Evaluation of Seven Elite Rhizobial Inoculants on It99k5731-1 Cowpea Variety in Soils of Minna Niger State of Nigeria

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Abstract— *Cowpea (Vigna unguiculataL. Walp) is an important source of dietary protein for man, animals and improves soil fertility through biological nitrogen fixation. However, its production potential is limited by a number of factors, one which may be low availability of Nitrogen in the soil which could partly be due to the inadequate numbers of effective rhizobial strains in some soils to fix the required nitrogen. Evaluation of seven rhizobial strains was carried out on yield and yield parameters of cowpea variety IT99K573-1-1 during the cropping season. Prior to the commencement of the trial, soil samples were collected (0 -15cm^2) from each filed and processed for routine soil analysis. The field trials were conducted in Randomized Complete Block Design (RCBD) with nine treatments replicated at five different locations in Minna. Each of the treatment plots was 36m^2 consisting of six manually made ridges of 6m long and an inter-ridge spacing of 80cm. The treatments were; control (no inoculation nor N fertilizer), 60kgNha^{-1}, rhizobial inoculants strains 2NAG53e, 2NAG91a, 2NAG9d, 2NAG5261, CB756 (ref), BR3262(ref) and BR3267(ref). Cowpea seeds were mixed with the inoculants as treatment at planting. All plots received a dose of 30kgPha^{-1} (as Single Super Phosphate) at planting. Destructive sampling was done at 50% flowering to obtain data on number of nodules, nodules dry weight and shoot dry weight. Data was collected for Pod load, pod weight, 100 seed weight, and grain yield at full maturity. From the fertility and suitability rating all the fields had one or two limiting factor for crop production. There was a significant difference between 2NAG5261and the 60kgNha^{-1} treatment but all treatments were not significantly different from the control in terms of number of nodules. However, there was no significant difference at (P<0.05) in all inoculated plants, urea fertilized plants and the control. Statistically, there was also, no significant difference at (P<0.05) in all inoculated plants, urea fertilized plants and the control in terms of nodule dry weight. There was a significant different (P<0.05) between strain 2NAG9d and BR3267(ref) but there was no significant different between the control and all the inoculated plants in shoot dry weight. Higher mean value obtained from plants treated with 2NAG9d, indicated percentage increase in shoot dry weight but was not significantly different from the control and the urea supplied plants. Means of statistical analysis indicated no significant difference (P<0.05) for pod weight per plant among all the treatments and the control. The 60kgNha^1 treatments, rhizobia strains CB756(ref), 2NAG91a 2NAG53e, and 2NAG9d gave the highest mean values of (1067.2kg, 883.9kg, 878.9kg, 832.8kg and 819.4kg) respectively which were more than the control that had a mean value of 769.4kg. Statistically, there was no significant difference between the control and other treatments. There was no response to inoculation in terms number of nodules, nodules dry weight, shoot dry weight, pod weight per plant, pod weight per kilogram per hectare, one hundred seed weight and total grain yield of IT99K-573-1-1 cowpea variety. The evaluation of these inoculants should also be conducted using other cowpea varieties and other legumes in other places outside Minna in order to capture the differences that may exist in physical, chemical and biological properties of soils because inability of cowpea to respond to inoculation could be attributed not only to the crop variety but also environmental conditions and can be site specific.*

Keywords— Cowpea (IT99K573-1-1), Rhizobial inoculants, Biological nitrogen fixation, Nodulation, Shoot dry weight, Grain yield, Soil fertility, Minna (Niger State), Symbiotic effectiveness, Legume–rhizobia interaction.

I. INTRODUCTION

Cowpea is a very important leguminous crop which serves as a major source of protein for man and his livestock in developing countries like Nigeria and even some developed countries (Singh 2005; Langyintuo *et al*., 2003). It is one of the legume crops commonly sown in rotation with both cereals and tubers to replenish nitrogen content of soil, reduces soil erosion and weeds as a cover crop (Sanginga *et al*., 2003).

Despite its environmental and economic contributions to human existence its production in Nigeria and other developing countries is still 50% below its estimated yield potential (FAO 2012). Many researchers and farmers attribute low yield of cowpea to degraded soil fertility, poor agronomic management and inadequate indigenous rhizobial strains in the soil to effectively convert the atmospheric nitrogen in a usable form through a symbiotic relationship between the cowpea and rhizobia. The application of urea fertilizer has many economic limitations but cowpea has the ability under favorable conditions to derive 65% to 70% accumulated nitrogen from biological nitrogen fixation (Jensen, 1997) which can lead to improved shoot biomass and consequently improved yield parameters and total cowpea yield. Many soils however, do not have adequate amount of native rhizobia in terms of quality or effectiveness to enhance biological nitrogen fixation (FAO, 2012). Adler (2008) also suggested that due to the facts that inoculants price is low compared to the potential benefits it provide, farmers should be encourage to inoculate legumes with effective strains. These situations call for the use of inoculants that are symbiotic effective and can enhance cowpea nodulation, growth and yield. Therefore, the objective of this research was to evaluate the effect and symbiotic effectiveness of seven elite rhizobia inoculants on yield and yield parameters of cowpea variety IT99K573-1-1 in Minna, Niger State of Nigeria.

II. MATERIAL AND METHOD

2.1 Study sites:

A field experiment was conducted in Minna, Niger state of Nigeria. Minna lies within the southern Guinea Savanna Zone of Nigeria, (9^0 41N and Longitude 6^0 30E) and has sub-humid tropical climate with a mean annual rainfall of 1200mm (90% of the rainfall is between the month of June and August). The temperature rarely falls below 22^0C and the peak are 40^0 (February to March) and 36^0C (November to December. (Juo, 1998). The experiment was carried out on five farmers' fields within a distance of not less than 20 kilometer apart around Minna. The Fields were located at Gidan Kwano($9^0$31' 589" N and 6^0 26'284" E), Kodoko ($9^0$34' 855" N and 6^0 32' 422" E), Sauka Kahuta (9^0 32' 99" N and 6^0 32' 432" E), Tutungo (9^0 30; 385" N and 6^0 35' 474" E) and Gurusu (9^0 37'917" N and $6^0$38' 877" E)

2.2 Soil Sampling and analysis:

Soil samples were collected at eighteen (18) different points within each field at a depth of 0-15cm. The samples were bulked, thoroughly mixed to form a composite and sub- samples of the composite were taken for routine analysis. Soil samples were air dried and the aggregates were gently crushed and sieved through 2mm and 0.5mm screens for physical and chemical analysis Soil particle size was determined using the boyoucous hydrometer method, Soil pH in H_2O and $CaCl_2$ was determined using glass electrode pH-meter, Walkley and Black method was applied to determine organic matter content, Micro-Kjeldahl digestion procedure was used to determine total Nitrogen, Bray P1 method was applied to determine the available phosphorus, Exchangeable bases (Ca^{2+} Mg^{2+} Na^{+} K^{+}) were extracted with ammonium acetate and determined using Atomic Absorption Spectrophotometer, Exchangeable acidity was extracted with INKCl and determined by titrimeric method, Effective cation exchangeable capacity (ECEC) was obtained by the summation method.

2.3 Field trials:

2.3.1 Land preparation, Experimental design and treatments:

Each of the five farmers' fields used for trial served as replicate. The fields were cleared and ridging was done manually. Each field (replicate) had nine plots, and each plot measured $36m^2$. Each field had a total land area of $324m^2$ ($0.324ha^{-1}$). The treatments were; control (no inoculation nor N fertilizer), $60kgNha^{-1}$, 2NAG53e, 2NAG91a, 2NAG9d, 2NAG5261, CB756(ref), BR3262(ref) and BR3267(ref) strains of bacteria

2.3.2 Planting and crop management:

Cowpea seeds of variety IT99K573-1-1 and all the inoculants were obtained from International Institute of Tropical Agriculture (IITA) Kano substation. The seeds were thoroughly mixed with different inoculants prior to planting. Seeds were planted at rate of four seeds per hole and were later thinned to two plants per stand two weeks after planting. Single Supper Phosphate (SSP) was applied at the time of planting of cowpea in all the plots and fields at the rate of 30kgP_2O_5/ha^{-1}. Manual weeding was done at two and six weeks after planting while combat insecticide was used to control insect pest at 800ml per hectare.

2.4 Data collection and Analysis:

Numbers of nodule were counted at 50% flowering by destructive sampling; nodules dry weight, and shoot dry weight were also weighed. Symbiotic effectiveness (SE) and Response to inoculation were calculated using:

$$\%SE = \frac{DwI}{DWN} * 100 \quad (1)$$

Where DWI= Dry weight of inoculated shoot, where DWN =Dry weight of nitrogen applied plants

Response to inoculation (RI) was calculated using the formula

$$\%RI = \frac{DWI-DWU}{DWU} * 100 \quad (2)$$

Where DWI = Dry Weight of Inoculated shoot, where DWU = Dry Weight of un-inoculated shoot

The data was subjected to statistical analysis using analysis of variance (ANOVA) Statistical Analysis System (SAS) version 9.2 Software (SAS, 2009), while the means were separated using the Least Significant Difference (LSD) at 5% level of probability.

III. RESULTS AND DISCUSSION

Results show that the soil texture in all the five fields is loamy sand. The soil texture was suitable for cowpea cultivation as also, observed by Dugje *et al.* (2009) that loamy sand and sandy loam gives the best yield. All pH results from the farmer fields as shown in table I fall between 6.2 to 7.6 for pH (H_2O) and 5.0 to 5.9 for pH ($Cacl_2$). Fanton *et al*, (1993), and Fanton and Helyar (2007) stated that soil pH from 5.0 to 9.0 is a range for availability of most macro and micro nutrients. Therefore, pH of the soils does not affect the availability of any nutrient element in the soil and the pH range was good for nutrients availability because at this level also most microbes are available for nutrient cycling.

The organic carbon of the five fields ranged from 1.03- 2.507gKg^{-1}.This shows that organic carbon in Gidankwanu, Kodoko, Saukakahuta and Tutungu was moderate, only Gurusu had high amount of carbon with a value of 2.51g/kg as shown in the table below. Moderate amount of organic carbon could be due to high amount of decomposable plants materials in the soil that can sequester carbon. The amount of carbon and nitrogen in an environment will depend on the quantity and quality of plant materials in the soil. This finding contradicts the generalization by Aliyu (2013) who observed low organic carbon and very low total nitrogen as common feature of savanna soil.

Nitrogen was low in Gidankwanu and Gurusu with 0.15g/kg and 0.12g/kg respectively. In kodoko, Saukakahuta and Tutungu available nitrogen was moderate with 0.16g/kg, 0.18g/kg and 0.19g/kg respectively.

Available P was moderate only in Gidankwanu with 9.09mg/kg. P was low in kodoku,Saukakahuta, Tutungu and Gurusu with values ranged from 2.22mg/kg, 5.35mg/kg, 3.82mg/kg and 5.29mg/kg respectively.

The exchangeable cations, Na was high in Gidankwanu, Kodoko, Sauka and Gurusu and moderate in Tutungu, Ca was low in Gidankawnu, Saukakahuta, and Tutungu but moderate in Kodoko and Gurusu. K was high in Kodoko, Saukakahuta and Tutungu while it was very high in Gurusu and moderate in Gidankwanu. Mg moderate in Gidankwanu, Saukakahuta and Tutungu but was high in kodoko and Gurusu with values as shown in the table1 below.

The Effective Cation Exchange Capacity was low in G.k, Suakakahuta and Tutungo moderate in kodoko and Gurusu with 15.5 and 17.5 values respectively as shown in Table 1.

From the fertility and suitability rating all the fields have one or two limiting factor for crop production. Phosphorus is moderate in Gidankwanu while, Na is low Gidankwanu. Fertility rating was done based on soil fertility rating by Esu (1991) and Shehu *et al.* (2015)

TABLE 1

PHYSICAL AND CHEMICAL PROPERTIES OF THE FARMERS' FIELD USED FOR THE TRIAL

Soil parameters	GidanKwano	Kodoko	Saukakahuta	Tutungo	Gurusu
Sand (gKg^{-1})	730	770	770	750	690
Silt (gKg^{-1})	100	100	100	100	140
Clay (gKg^{-1})	170	130	130	150	170
Textural class	LS	LS	LS	LS	LS
pH(H_2O)	6.2	7.61	6.71	6.29	6.48
pH($CaCl_2$)	5.1	5.9	5.4	5.3	5
Organic Carbon (gKg^{-1})	1.32	1.07	1.03	1.71	2.51
Total Nitrogen (gKg^{-1})	0.15	0.16	0.18	0.19	0.12
Available Phosphorus (mg/Kg)	9.09	2.22	5.35	3.82	5.29
Xchangeable cations($cmol^{+}Kg^{-1}$)					
Ca	4.45	6.66	4	4.89	6.66
Mg	2.14	5.92	1.38	2.81	7.32
K	0.52	1.74	1.5	1.01	2.65
Na	1.24	1.15	0.77	0.64	0.73
Exchangeable Acidity	0.2	0.25	0.2	0.2	0.2
ECEC	8.35	15.47	7.65	9.35	17.35

3.1 Number of Nodules (NN):

There was significant difference (P<0.05) between rhizobia strain 2NAG5261, 2NAG53e and 2NAG9d but all treatments were not significantly different from the control in terms of number of nodules. The 2NAG5261treatment gave the highest number of nodules than the control but there was no significant difference between the treatments and the control. There was also a significant difference between 2NAG5261and the $60kgNha^{-1}$ treatment. This shows the promoting and positive impact of effect of this 2NAG5261 nitrogen source treatment over chemical nitrogen application on number of nodules in plants which is agreement with the finding by Manish *et* al (2011). Lack of response to inoculation in terms number of nodules found in other treatments could be attributed to low concentration of phosphorus in the soil or it can also signifies that the population of the indigenous rhizobia was higher and highly competitive than the introduced strains.

3.2 Nodule dry weight (NDW):

Statistically there was no significant difference at (P<0.05) in all inoculated plants, urea fertilized plants and the control. Plants treated with rhizobia strained 2NAG5261produced the highest mean value for number of nodules but could not translate in to the highest nodule dry weight. This is because the numbers of nodule were many but their size was not big to translate into higher weight. This agrees with Chiamaka (2014) which proved that the difference between nodule dry weight of an inoculated plant could be due to the ability of the most effective introduced rhizobia strain to produce bigger size of nodules. Nyoki and Ndakidemi (2014) also attributed the difference between dry weights of nodules obtained from plant inoculated with different rhizobia strain to the size of nodules produced.

3.3 Shoot dry weight (SDW) in gram per plant:

There was a significant different (P<0.05) between strain 2NAG9d and BR3267 (ref) but there was no different between the control and all the inoculated plants. Rhizobia strain 2NAG9d gave a higher mean value of 9.20g while strain BR3267(ref) gave the lowest mean value of 6.73g for SDW in gram per plant. The highest mean values were obtained from rhizobia strains 2NAG9d, $60kgha^{-1}$ treatment, 2NG5261, 2NG91awith mean values of 9.20g, 8.30g 8.21g and 8.05g respectively. Rhizobia strains 2NG53e, CB756(ref), BR3262(ref) and BR3267(ref) gave lowest shoot dry weight (SDW) than the un-inoculated that obtained mean value of 7.796g as shown in Table 2. Higher mean value obtained from plants treated with 2NAG9d, indicated percentage increase but was not significantly different from the control and the urea supplied plants. Aliyu *et al*. (2013)

attributed greater shoot biomass in inoculated plants than un-inoculated plants to high competition between native rhizobia population and the introduced rhizobia strains.

TABLE 2

EFFECT OF VARIOUS N SOURCES ON NUMBER OF NODULES, NODULES DRY WEIGHT AND SHOOT DRY WEIGHT

N Source	Nodule Number (Per plant)	Nodules dry Weight (g/pl^{-1})	Shoot dry weight (g/pl^{-1})
Control	14^{ab}	0.17^{a}	7.79^{ab}
$60kgha^{-1}$	9^{b}	0.14^{a}	8.30^{ab}
2NAG53e	11^{b}	0.28^{a}	7.20^{ab}
2NAG91a	13^{ab}	0.17^{a}	8.05^{ab}
2NAG9d	11^{b}	0.15^{a}	9.20^{a}
CB756(ref)	12^{ab}	0.16^{a}	7.08^{ab}
2NAG5261	17^{a}	0.22^{a}	8.21^{ab}
BR3262(ref)	14^{ab}	0.19^{a}	7.08^{ab}
BR3267(ref)	14^{ab}	0.19^{a}	6.73^{b}
SE±	1.99	0.06	0.84

Means with the same superscript are not significantly different

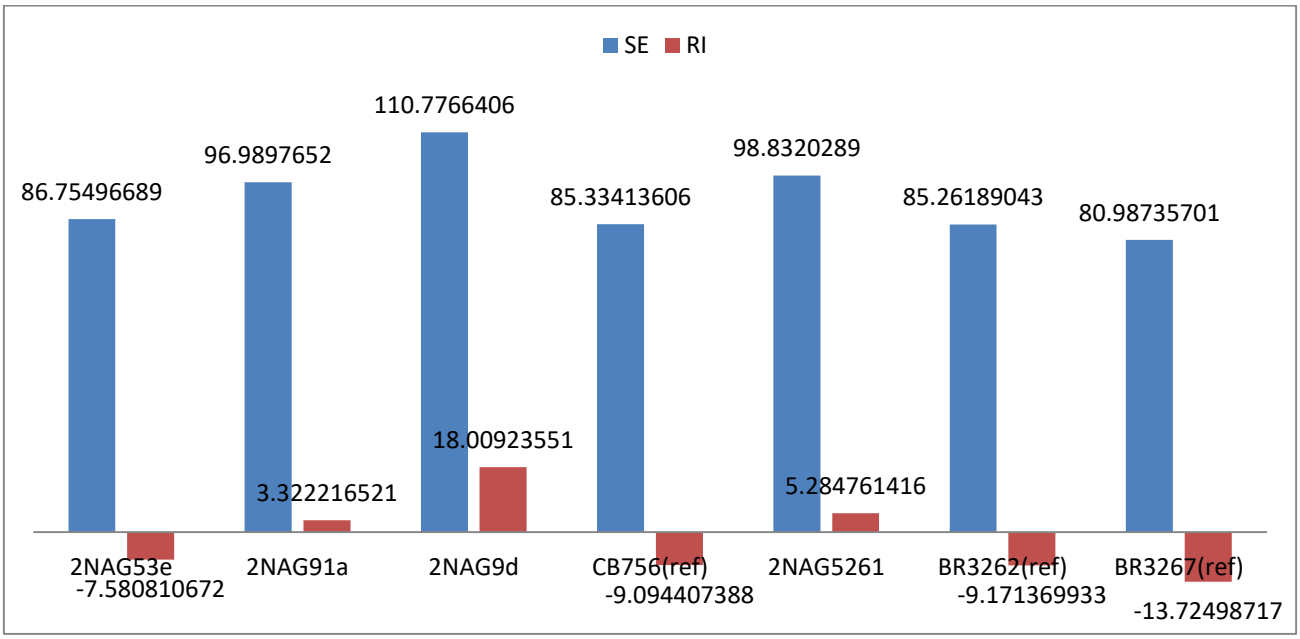

FIGURE 1: Shoot dry weight as a measure of Symbiotic Effectiveness (SE) of seven elite cowpea rhizobia and Response to Inoculation (RI)

3.4 Response to inoculation (RI) and Symbiotic effectiveness (SE) of shoot respectively:

Response to inoculation in IT99K-1-1 cowpea variety was highest in plants treated with 2NAG9d followed by 2NAG5261 and 2NAG91a inoculants with 18.00%, 5.28% and 3.32% respectively with no significant difference. Plants treated with 2NAG53e, CB756(ref), BR3262(ref) and BR3267(ref) inoculants had -7.58%, -9.09%, -9.17% and -13.72% respectively indicating a negative response to inoculation.

The symbiotic effectiveness (%SE) for the inoculants ranges from 80.98% to 110.99%. The plants treated with 2NAG9d had the highest percentage for symbiotic effectiveness followed by plants treated with 2NAG5261 and 2NAG91a rhizobial strains with 110.77%, 98.83% and 96.98% respectively as indicated in (figure1) Plants treated with 2NAG53e, CB756(ref), BR3262(ref) and BR3267(ref) inoculants had 86.75%, 85.33%, 85.26% and 80.98% respectively for symbiotic effectiveness.

Shoot dry weight is mostly considered to indirectly measure symbiotic effectiveness between legumes and the nitrogen fixing bacteria. Symbiotic effectiveness is also an important measure use in evaluating and determining strains for inoculants production and recommendation.

There was no significant difference in response to inoculation of cowpea variety IT99K-1-1 even though, highest values were observed in plants treated with 2NAG9d strain followed by plants treated with 2NAG5261 and 2NAG91a strains with 18%, 5.3% and 3.3% increased respectively as shown in figure 4.1. Plants treated with 2NAG53e, CB756(ref), BR3262(ref) and BR3267(ref) inoculants had -7.58%, -9.09%, -9.17% and -13.72% respectively which indicated a negative response to inoculation as shown in figure 1

Symbiotic effectiveness (SE) obtained from rhizobia strain 2NAG9d was 110.99% which was more than 100%, indicated that the shoot dry weight produced by plants treated with this strain was greater than that of urea supplied plants. This indicated that plants inoculated with this strain obtained more nitrogen than the urea applied plants. This also indicates the level of compatibility between the cowpea variety and the rhizobium strain. There was no response to inoculation at SE 86.75% but there was a proportional increase in response to inoculation from 96% to 110% (SE) This has shown that cowpea variety IT99K573-1-1 responded higher to 2NAG9d strain in terms of shoot biomass. This also means that symbiotic effectiveness of an inoculant has a direct relationship with response to inoculation provided all other environmental conditions and crop management practice are well checked. Low shoot biomass production in some of the inoculated cowpea plant compared to the control could also be a result of low nodule formation that reduced N_2 fixation and consequently reduced rapid plant growth and height. Low growth and shoot height as a result of low nodule formation was also observed by Peoples *et al.*(2001), Yoshioka and Maruyama (1990). Inoculation response was more significant in soils having lower indigenous rhizobia population and fertility (Imran *et al.,* 2015). Several reports by many authors observed that high population size of indigenous rhizobia is a major challenge for inoculant performance under field condition. (Jones *et al*., 1979; Dughri *et al*., 1983; Dudeja and Khurana 1988; Sheoran *et al*., 1997). To have successful inoculation with effective isolate that could result in an enhanced nodultion and growth most of these condition therefore must be in place. Number of available indigenous rhizobia may be insufficient to nodulate the host and the average effectiveness of the indigenous population in the soil has to be inadequate to support the host fixed nitrogen required (Bergersen, 1970). High shoot dry weight observed in 2NAG9d treatment could also be due to late maturity. According to Bidlack *et al*.(2007) late maturing variety accumulate more biomass in vegetative shoot component while early maturing varieties partitioned more photosynthate into reproductive structure.

TABLE 3

EFFECT OF N SOURCES (INOCULANTS) ON YIELD AND YIELD COMPONENTS OF COWPEA

N Sources	Pod load/plant	Pod yield (kgha^{-1})	100 seed wt(g)	Grain yield (kgha^{-1})
Control	4^{a}	769.44^{abc}	21.93^{a}	486.24^{abc}
60kgNha^{-1}	4^{a}	1067.22^{a}	21.83^{a}	643.49^{a}
2NAG53e	5^{a}	832.77^{abc}	21.20^{a}	505.52^{abc}
2NAG91a	5^{a}	878.88^{ab}	16.73^{a}	584.78^{ab}
2NAG9d	5^{a}	819.44^{abc}	17.43^{a}	474.98^{abc}
CB756(ref)	5^{a}	883.88^{ab}	21.19^{a}	630.99^{ab}
2NAG5261	4^{a}	538.33^{c}	17.15^{a}	327.62^{c}
BR3262	4^{a}	600.55^{bc}	17.70^{a}	395.78^{b}
BR3267	5^{a}	703.88^{bc}	16.57^{a}	452.74^{abc}
SE±	0.58	116.93	2.32	84.51

Means with the same superscript are not significantly different.

3.5 Effect of N sources on pod load per plant:

The highest number of pods per plant was obtained from CB756(ref), 2NAG91a, 2NAG53e, 2NAG9d and BR3267(ref) with mean values of 5, 5, 5, 5and 5 respectively as shown in (Table 3) while the lowest number of pods per plant was obtained from rhizobia strain 2NAG5261, control, 60kgNha^{-1} and BR3262(ref)with values of 4, 4, 4 and 4 respectively. Means of statistical

analysis indicated that there was no significant difference (P<0.05) among all the treatments and the control. This is contrary to *Malik et al*. (2006), who reported that when cowpea is inoculated with rhizobia strain, it increase the number of pods per plant as a result of improve growth and high nitrogen nourishment from biological nitrogen fixation. This result is in agreement withYamur and Engin (2004) who reported that inoculation did not affect the number of pod per plant in cowpea

3.6 Effect of N sources on pod weight per kg/ha^{-1}:

The 60kgNha^{1} treatments, rhizobia strains CB756(ref), 2NAG91a 2NAG53e, and 2NAG9d gave the highest mean values of (1067.2kg, 883.9kg, 878.9kg, 832.8kg and 819.4kg) respectively which were more than the control that had a mean value of 769.4kg as shown in (Table 3). 2NAG5261, BR3262 and BR3267(ref) all had lower mean values compared to the control as shown in (Table 4.5) The 60kgNha^{1} applied plants had the highest percentage increase of 38.7% followed by CB756(ref) with 14.9%, 2NAG91a (14.2%) 2NAG53e (8.2%) and 2NAG9d(6.5%) for pod weight/kgha^{-1}. Statistically, there was no significant difference between the control and other treatments. This has proven that inoculation has no significant effect on pod weight. The non significant effect of inoculation could be due to as assumed by Kimiti and Odee (2010) that effective native rhizobia that nodulates cowpea was in abundance in tropical soils and therefore, inoculation was not necessary.

3.7 Effect of inoculation on 100 seed weight per grams among the treatments:

Statistically there was no significant difference (P<0.05) in all the treatments and the control. BR3267 treatment had the lowest one hundred seed weight as shown in table, but was not significantly different from all other treatments. This is contrary to the findings reported by Ali *et al*., (2004) and Kazemi *et al*., (2005) that inoculation with Bradyrhizobia significantly increased one hundred seed weight in legumes.

3.8 Effect of treatment on cowpea yield (Seed weight/kg/ha):

The nitrogen applied plants obtained the highest mean value of 643.49kgha^{-1}which is 32% increase in yield followed by CB756(ref) and 2NAG91awith mean values of 630.99kgha^{-1} (29.7%) increase, 584.78kgha^{-1}(20.3%)increase in yield respectively while 2NAG5261 had 327.62kgha^{-1} which showed no yield increase compare to the control as shown in table 3.

Statistically there was a significant difference (P<0.05) between the nitrogen applied plants and 2NAG5261, BR3267 treatments in terms of grain yield. However, statistically there was no significant difference in cowpea yield between the control that obtained a mean value of 486.24kgha^{-1} and all the inoculants and the nitrogen applied plants. Despite the inoculation of cowpea, the grain yield was not different from the average cowpea yield of 483kg/ha estimated by the food and agriculture organization (FAO) of the united nation. This proved that inoculation of cowpea with these rizobia strains had no effect on cowpea yield and productivity in the study area. This could be due to high population size of ineffective native rhizobia in the soils or the inability of the introduced strains to compete effectively. Based on the result from the sites of trial is obvious that the sites contain very numerous number of native rhizobia capable of modulating cowpea. It could also be that, the introduced Bradyrhizobia were yet to adapt to the new environment, since conditions in the laboratory where they produced and tested was different from the field conditions. The newly inoculated cells take a longer time adapting to the new environment to get use to the new medium (Soil) and the physical conditions and inducing the necessary enzymes for growth before it can compete at the host rhizoplane to occupy a significant proportion in the nodules. Deaker *et al.,* (2004) and Graham (2009) also observed and stated that introduced rhizobia population requires a time period to adapt to the environment and their population size can increase 100 times one year after introduction. In a study by Soares *et al*., (2006) inoculation increased cowpea grain yield from 341kgha^{-1} to 957kgha^{-1}. Also, Zilli *et al*., (2009) reported that inoculation increased cowpea yield from 955kgha^{-1} to 2334kgha^{-1}. In (2011) Costa *et al*., also proved that inoculation of cowpea with effective rhizobia strains increased cowpea yield from 955kgha^{-1} to 1223kgha^{-1}. Contrary to this research, the nitrogen applied plants and the rhizobia strains CB756(ref), 2NAG91a, 2NAG53e applied plants with mean values of 643.49kgha^{-1}, 630.99kgha^{-1}, 584.78kgha^{-1} and 505.52kgha^{-1} respectively as shown in (Table 4.5) obtained higher mean values but were not statistically significantly different from the control. This is also not in agreement with Ulzen *et al*., (2016) that observed significant increase in grain yield of cowpea after inoculation with Bradyrhizobia inoculants. Almeida *et al*., (2010) proved that the application of three inoculants strains separately increased cowpea grain yield by 29 to 50% compared to the uninoculated control. Nyoki and Ndakidemi (2013) attributed increased in grain yield of cowpea due to effectiveness of Bradyrhizobial inoculants in fixing the required nitrogen to meet the nutrient requirement for cowpea. Therefore, the trial of these inoculants contrary to other researches did not show any increase in grain yield of the cowpea variety IT99K-573-1-1 in Minna.

IV. CONCLUSION AND RECOMMENDATION

From the fertility and suitability rating the soil texture and soil pH was suitable for cowpea production and microbes responsible for nutrient cycling. However, each of the fields (replicates) has one or two limiting factor for cowpea production and need more nutrient elements like phosphorus which is very important in nitrogen fixation and absorption.

There was no effect of inoculation in number of nodules, though plants treated with 2NAG5261 had high number of nodules than the plants treated with 60KgNha-^{1} but could not translate in nodules dry weight and grain yield. Shoot dry weight which is mostly considered to indirectly measure symbiotic effectiveness, nitrogen fixation in legumes had shown no statistical difference in all treatments and showed no significant difference in response to inoculation. There was no response to inoculation in terms number of nodules, nodules dry weight, shoot dry weight, pod weight per plant, pod weight per kilogram per hectare, one hundred seed weight and total grain yield of IT99K-573-1-1 cowpea variety.

This work therefore recommends that further trial of these inoculants should be carried out on other varieties of cowpea and other legumes because different varieties may respond differently to each inoculant due to genetic make- up. The evaluation of the these inoculants should also be conducted in other places outside Minna in order to capture the differences that may exist in physical, chemical and biological properties of soils because inability of cowpea to respond to inoculation could be attributed not only to the crop variety but also environmental conditions and can be site specific.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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