of inoculation and varieties on number of branches of soybeans at 6, 9 and 12 weeks after sowing (WAS) was presented in Table 2. The result of inoculation on number of branches was significant ($P<0.05$) at all the periods of measurement. With inoculated plant having higher number of branches than the un-inoculated ones. The result also indicated significant differences between varieties at all periods of measurement; with TGX 1951–3E and TGX 1945, having the highest and lowest number of branches at 6 WAS, respectively. However, at 9 and 12 WAS, TGX 1485–1D produced significantly highest number of branches while SC–SAGA produced the lowest number of branches at 9 WAS. This was statically at par with TGX 1955–4F which also significantly produced lowest number of branches at 12WAS but at par with SC–SAGA. Interactions between factors tested were not significant at all the periods of measurement.

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Table 2: Effect of inoculation and variety on number of branches of soybean

Treatments	Number of branches (plant^{-1})		
	6 WAS	**9 WAS**	**12 WAS**
Inoculation (I)			
With	11.94a	35.53a	58.80a
Without	10.88b	32.69b	53.85b
SE ±	0.34	1.02	2.35
Varieties (V)			
TGX 1835-10E	11.587abc	32.175abc	56.862ab
TGX 1904-6F	11.837abc	31.188abc	50.325abc
TGX 1935-3F	12.158ab	37.300ab	59.038ab
TGX 1951-3E	13.412a	35.888abc	58.887ab
TGX 1448-2E	11.291abc	35.9888abc	60.075ab
TGX 1955-4F	11.429abc	27.012c	41.538c
TGX 1485-1D	11.300abc	38.838a	65.000a
TGX 1987-62F	11.337abc	29.400abc	52.075abc
TGX 1945	9.416c	35.123abc	59.212ab
SC-SAGA	10.379bc	28.212c	45.300bc
SE ±	1.32	4.79	7.37
Interaction			
I x V	NS	NS	NS

Means followed by the same letter within column are not significantly different $p < 0.05$ NS= Not significant

- Number of leaves plant^{-1}:The effect of inoculation and varieties on number of leaves/plant of soybean at 6, 9 and 12 WAS was presented in Table 3. The effect of inoculation on number of leaves only manifested at 6WAS. Inoculated plants produced significantly higher number of leaves than un-inoculated plants. There were no significant differences in both 9 and 12 WAS periods of measurement. Similar trend was observed with the effect of variety on the number of leaves per plant at 6 WAS. Significantly ($P<0.05$) higher number of leaves were produced by TGX 1951–3E, but at par with TGX 1935 – 3F while SC–SAGA produced the lowest but also at par with TGX 1835–10E. There were no significant differences between the two (9 and 12WAS) periods of measurement. The effect of inoculation x variety interaction on number of leaves was also not significant.

Table 3: Effect of inoculation and variety on number of leaves of soybean

Treatments	Number of leaves (plant^{-1})		
	6 WAS	**9 WAS**	**12 WAS**
Inoculation (I)			
With	40.75a	114.04	138.55
Without	38.65b	108.13	133.61
SE ±	0.79	8.66	8.78

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Varieties (V)			
TGX 1835-10E	38.450bc	92.41	116.50
TGX 1904-6F	40.025bc	104.46	128.84
TGX 1935-3F	44.600ab	115.41	141.50
TGX 1951-3E	56.388a	139.12	162.63
TGX 1448-2E	42.388bc	134.63	162.50
TGX 1955-4F	35.712bc	114.13	116.63
TGX 1485-1D	42.650bc	110.41	136.91
TGX 1987-62F	33.175bc	95.65	118.09
TGX 1945	33.625bc	107.50	131.50
SC-SAGA	31.050c	95.19	118.21
SE ±	5.83	17.42	18.30
Interaction			
I x V	NS	NS	NS

Means followed by the same letter within column are not significantly different $p < 0.05$ NS= not significant

- Yield and Yield Components. The effects of inoculation and varieties on shoot weight (t ha^{-1}), 100 seed weight (g) and grain yield (t ha^{-1}) of soybean varieties are presented in Table 4. The effect of inoculation on shoot weight was not significant ($P > 0.05$). Significant ($P < 0.05$) differences in 100 seed weight and grain yield between inoculated and un-inoculated plants were observed, with inoculated plants producing heavier seeds and higher grain yield (t ha^{-1}) compared to un-inoculated. There were significant ($P < 0.05$) differences between varieties on all the yield attributes measured, with more shoot produced by TGX 1935–3F that was statistically at par with TGX 1987–62F. Lighter shoot biomass was significantly produced by SC–SAGA but statistically comparable with TGX 1945 in both fresh and dry state. Heavier 100 seeds were produced by SC–SAGA while TGX 1904–6F produced significantly lighter 100 seeds. TGX 1448-2E produced significantly ($P < 0.05$) higher grain yield (t ha^{-1}) but at par with TGX 1835–10E, while least was produced by SC-SAGA. Interaction effect between inoculation and variety on 100 seeds was not significant ($P > 0.05$).

Table 4: Effects of Inoculation and variety on yields of soybean

Treatments	Shoot weight (t ha^{-1})		100-Seed weight	Grain yield
	Fresh	Dry	(g)	(t ha^{-1})
Inoculation				
With	12.29a	3.80a	179.15a	0.888a
Without	11.37a	3.55a	137.66b	0.641b
SE ±	0.37	0.16	0.17	0.35
Varieties (V)				
TGX 1835-10E	11.80cd	3.92ab	12.50b	0.930ab
TGX 1904-6F	12.34bcd	3.83ab	8.95f	0.904ab

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International Journal of AdvancedResearch in Science, Engineering and Technology
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TGX 1935-3F	14.15a	4.24a	10.48de	0.921ab
TGX 1951-3E	11.33d	3.61b	11.19cd	0.722c
TGX 1448-2E	13.24abc	4.00ab	9.25de	0.958a
TGX 1955-4F	11.0d	3.56b	10.37de	0.786bc
TGX 1485-1D	12.02cd	3.91ab	11.59c	0.699cd
TGX 1987-62F	13.87abc	4.11a	10.66de	0.819abc
TGX 1945	9.29e	3.02c	10.09e	0.537de
SC-SAGA	9.25e	2.89c	16.90a	0.388e
SE ±	0.77	0.22	0.14	0.82
Interaction				
I x V	NS	NS	NS	NS

Means followed by the same (s) letter within a treatment column are not significantly different at $P < 0.05$ NS= Not significant.

IV. DISCUSSION

The study revealed that inoculation significantly ($P<0.05$) influenced100 seed weight (g) as well as grain yield (t ha^{-1}) of soybean. Though inoculation did not significantly influenced biomass yield higher biomass was observed with inoculated plant than un-inoculated ones. The reason could probably be attributed to higher rate of nitrogen fixation by inoculated plants, which played a vital role in the vegetative growth of soybean (Islam *et. al*., 2004). Increases in yield due to inoculation have also been reported earlier in similar legume crops such as chickpea (Pareek, 1979), Mungbean (Dubey, 1987) and soybean (Kumar *et. al*; 1996). Kumaga and Ofori (2006) observed significant increase in grain yield due to inoculation of soybean in savanna Acrisol of Legon, Ghana. Higher grain yield due to inoculation was also reported by the findings of Islam *et. al.* (2004).The increase in grain yield under inoculation was significantly higher than yield under un-inoculation, indicating the potential of increasing grain yield of promiscuous varieties through inoculation with effective and competitive *Bradyrhizobium* (Kumaga and Afori, 2006). Njira*et. al.* (2013) reported that grain yield of inoculated soybean was higher as compared to the un-inoculated soybean in his work conducted, in five sites of Kasungu of central Malawi. Data on yield and other studied characters of the different varieties varied significantly. Mishra and Vyas (1992) reported variation among three varieties of soybean. Significant variations among the ten varieties were observed on all the measured attributes. Among the varieties, TGX 1935-3F, TGX 1987-62F and TGX 1835-10E produced higher grain yield compared to the others as well the local variety. Therefore, it could be confirmed that inoculation enhances the performance of these varieties of soybean.

V. CONCLUSION

Based on the results obtained from this study, it can be concluded that inoculation enhances growth and development of soybean there by increasing yield. The varieties TGX 1935-3F, TGX 1987-62F and TGX 1835-10E performed similar, but better than the other improved and local varieties in terms of grain yield. Inoculation improved yield of most of the soybean varieties. It could be recommended to carry out more studies under different soil types in the same agro ecological zone.

VI. ACKNOWLEDGEMENT

The authors wish to acknowledge the immense contribution of Professor Jibrin M. Jibrin of Bayero University Kano, for inspiring and guiding this work throughout its completion and the support received through N2Africa project funded by The Bill & Melinda Gates Foundation.

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