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(Research Article)

Response of groundnut (*Arachis hypogea*) to rhizobia inoculation, mineral nitrogen and inoculation amendment at the two agro ecological zones of northern Nigerian savannah

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Abstract

Nitrogen is the most limiting major nutrient required by all living plants. Nitrogen fertilizer is costly and too much application of nitrogen causes detrimental effects to our ecosystem. Alternatively, the use of commercial microbial inoculants will be an alternative to chemical fertilizer for the small holder farmers in northern Nigeria. Groundnut (pea nut) was selected as a test crop for the inoculation. The experiment was conducted at Sudan savannah in Kano State and Guinea savannah in Bauchi state of Nigeria during the 2016 cropping season. The design of the experiment was RCBD with seven treatments and four replications in each site. Two rhizobia inoculants were tested on groundnut in two agroecological zones of northern Nigeria to monitor their performance and their ability to establish symbiotic and nodulate the crops. The treatments combinations were; histic, biofix, nitrogen, cattle manure, histic + cattle manure, biofix + cattle manure and control. In the groundnut field, Biofix produced higher nitrogen fixed than all treatments in the Sudan savanna, while in the Guinea savanna no significant differences (P = 0.67) were observed between the treatments and the control. However, inoculated plots had higher nitrogen fixation than the control.

Keywords: Biological nitrogen fixation; Rhizobium; Inoculants; Grain uptake; Groundnut

1. Introduction

Groundnut (*Arachis hypogaea* L.) or peanut is one of the important legume crops of tropical and semi-arid tropical countries of the world, where it supplies edible oil and vegetable protein [18]. The productivity of groundnuts varies from 3500 kg/ha in the United States of America to 2500 kg/ha in South America, 1600 kg/ha in Asia and less than 800 kg/ha in Africa. According to V. Prasad et.al., [18] groundnut yields in Africa are lower compared to the average world yields. In Nigeria average yield are much lower (0.6-0.7 tons/ha.), and this is a serious challenge in the African farming system [18]. Groundnut is an annual crop which grows best in light textured sandy loam soils with neutral pH. Best temperature for their growth and development ranges from 28 to 30 ºC and the crop requires rainfall of about 500-600 mm. The main yield limiting factors in semiarid regions are drought and high temperature stress [2]. There were low literatures on groundnut inoculation as compared to soybean. However, inoculation of groundnut seed with right rhizobia could enhance nitrogen fixation [2].

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This research aimed at testing the effectiveness of microbial inoculants on groundnut as well as subjecting it to various treatments to monitor their response and yield performance in the Sudan and Guinea Savanna Agro ecological zones of Northern Nigeria.

2. Material and methods

2.1. Study site and soil characteristics

The research was conducted at 2 locations: Kano University Science and Technology Research farm at Bagauda (Sudan savannah) located latitude 11° 37. 409' N and longitude 08° 22. 994' E, altitude 481 meters (or about 1580 feet) above sea level and Abubakar Tafawa Balewa University Research farm at Gubi (Guinea savanna) located latitude 10°27.985' N and longitude 9°49.768' E. The area is situated at about 666.5 m above sea level. The study was conducted during 2016 cropping season.

Initial soil sample was done by collecting twelve core soil samples from depth of 0-15 cm from each block from the two experimental sites following a 'W' design before planting. Composite sample was obtained after careful mix of the soil and then air dried before sieving through a 2 mm mesh sieve. The collected samples were levelled and packed in a clean polythene bags before being taken to the laboratory for selected chemical and physical analyses. Particle size distribution of soil sampled was determined using the Bouyoucos hydrometer method [1]. Soil pH was determined according to U V Satpute et.al. [8]. The modified Walkey and Black procedure as described by EV Tairo et.al [9] was used to determine organic carbon. The method involved chemical or wet oxidation then followed by the measurement of expelled CO_2. Soil total nitrogen content was determined using the Macro - kjeldahl method. The method involved digestion, distillation and titration as described by B Chinthapalli et.al. [10]. Available phosphorus was determined through Bray No 1 method to extract the readily acid soluble forms of phosphorus from the soil as described by SU Asawalam et.al. [11]. Exchangeable bases (K, Ca, Mg and Na) were determined by 1.0 M ammonium acetate (NH4OAc) extract. The exchangeable acidity was determined using titration method as described by AL Page et.al, [12].

2.2. Experimental layout

Field experiment were carried out in two agro ecological zones of Nigerian savannas Bagauda (Sudan savannah) in Kano and Gubi (Guinea savannah) in Bauchi States of Nigeria in 2015 cropping season. The design of the experiment was Randomized complete block design (RCBD) replicated four times. Land preparations were done before planting the seeds. After clearing and land preparations, experimental plots were demarcated. Plot size was 4 by 4.5m. There were seven treatments replicated four times. Soybean crop were used for the experiment. The major nutrient uptake was determined in each plot. BNF was also computed for each plot using N difference method. Maize was used as a reference crop for estimating the BNF in kg ha^{-1} using N difference method.

The parameters measured were N, P and K uptake for soybean and BNF. The formulas used during computation were as follows:

$$\text{N, P, K uptake}\,\frac{\text{kg}}{\text{ha}} = \text{dry matter}\,\frac{\text{kg}}{\text{ha}} \times \frac{\%\,\text{N,P,K}}{100} \text{......[13].}$$

$$\text{BNF}\,\frac{\text{kg}}{\text{ha}} = \text{ N uptake in Legumes} - \text{ N uptake reference Crop ....[14].}$$

2.3. Analysis of cattle manure

Cattle manure was analyzed in the laboratory for N, P, K, Mg and OC using standard protocols. Lignin and polyphenol was determined using protocol ascribed to [15].

Calculation:

$$\text{Polyphenol (mg kg} - 1) = \text{graph reading} \times \text{dilution of aliquot} \times \text{dilution of sample}$$

Where:

$$\text{Sample dilution} = \frac{final\ volume\ of\ sample}{weight} = 50/1\ [15]$$

3. Results

3.1. Chemical analysis of cattle manure

Analysis of the lignin and polyphenol contents of the cattle manure used revealed that the contents of these two important parameters were within the safe limit as could be seen in (Table 1). Lignin content was 10.73% and the polyphenol was 2.97%. It was opined by [11] that organic materials having lignin and polyphenol contents of< 15% and < 4% respectively could be used as soil amendments.

Table 1 Chemical analysis of cattle manure

Parameters	Lignin polyphenol (%)		pH	N	P(%)	K	C	C/N ratio	Fe (mgkg-1)	Mn
Values	10.73	2.97	7.1	1.35	0.48	0.73	26.95	19.96	2.82	1.27

3.2. Grain N uptake of groundnut at Sudan and Guinea savannahs

Figure 1 shows results of grain N uptake of groundnut in the Sudan and Guinea savanna agro-ecological zones. In the Sudan savanna, no significant differences were observed among the treatments. However, increases in uptake of 23, 7 and 6 % over the control were observed in Biofix, Biofix + cattle manure and Histick, respectively. Similarly, results in the Guinea savanna did not show any significant differences (P = 0.79) among the treatments.

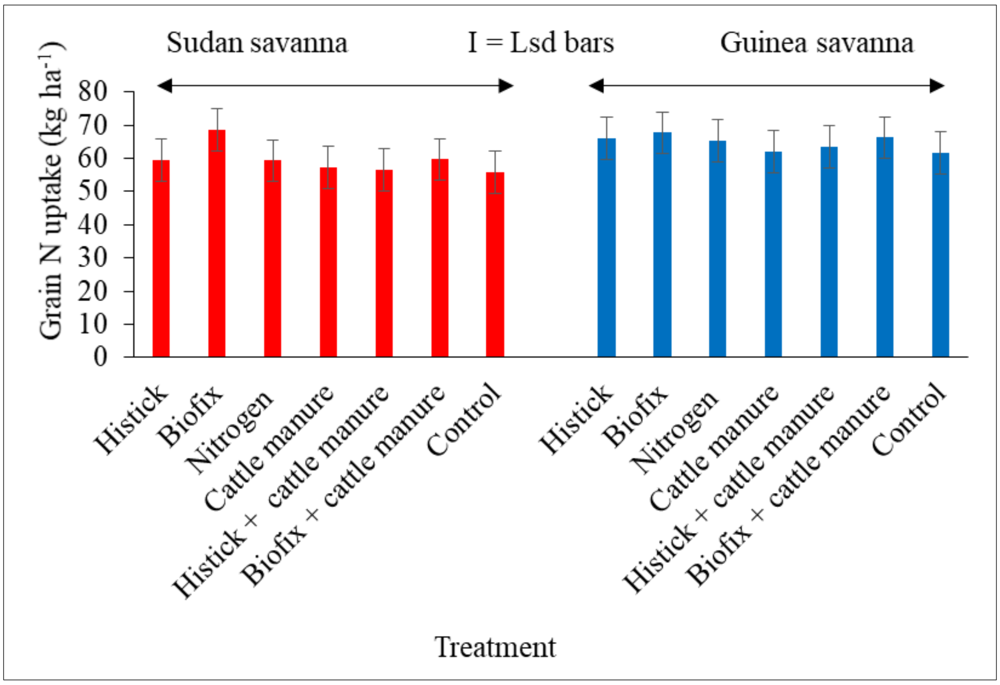

Figure 1 Grain N uptake of groundnut in the Sudan and Guinea savanna agro-ecologies

3.3. Grain P uptake of groundnut in the Sudan and Guinea savanna agro-ecologies

Figure 2 shows the results for grain P uptake of groundnut. In the Sudan savanna, significant differences existed among the treatments (P = 0.001). Biofix gave the highest grain P uptake (6.99 kg ha^{-1}) which was significantly different from the control. All other treatments were statistically at par. In the Guinea savanna zone, the results showed significant differences (P= 0.029) among the treatments. The control produced the least P uptake (5.28 kg ha^{-1}) while Biofix produced the highest uptake (7.32 kg ha^{-1}).

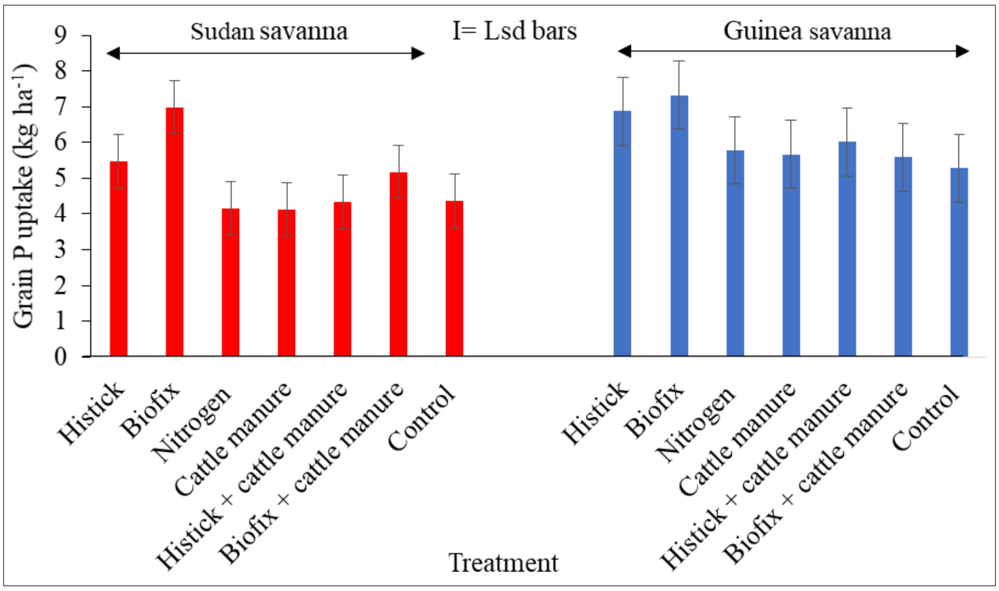

Figure 2 Grain P uptake of groundnut in the Sudan and Guinea savanna agro-ecologies

3.4. Grain K uptake of groundnut in the Sudan and Guinea savanna zones

Figure 3 shows the results of grain K uptake for groundnut. In the Sudan savanna, significant differences occurred among the treatments (P ≤0.001). Biofix enhanced the highest K uptake (22.48 kg ha^{-1}) which was not significantly different from that of Histick, 50 kg N ha^{-1}, and Biofix = cattle manure. No significant differences between Histick, cattle manure, Histick + cattle manure and the control were observed. Furthermore, in the Guinea savanna zone, grain K uptake did not show any significant differences among the treatments (P = 0.14). However, increase of 19 and 13 % over the control were observed for Histick and Biofix, respectively.

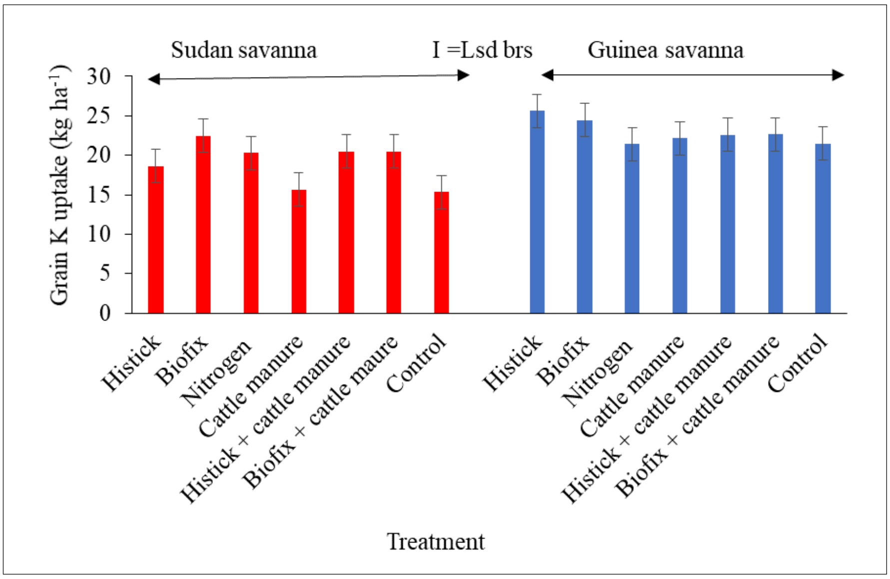

Figure 3 Grain K uptake of groundnut in the Sudan and Guinea savanna agro-ecologies

3.5. Nitrogen fixation in groundnut in the Sudan and Guinea savanna zones

The highest nitrogen fixed (11.58 kg ha^{-1}) was observed under Biofix whilst the least (7.41 kg ha^{-1}) was observed under cattle manure (Table 2).

Biofix, Biofix + cattle manure and control were statistically similar in N fixed. In the Guinea savanna, there was no significant differences.

Table 2 Nitrogen fixation in groundnut

Treatments	Nitrogen fixation (kg ha^{-1})	
	Sudan savanna	**Guinea savanna**
Histick	10.12 ^{ab}	16.95 ^{a}
Biofix	11.58 ^{a}	16.80 ^{a}
Nitrogen*	7.76 ^{c}	15.35 ^{a}
Cattle manure**	7.41 ^{c}	15.50 ^{a}
Histick + cattle manure	8.59 ^{bc}	15.85 ^{a}
Biofix + cattle manure	10.08 ^{ab}	15.33 ^{a}
Control	9.90 ^{ab}	14.40 ^{a}
F pr.	<0.006	0.67
CV (%)	15.0	13.7

*Nitrogen = 50 kg N ha^{-1}; **Cattle manure = 4 tonnes ha^{-1}; Means with same letters in same Column are not significantly different at 5%.
*Means in the same column with the same superscript are not significantly different (P≥0.05).

4. Discussion

Result of chemical analysis of cattle manure (Table 1), showed that lignin and polyphenol contents of 10.73% and 2.97%, respectively This gives an indication that the manure that was used was a good quality material. It was opined by MA Laditi [16] that organic materials having the contents of lignin and polyphenol < 15% and < 4% respectively could be used as soil amendments. The lignin content of the cattle manure corroborates with what A Opoku [17] found (10.1 %) in cattle manure while working at Maradi (Niger). The level of N fixation was also high in treated plots when compared to control. Even though not significant.

The low performance of inoculants in Guinea savanna and Sudan savanna may be due to the presence of native competitive strains of rhizobia. One of the reasons behind failure of successful inoculation with efficient rhizobia is the competition for nodule occupancy postured by native rhizobia [4]. Organic manure with lignin and phelophenol contents of 10 – 15% and 3 – 4%, respectively have been reported to be of good quality [3]. This could be a good reason for better uptake of N in combine treatments of inoculants and cattle manure than the control which gives least values in all the locations. For the P uptake it as observed. In the Sudan savanna, groundnut inoculation with Biofix gave the highest P uptake. In the Guinea savanna zone, groundnut responded to inoculation. Biofix gave the highest uptake followed by Histick. This corroborates the earlier finding of A Belachew et.al. [5] who reported increased P uptake following inoculation of peanut. In groundnut field at the Guinea savanna, there were no significant differences in grain potassium uptake among the observed treatments. This is contrary to the findings by Eutropia V et.al. [7] who reported effective rhizobia strains enhanced the growth and grain uptake of K and some macronutrients in soybean.

5. Conclusion

It was concluded that Biofix inoculant performed better than Histick in most of the growth and yield parameters measured. Combined application of inoculants with cattle manure proved in yield enhancement in both soybean and groundnut plots when compared to sole application of cattle manure in both locations.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare that they have no competing interests with regard to this publication.

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