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YIELD RESPONSE OF COWPEA (*VIGNA UNGUICULATA (L.) WALP*) RESPONSE TO BIO–FERTILIZER (*IFE BRADYRHIZOBIUM*) IN THE DRY SUB–HUMID AND SUB –HUMID AGROECOLOGICAL ZONES OF NIGERIA

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Abstract

Leguminous crops such as cowpea, groundnut and soybean have the ability to fix atmospheric nitrogen in association with rhizobia bacteria, thereby increasing soil fertility and consequently improved crop yield. On–farm evaluation of the response of cowpea to Ife Bradyrhizobium strain 9 inoculant was established at Special Programme for Food Security (SPFS) sites in five cowpea–growing states of Northern Nigeria (Kogi, Katsina, Nasarawa, Niger and Bauchi) during the 2004 cropping season. The demonstration consisted of two treatments T_1 (Zero Bradyrhizobium inoculant) and T_2 (Bradyrhizobium inoculant at the rate of one cupful for 25 kg seed). The treatment effect was evaluated on a 0.25 ha gross plot size and 35 x 35 m sub–plot with an improved cowpea variety (IT93K–277–2) as the test crop. Single Super Phosphate fertilizer was applied to both plots basally at the rate of 40 kg P_2O_5 ha^{-1}. Average of ten (10) farmers participated per state. The results obtained showed that crop response to the Bradyrhizobium inoculant was positive and highly significant ($P < 0.001$) in three sites (Osara, Aricha and Doma), positive but not significant in three sites (Karmo, Aiyetoro and Boto) and negative in three sites (Agbaduma, Piro and Wabu). The average percentage yield increase between inoculated and un–inoculated plots was about 25 % in the four states.

Keyword: *Bradyrhizobium* innoculum, cowpea, Biological Nitrogen Fixation (BNF)

INTRODUCTION

Soil fertility is closely linked to productivity and is a function of individual soil variables (inherent and influenced). There is a belief that soil fertility is declining in Nigeria as evidenced by appearance of widespread distribution of soil deficiencies in major macronutrients and micronutrients ascertained from commensurate crop responses and soil test analyses (Mbagwu & Obi, 2003). Emerging evidence points to the fact that a reversal of soil fertility decline requires the adoption of Integrated Nutrient Management (INM) as a pragmatic and feasible approach to overcome the limitations of past research approaches (Franzluebbers *et al*., 1998). As a holistic approach to soil fertility management, INM embraces responses to the full range of driving factors and consequences, namely biological, physical, chemical, social, economic and political aspects of soil fertility decline. The approach also addresses nutrient deficiencies; inappropriate germplasm and cropping system design; pest disease interaction with soil fertility; linkage between land degradation and poverty and global policies; incentives as well as the role of institutions in soil fertility management (Bationo, 2003).

In the quest to address declining soil fertility, grain legumes have often been proposed in INM strategies principally due to their supply of nitrogen through Biological Nitrogen Fixation (BNF) processes (Sanchez *et al*., 1997). Although the magnitude of BNF is methodologically difficult to quantify, overall estimates are in the order of 25 to 100 kg N ha^{-1} / crop for grain legumes (Giller & Wilson, 1991). Besides nitrogen fixation, grain legumes such as cowpea (*Vigna unguiculata*), plays a paramount role in human nutrition and market economies in rural and urban areas of Nigeria. In furtherance of the effort to promote improved soil fertility, higher cowpea yield and increased protein intake, the Soil Fertility Initiative (SFI) introduced the use of *Bradyrhizobium* inoculant for cowpea production to SPFS farmers through on farm demonstration. The objective of this study was to evaluate the response of improved cowpea variety to *Rhizobium* inoculation at nine Special Programme for Food Security (SPFS) sites.

MATERIALS AND METHODS

The on farm demonstration trials were established at SPFS sites in five cowpea–growing states of Northern Nigeria (Kogi, Katsina, Nasarawa, Niger, and Bauchi) during the 2004 cropping season (Table 1). The trial consisted of two treatments T_1 (Zero *Bradyrhizobium* inoculant) and T_2 (*Ife Bradyrhizobium strain 9* inoculant at the rate of one cupful for 25 kg seed (Odeyemi *et al.*, 1982). The treatment effect was evaluated on a 0.25 ha gross plot size and 35 x 35 m sub–plot with an improved cowpea variety (IT93K–277–2) as the test crop. Single Super Phosphate fertilizer was applied to both plots basally at the rate of 40 kg P_2O_5 ha^{-1}. Average of ten (10) farmers participated per state. The seeds were moistened with small quantity of water and the *Rhizobium* inoculant applied; the mixture was thoroughly mixed until all seeds were well coated with the inoculant. The seeds were then spread on polythene bag under shade to air dry for ten (10) minutes before sowing. The un–inoculated seeds were moistened with water and air dried for ten minutes and sown. The demonstrations were planted at 30 cm within row and 75 cm between row spacing; three seeds per hill were sown and later thinned to two plants per stand ten days after planting. Weeds were controlled through manual hoe weeding, while insect pest were controlled through regular spraying of insecticide (Karate). Soil samples were taken for routine analysis before planting and after harvest. Yield parameters (grain) were estimated from a 25 m^2 net plot. Data collected were pooled across demonstration sites, individual farmers plots were treated as replicates per site. Statistical analysis of the data collected was performed using Analysis of Variance (Anova) and the means were separated using LSD ($p = 0.05$).

RESULTS AND DISCUSSION

The physico–chemical characteristics of the study areas are shown in Table 1. The textural class of the demonstration sites ranges from sandy (Aiyetoro, Osara and Agbaduma) to sandy clay loam (Doma) to sandy loam (Aricha and Koma) to loamy sand (Boto, Wabu, and Piro) and loam for Kutemishi. Soil reaction also ranges from strongly acid (Kutemishi, Aiyetoro, Osara and Agbaduma), to moderately acid (Aricha and Koma), and slightly acid (Doma, Boto, Wabu and Piro). Nitrogen content of the study areas was generally low (0.051 %) Organic carbon of the soils varied from very low (Boto) to low (Wabu, Piro, Doma, Aricha, Koma and Kutemishi) to high (Agbaduma and Osara) and very high (Aiyetoro).

Response of cowpea to *Rhizobium* inoculation

The effect of application of *Ife Bradyrhizobium strain 9* inoculation on the yield of improved cowpea variety (IT 90K–2–77–2) is shown in Table 2. Responses of cowpea to *Rhizobium* inoculation were site specific, this was however not surprising, because *Rhizobium* growth, population and activities in the soil are directly dependent on a number of factors, such as soil temperature, soil moisture (Diatloff, 1970; Bushby & Marshall, 1977; Horowitz, 1979; Sanchez, 1976), macro and micro nutrients (Munns, 1977; Smith, 1982), especially extractable phosphorous /or potassium (Amijee & Giller, 1998), molybdenum and soil pH (Brick, 2004).

Treatment of cowpea seeds with *Rhizobuim* inoculum produced a significant ($p < 0.001$) yield advantage of 197.3 kg/ha representing 54.8% increase over 360 kg/ha recorded for uninoculated plots at Osara site, Kogi state. Similar trend were also observed at Doma and Aricha sites in Nasarawa state, where *Rhizobium* innoculum also gave significant ($p < 0.001$) yield advantages of 44.0 % and 23.03 % respectively. Similar positive yield responses were also observed for inoculated common bean (Vessey, 2004). The improved yield observed in rhizobium treated plots may be attributed to increased atmospheric nitrogen fixation brought about by improved nodulation as a result of seed inoculation with *Rhizobium*. Higher but non–significant yield were also observed for inoculated plots at Karmo, Aiyetoro and Boto sites (Table 2). However, yield depressions were observed at Agbaduma, Piro and Wabu. There are various reasons that might be attributed for a lack of response to *Rhizobium* inoculation. Probably the most common reason is lack of non–N limiting conditions due to high mineral N levels in the soil (not in this case, Table 1).

Table 1: Physico–chemical properties of the demonstration sites

Sites/ Properties	Boto	Wabu	Piro	Doma	Aricha	Koma	Kutemishi	Aiyetoro	Osara	Agbaduma
Sand (%)	85.99	84.07	85.90	69.00	71.94	67.00	37.00	89.10	86.54	88.83
Silt (%)	7.80	13.01	8.62	10.00	16.25	13.00	42.00	8.03	10.56	9.27
Clay (%)	6.26	3.17	3.86	21.00	11.81	20.00	21.00	2.87	2.90	1.91
Textural class	**Loamy sand**	**Loamy sand**	**Loamy sand**	**Sandy clay loam**	**Sandy loam**	**Sandy loam**	**Loam**	**Sand**	**Sand**	**Sand**
Latitude	9.75	12	10.85	9.38	8.92	8.38	–	8.1	7.68	–
Longitude	9.56	10.65	10.16	9.35	8.38	7.19	–	6	6.4	–
PH (H_2O)	7.27	7.51	7.43	6.50	5.78	5.67	5.30	5.34	5.49	5.36
OC (g/Kg)	3.7	4.5	4.4	7.1	6.6	5.8	7.2	24.9	19.6	14.3
Total N (%)	0.04	0.04	0.05	0.06	0.06	0.05	0.09	0.04	0.05	0.03
Av P (mg/kg)	12.32	10.67	12.48	13.88	10.43	10.77	10.08	2.95	5.27	5.28
Exchangeable bases (cmol/kg)										
Ca	1.90	1.55	1.94	3.33	3.28	3.91	4.35	3.07	3.53	2.43
Mg	2.01	2.27	1.89	0.54	0.79	0.85	1.80	0.80	1.00	0.60
K	0.34	0.26	0.33	0.56	0.37	0.31	0.50	0.14	0.11	0.20
Na	0.14	0.14	0.17	0.42	0.47	0.42	0.35	0.12	0.10	0.11

Table 2: Yield response of cowpea (*Vigna unguiculata*) to *Rhizobium* innoculant in nine demonstration sites

Demonsration sites	Doma	Aricha	Karmo	Aiyetoro	Osara	Agbaduma	Boto	Piro	Wabu	Mean
Treatment										
Uninnoculated	422^{b}	508^{b}	753.7^{a}	389.6^{a}	360^{b}	600^{a}	476^{a}	236.6^{a}	408^{a}	461.5^{a}
Rhizobium Innoculant	608^{a}	625.5^{a}	765.6^{a}	428.5^{a}	557.3^{a}	530.7^{a}	526^{a}	102.8^{b}	296.5^{b}	493.4^{a}
Mean	515.0	566.8	759.7	409.1	458.7	565.4	501.0	169.7	352.3	
LSD										
Treatment	34.56^{ns}									
Site	73.32***									
Treatment X site	103.69***									
CV %	3.1									

*** Significance at $p < 0.001$; means followed by different letters are statistically different. (LSD 5 %)

Alternatively, other factors (e.g., drought stress, hypoxia, phosphorus limitations, disease) may be more limiting to growth than N (Bacanamwo & Purcell, 1999; Bremer *et al*., 1988; Carranca, *et al*., 1999; Purcell & King. 1996). It is also possible that the endemic soil population of *Rhizobia* is sufficient in concentration and effectiveness to maximize nodulation and N_2 fixation in the grain legume (Vessey, 2004). However, even where yield responses are not evident, inoculation may still have benefits by increasing seed N levels and N levels in plant residues (McKenzie *et al*., 2001).

CONCLUSION

This demonstration revealed that inoculation of legume crops with *Rhizobium* can increase the legume yield as much as 54 %, although the responses were site specific, due to the fact that *Rhizobium* innoculum is very sensitive to soil conditions, such as low level phosphorus, low pH (although not the case with Wabu and Piro) and some micronutrient deficiency among other factors. It is therefore imperative to maintain proper soil fertility in order to ensure proper nodulation and nitrogen fixation. However, given the modest cost of inoculation compared to the potential agronomic and economic benefits, farmers are encouraged to inoculate their legume crops in all circumstances.

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