VOL. 9, NO. 10, OCTOBER 2014 ISSN 1990-6145
ARPN Journal of Agricultural and Biological Science

www.arpnjournals.com

EFFECT OF BIO-FERTILIZER AND ORGANIC MANURE ON GROWTH AND NUTRIENTS CONTENT OF PEARL MILLET

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ABSTRACT

Field experiment was conducted to study the effect of bio-fertilizer, Arbuscular mycorrhizal fungi (AMF) (*Glomus mossea*) and *Azospirillum brasilense* alone or in combination with cow dung (CD) or poultry manure (PM) on growth of pearl millet. The experiment was laid out in randomized complete block design with six treatments and three replications. Treatments were: T_1 (Control), T_2 (Bio-fertilizer), T_3 (Bio-fertilizer + 5 ton ha^{-1} CD), T_4 (Bio-fertilizer + 2.5 ton ha^{-1} PM), T_5 (10 ton ha^{-1} CD), T_6 (5 ton ha^{-1} PM). Bio-fertilizer and organic manure singly or in combination enhanced plant growth, % root colonization by AM fungi, shoot and root dry biomass and nutrients concentration (N, P and K) compared to control. Bio-fertilizer + PM recorded highest plant performance *viz*; plant height (72.6 cm), number of tillers/plant (4.1), shoots and root dry biomass (8.8 and 3.9 g) followed by bio-fertilizer alone and poultry manure. Applying 10 ton^{-1} of cow dung produced plants with the lowest growth attributes although not a par with control. N and P concentrations varied significantly between all treatments. Bio-fertilizer + PM recorded the highest concentration of N and P, and values were significantly higher than all the treatments. There was no definite trend for K concentration among all treatments. Inoculated and un-inoculated plants were colonized by AM fungi. Inoculated plants were significantly colonized compared to un-inoculated plants. Significant difference in % root colonization was observed between inoculated plants. Bio- fertilizer + PM recorded the highest root colonization of 62% followed by bio-fertilizer alone (56.7%). From the findings of this study, it can be concluded that application of bio-fertilizer and organic manure alone or in combination could improve pearl millet production in low-input agriculture. Results also showed that bio-fertilizer tended to reduce by half the application rates of organic manure. Bio-fertilizer in combination with 2.5 ton ha^{-1} of PM could be recommended for millet production in the study area.

Keywords: bio-fertilizer, cow dung, poultry manure, pearl millet, Arbuscular mycorrhizal fungi (AMF), *Azospirillum brasilense.*

INTRODUCTION

Pearl millet (*Pennisetum glaucum* (L.) is an important grain crop ranking as sixth most important world cereal, (Singh *et al*., 2003; Henry and Kettlewell, 1996), grown, especially in drought-prone semi-arid regions of Africa and Southeast Asia (The Syngenta Foundation for Sustainable Agriculture, 2002; Baltensperger, 2002). The crop is cultivated for its grain and as forage. It grows on low fertility soil with annual mean rainfall of 200 mm, compared to maize and sorghum (Tabosa *et al*., 1999; Ali, 2010). It has low nutrients demand but, could produce appreciable yields with adequate nutrients supply (Bationo and Mokwunye, 1991; Maman *et al*., 2000). Major constraints to crop productivity in several African regions include, low soil organic matter contents, unreliable rainfall and poor soil nutrients availability due to intensive land cultivation coupled with poor soil management techniques. Chemical fertilizers have outstandingly boosted crop yields about three decades back. However, yields are currently getting low or stagnated. Moreover, poor-resource holder farmers in developing countries apply little or no fertilizer due to high cost of procurement. Furthermore, long term and any how applications of chemical fertilizers have caused ecological problems, and degraded soil physico-chemical and biological qualities thereby lead to poor crop yields. In an effort to safe guard the environment, maintain soil as the store house and enhance sustainable crop yields, replacing chemical fertilizer is of paramount importance. In such scenario, bio-fertilizer (microbial inoculants) and organic manure could be recommended.

Bio-fertilizer and organic manure are cheap and eco-friendly source of plant nutrients for sustainable crop production in low-input agriculture. The role of bio-fertilizers alone or in combination with organic or inorganic fertilizers has recently gained recognition in sustainable crop production (Kennedy *et al*., 2004; Bloemberg *et al*., 2000; Abdullahi and Sheriff, 2013). These microorganisms play crucial roles such as, producing plant growth stimulating hormones, nutrients cycling thereby enhancing plant nutrients availability and uptake, nitrogen fixation, improve plant health, drought resistance and, reclaim degraded soil (Barea *et al*., 1998; Dobbelaere *et al*., 2001; Hodge *et al*., 2001; Bonfante, 20003; Vassey, 2003). Application of organic manures similarly, has positive effects on soil physical and biochemical properties. It lowers soil bulk density; increases water holding capacity, CEC, build up beneficial soil microbes, improve good soil structure and enhance stable soil aggregates (Doran, 1995; Drinkwater *et al*., 1995; Stamatiadis *et al*., 1999). The objective of this work was to study the effect of bio-fertilizer, Arbuscular mycorrhizal fungi (AMF) (*Glomus mossea*) and *Azospirillum brasilense* alone or in combination with cow dung (CD) or poultry manure (PM) on growth of pearl millet.

MATERIALS AND METHODS

Field trial was conducted at 2008/2009 rainy season, between July and August in semi-arid region of northeastern Nigeria. The soil was characterized as sandy loam (57% sand, 23.4% silt and 19.7% clay), neutral (pH 6.7), with EC value of 0.65 dS m^{-1}. The soil had low nitrogen (0.19%), organic carbon (0.68%), available soil P (5.6 mg kg^{-1}), and exchangeable K (0.34 meq/100 g soil). The experiment was laid out in randomized complete block design with six treatments and three replications. Treatments were: T_1 (Control), T_2 (Bio-fertilizer), T_3 (Bio-fertilizer + 5 ton ha^{-1} CD), T_4 (Bio-fertilizer + 2.5 ton ha^{-1} PM), T_5 (10 ton ha^{-1} CD), T_6 (5 ton ha^{-1} PM).

Azospirillium brasilense was isolated from rhizosphere of maize from the experimental farm, grown in nutrient broth for 48 h at 32°C in rotary shaker at the microbiological unit, Lake Chad Research Institute, Maiduguri. Viable cell suspension of *Azospirillium brasilense* (10^9cfu ml^{-1}) was applied as seed and soil application. Mycorrhizal inoculum containing extramatrical hyphae, spores, and root fragments of maize infected with *Glomus mossea* grown for 3 months was used as soil inoculums. Pearl millet seeds (SOSAT-C88) was obtained from seed bank at Lake Chad Research Institute, Maiduguri. The seeds were soaked in *Azospirillum* culture for 1 h which was sown immediately with 10 g of AMF inoculums (15 spores g^{-1}soils) placed 3-5 cm below soil surface. Composted poultry manure (2.3% N, 1.5% P, 1.7% K and C/N 14.1) and cow dung (1.3% N, 0.68% P, 1.2% K and C/N 21.3) were incorporated to individual plot 1 week prior to seed sowing according to treatments. *A. brasilense* culture was sprayed in soil 1 week after seedling emergence at 500 ml ha^{-1} in 2000 l of water. Six seeds were sown at 75 × 50 cm between and within rows in 2m × 2m and later thinned to sthree per hill. Inoculated and un-inoculated plots were separated by 1 m unplanted boarder. Seeds were sown on 13thJuly and plants harvested 6 weeks after sowing (WAS). Observations on plant height, dry biomass of shoots and roots (constant weight after oven drying @ 65°C), shoot content of N, P, and K were analyzed using Kjeldahl apparatus for nitrogen, while phosphorous and potassium were determined, by acetic acid extraction and measured with spectrophotometer and flame photometer as outlined by Johnson and Ulrich, (1959) and Knudsen *et al*., (1982) for P and K respectively. Root colonization by AM fungi was determined by root clearing and staining (Philips and Hayman, 1970). Data were subjected to analysis of variance and differences among treatment means were separated using Fisher's least significant difference (LSD) at $P \leq 0.05$.

RESULTS

Plant growth characteristics

Plant growths characteristics *viz*; plant height, number of tillers/plant, shoot and root dry biomass are presented in Figure-1 and Table-1. Bio-fertilizers and organic manures either alone or in combination significantly produced plants with high growth qualities compared to control Combination of bio-fertilizer with poultry manure (Bio- fertilizer + PM) produced plants with the highest growth biometrics; plant height (72.6 cm), number of tillers/plant (4.1), shoots and root dry biomass (8.8 and 3.9 g) followed by single applications of bio-fertilizer and poultry manure. Applying 10 ton^{-1} of cow dung produced plants with the lowest growth attributes although not a par with control.

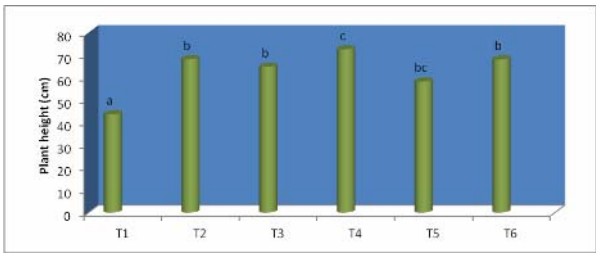

Figure-1. Effect of bio-fertilizers and organic manures on plant height of pearl millet 6 WAS.

Legend: T_1: (00) Control, T_2: (Bio-fertilizer), T_3: (Bio-fertilizer + CD), T_4: (Bio- fertilizer + PM), T_5: (CD), T_6: (PM).

Table-1. Effects of bio-fertilizer and organic manure on growth components of millet 6 WAS.

Treatments	No. of tillers/plant	Dry biomass (g/plant)	
		Shoot	Root
T_1: (control)	2.2^{a}	3.2^{a}	1.2^{a}
T_2: (Bio-fertilizer)	3.8^{ab}	7.9^{bc}	3.7^{b}
T_3: (Bio-fertilizer + CD)	3.0^{b}	5.8^{c}	2.6^{ab}
T_4:(Bio-fertilizer + PM)	4.1^{c}	8.8^{b}	3.9^{b}
T_5: (CD)	2.6^{a}	3.2^{a}	1.4^{a}
T_6: (PM)	3.3^{b}	7.6^{bc}	3.3^{bc}
LSD (5%)	0.47	0.53	0.31

Values followed by the same superscript are not significantly ($P<0.05$) different according to Fischer's LSD test

Mycorrhizal root colonization

As shown in Figure-2, inoculated and un-inoculated plants were colonized by AM fungi. Inoculated plants were significantly colonized compared to un-inoculated plants. Significant difference in % root colonization was observed between inoculated plants. Bio-fertilizer + PM recorded the highest root colonization of 62% followed by bio-fertilizers alone.

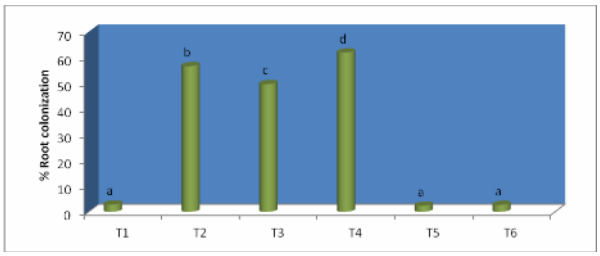

Figure-2. Effect of bio-fertilizers and organic manures on % root colonization of pearl millet 6 WAS.
Legend: T_1: (00) Control, T_2: (Bio-fertilizer), T_3: (Bio-fertilizer + CD), T_4: (Bio- fertilizer + PM), T_5: (CD), T_6: (PM).

Nutrients content

Nutrients concentration (N, P, and K) in plant shoots were significantly higher in treated plants compared to control. N and P concentrations varied significantly between all treatments (Table-2). Bio-fertilizer + PM recorded the highest concentration of N and P, and values were significantly higher than all the treatments. There was no definite trend for K concentration; values were statistically similar among the treated plants. Only for plants treated with CD recorded low K.

Table-2. Effect of bio-fertilizer and organic manure on N, P, and K concentration in shoots of pearl millet 6 WAS.

Treatments	**Concentration** (%)		
	N	**P**	**K**
T_1: (control)	1.2^a	0.23^a	1.03^a
T_2: (Bio-fertilizer)	3.60^b	0.49^b	1.87^b
T_3: (Bio-fertilizer + CD)	3.23^c	0.41^c	1.86^b
T_4(Bio- fertilizer + PM)	3.92^d	0.52^d	1.82^b
T_5: (CD)	2.11^e	0.27^e	1.76^{ab}
T_6: (PM)	3.17^c	0.42^f	1.86^b
LSD (5%)	0.14	0.02	0.10

Values followed by the same superscript are not significantly ($P<0.05$) different according to Fischer's LSD test

DISCUSSIONS

As observed in this study, application of bio-fertilizer and organic manure alone or in combination enhanced plant growth, % root colonization by AM fungi, shoot and root dry biomass and nutrients concentration (N, P and K) compared to control. Bio-fertilizer + PM recorded highest plant performance followed by bio-fertilizer alone. Improved plant growth could be attributed to the energy source provided to the microbes via organic manure thereby enhancing biological activities and availability of nitrogen, growth promoting hormones and phosphorus mobilization by *Azospirillum* and AM fungi, respectively. Several studies have revealed the positive effects of organic and bio-fertilizers singly or in combination with organic amendments to increase plant nutrients availability, uptakes and increase crop yield (Ezhil Bama and Ramakrishnan, 2010; Saxena and Tilak, 1994; Nadar *et al*., 2008; Maman and Mason, 2013). Similar to the finding of this study, Abdullahi *et al*. (2013) reported enhanced sesame growth and nutrients uptake with the combination of bio-fertilizer and poultry manure. Osman and Abd El-Rahman (2010) observed high growth response, quality yield of fruit and leaf nutrients concentrations (N, P, K, Ca and Mg) in Fig with the application of *Azospirillum* + poultry manure and Azotobacter + poultry manure. Positive growth response of pearl millet to bio-fertilizer application compared to chemical fertilizers was also reported by Campo (2006) and Galbiatti *et al*. (2011). Root colonization recorded in un-inoculated plants in this study might be due to presence of natural AM fungi spores in the experimental plots. Since present study was conducted under natural field conditions where, native AM fungi spores could be present, with low population and poor colonization potential. Combined effect of bio-fertilizer + PM and single application of PM were superior to bio-fertilizer + CD and CD alone; this is due to differences in chemical composition and wider C/N ratio of the cow dung. Contrary to the result of this study, Sadiq *et al*. (2012) recorded highest growth and yield of pearl millet treated with cow dung compared to poultry manure under the same agro-ecological condition where this study was conducted.

From the findings of this study, it can be concluded that application of bio-fertilizer and organic manure either singly or in combination could improve pearl millet production in low-input agriculture. Results also suggested that bio-fertilizer have reduced by half the application rates of organic manure. Bio-fertilizer in combination with 2.5 ton ha^{-1} of PM could be recommended for millet production in the study area.

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