Journal of Agricultural Science and Food Research

Research Article

Open Access

Morphological and Yield Assessment of Soybean (*Glycine max* L.) as Influenced by Arbuscular Mycorrhizal Fungi and Other Soil Amendments

Afolayan ET[*] **and Eguavon MI**

Biology Department, Federal College of Education, Abeokuta, Ogun State, Nigeria

***Corresponding author:** Afolayan ET, Biology Department, Federal College of Education, Abeokuta, Ogun State, Nigeria, Tel: +2349099371252; E-mail: tailayo021204@yahoo.com

Rec date: October 23, 2017; **Acc date:** October 30, 2017; **Pub date:** November 15, 2017

Abstract

Soy Bean is one of the staple foods in Africa. It is used for both food and drinks of different types. Desertification, over cultivation and over grazing had limited its production. This work examines the growth responses of three accessions of soybean (*Glycine max*) as influenced by Arbuscular Mycorrhizal Fungi (AMF) inoculation, Poultry manure and different inorganic fertilizers applications. The seed sample for this study comprises of three (3) different accessions of soy-bean with seven (7) treatments which are Arbuscular mycorrhizal fungi (AMF), combination of Abuscular Mycorrhizal fungi and NPK Fertilizer (AMF+NPK), combination of Abuscular Mycorrhizal Fungi with Poultry manure (AMF+PM), NPK Fertilizer only (NPK), Poultry Manure (PM), combination of NPK Fertilizer and Poultry Manure (NPK+PM) and the untreated which serves as control. Parameters measured were; leaf length, leaf breath, stem height, number of leaves and number of flowers. Data collected were analyzed using ANOVA, while means were separated using Duncan Multiple Range Test. Results obtained revealed that plants with combined treatments of NPK+PM had the highest values for stem height, leaf breadth, number of flowers and number of leaves. Combined treatments of AMF+PM also significantly improved the growth of soya beans. For sustainable soy bean production, organic and inorganic fertilizers are recommended for optimum yield.

Keywords: Arbuscular mycorrhizal fungi; Soy-beans; Growth and yield

Introduction

The soybean (*Glycine max* L.) belong to the family Leguminosae and sub-family Papilionoidae. It originated in Eastern Asia, probably in north and central China. It is believed that cultivated varieties were introduced into Korea and later into Japan some 2000 years ago. Remarkably, seeds such as soybeans containing very high levels of protein. Soybeans and corn have a range of soluble carbohydrate protecting the seed's cell viability [1]. Although the USA and Brazil account today for most of the soybean production of the world the introduction of this crop to Western agriculture is quite recent. Soybeans are, primarily, an industrial crop, cultivated for oil and protein. Despite the relatively low oil content of the seed (about 20% on moisture-free basis), soybeans are the largest single source of edible oil and account for roughly 50% of the total oilseed production of the world. They can grow in a wide range of soils, with optimum growth in moist alluvial soils with a good organic content. Soybeans, like most legumes, perform nitrogen fixation by establishing a symbiotic relationship with the bacterium Rhizobium japonicum [2]. For best results, though, an inoculum of the correct strain of bacteria or fungi should be mixed with the soybean (or any legume) seed before planting.

AMF form symbiotic relationship with the root of higher plants by contributing significantly to plant nutrition and promoting growth in the cultivation of agricultural crop species, such as hardwood tree seedlings, corn (*Zea mays*), carrot (*Daucus carota*), grape (*Vitis vinifera*), soybean (*Glycine max*) and yam (*Dioscorea rotundata*). AMF showed increased productivity of a variety of agronomic crops including yam. It is reported that there is an enhanced leaf length and flower production in plants inoculated with Arbuscular mycorrhizal fungi (AMF) combined with either NPK fertilizers and poultry manure. It is suggested the replacement of inorganic fertilizers with organic manure and AMF in view of their ecological friendliness [3]. It is reported that mycorrhizal has a symbiotic relationship with plants roots and that every plant has its specific which relates with it in manure [4]. The role of AMF in enhancing plant growth and yield of crops has been previously reported [5]. The capacity of AMF to influence plant growth, water and nutrient content has been widely reported over the years [6].

Poultry manure promotes and enhances the growth and yield of plants because it is not all macro and micro nutrients that are readily available for the plant uptake, and this could bring about slow growth and poor yield [7]. The use of organic manure has been reported to enhance soil productivity, increase the soil organic carbon content, soil micro-organism, improves soil structure, the nutrient status of the soil and enhance crop yield. It is observed that application of 10 t/ha of poultry manure gave significantly greater number of fresh pods and fresh pod weight in okra compared with 50 kg N+22 kg P+6 kg K ha^{-1} [8,9]. Manure application has also been found to encourage early maturity, uniformity in ripening, increased fruit size and yield of tomatoes. Moreover, poultry manure contains essential nutrient elements associated with high photosynthetic activities and thus promoted roots and vegetative growths. Judicious use of combinations of organic and inorganic nutrients resources is a feasible approach to overcome challenges soil fertility. It is also found that there is a synergistic effect of organic and Inorganic fertilizer on maize yield. Nwangburuka opined that, AM+PM combination has favorable interaction that promotes growth [10]. This mutualistic association provides the fungus with relatively constant and direct access to carbohydrates, such as glucose and sucrose. The carbohydrates are translocated from their source (usually leaves) to root tissue and on to the plant's fungal partners. In return, the plant gains the benefits of the mycelium's higher absorptive capacity for water and mineral nutrients due to the comparatively large surface area of mycelium: root ratio, thus improving the plant's mineral absorption capabilities [11-13].

Fasola et al. reported that Poultry manures are good soil conditioners that should be incorporated into the soil to save nitrogen [14]. Manure varies in nutrients depending on the type of nutrition subjected to an animal and kind of animal. It is resolved that the use of poultry manure as organic amendment significantly improved the physio-chemical and morphological properties of the soil. The performance of the combinations of organic fertilizers and AMF compared to inorganic fertilizer had been reported in organic agriculture [15,16].

The objective of this research was to examine the growth responses of Soybeans to Arbuscular mycorrhizal fungi (AMF), Poultry manure and NPK fertilizer application.

Materials and Methods

This research was carried at the Botanical Gardens, Biology Department, Federal college of Education, Abeokuta, Ogun State from January to April 2014. The accessions of Soybean were obtained from three (3) different market locations in South-western States of Nigeria (Abeokuta in Ogun State, Ibadan in Oyo State and Ketu in Lagos State). The Arbuscular mycorrhiza species was collected from the Department of Crop protection and Plant Physiology, College of plant Sciences, Federal University of Agriculture, Abeokuta, Ogun state, Nigeria. The experiment which was laid out in a completely randomized design was replicated thrice. The treatments consisted of AMF, PM, NPK, AMF+NPK, AMF+PM, PM+NPK and the untreated plants (Control). 20 g of AMF (*Glomus mosseae*) were inoculated in 4 kg polythene bag filled with sterile soil while 200 kg/ha of NPK and 20 g of PM were also used as NPK and PM treatments respectively. The treatments were applied two weeks after planting. Data were collected on some morphological characters of soybean such as plant (stem) height, leaf length, leaf width, number of leaves and number of flower. These were subjected to analysis of variance and Duncan Multiple Range Test at $P<0.05$ to find out the Significant difference between treatment means.

Results and Discussion

DV	Source	SS	Df	MS	F	P
Stem Height	Location	8207.291	2	4103.645	25.643	0.000
	Treat	7571.017	6	1261.836	7.885	0.000
	Location * treat	2991.996	12	249.331	1.558	0.100
	Error	97456.746	609	160.027		
	Total	116227.020	629			
Leaf Breadth	Location	62.805	2	31.402	8.226	0.000
	Treat	249.931	6	41.655	10.912	0.000
	Location * Treat	98.827	12	8.236	2.517	0.012
	Error	2324.837	609	3.817		
	Total	2736.400	629			

Table 1: Showing ANOVA test of location and treatment.

Results indicated that Table 1 shows a significant main effect of location on stem height [F (2,606) =25.643, p<0.001]. There is also a significant main effect of treatment on stem height [F (6,609) =7.885, p<0.001]. The table however show no significant interactive effects of location and treatment on stem height [F (12,609)=1.558, p>0.05]. The table also shows a significant main effect of location on leaf breadth [F (2,609)=8.226, p<0.001]. There is also a significant main effect of treatment on leaf breadth [F (6,609)=10.912, p<0.001]. The table also shows significant interactive effects of location and treatment on leaf breath [F (12,609)=2.157, p<0.05].

Treatment	N	Abeokuta (Mean)	Ibadan (Mean)	Lagos (Mean)
AMF	30	41.033	30.263	38.430
AMF+NPK	30	44.380	34.680	37.183
AMF+PM	30	42.063	32.520	42.667
NPK	30	37.573	30.160	36.730
PM	30	45.137	41.797	36.263
NPK+PM	30	47.397	43.157	41.793
Control	30	41.680	27.800	35.540
Stem Height	210	42.75 ± 1.03a	33.91 ± 0.83c	38.37 ± 0.74b

Table 2: Stem height of different accession of soya beans at flowering using Duncan Multiple Ranger Test.

Means with the same letter along the column are not significantly different (DMRT at p<0.05).

Table 2 shows the stem height of different accessions of soybean treated with mycorrhizal fungi and other soil amendment. Results from Abeokuta accessions revealed that the combined treatment of

NPK+PM had the highest value for stem height (47.40), while AMF treated plants had the least value (41.03). For Ibadan accessions, NPK +PM treated plants had the highest value for stem height (43.16), while untreated plants had the least value (27.8). Results for Lagos accessions show that plant treated with AMF+PM had the highest value (42.7) for stem height while the control had the least value (35.18). In conclusion, there is significant difference between the three different accessions in their stem height with Abeokuta accession having significantly higher value above Lagos and Ibadan.

Treatment	N	Abeokuta (Mean)	Ibadan (Mean)	Lagos (Mean)
AMF	30	6.790	7.263	8.430
AMF+NPK	30	7.060	9.680	10.183
AMF+PM	30	7.793	9.520	9.667
NPK	30	6.463	7.160	8.730
PM	30	7.437	7.797	7.263
NPK+PM	30	8.237	10.157	8.793
Control	30	6.533	5.800	6.540
Leaf breadth	210	7.05 ± 0.16a	7.21 ± 0.14a	6.47 ± 0.12b

Table 3: Leaf breath of different accession of soya beans using Duncan Multiple Range test.

Means with the same letter along the column are not significantly different (DMRT at $p<0.05$).

Table 3 shows the leaf breadth of different accessions of soy beans treated with Mycorrhizal Fungi and other soil amendments. Results obtained from Abeokuta accession shows that combined treatment of NPK+PM had the highest value for leaf breadth (8.24), while NPK treated plants had the least value (6.46). Among Ibadan accession, NPK+PM treated plants had the highest value for leaf breadth (10.16) while untreated plants had the least (5.8). Results of Lagos accession reveals that plants treated with AMF+NPK had the highest value (10.2) for leaf breadth while the untreated treated plants (control) had the least value (6.5). Summarily, there is no significant difference between the Abeokuta and Ibadan accessions but were significantly different from Lagos accessions in their leaf breadth.

Source	SS	DF	MS	F	P
Location	23.086	2	11.543	2.096	0.124
Treat	207.067	6	34.511	6.265	0.000
Location*Treat	115.975	12	9.665	1.755	0.053
Error	3123.226	567	5.508		
Total	3464.509	5.587			

Table 4: Showing ANOVA test of location and treatment of leaf length.

Table 4 shows a non-significant main effect of location on leaf length [$F(2,567)=2.096$, $P>0.05$]. There is significant main effect of treatment on leaf length [$F(6,567)=6.265$, $p<0.001$]. The table however show no significant interactive effects of location and treatment on leaf length [$F(12,567)=1.755$, $p>0.05$].

DV	Source	SS	Df	MS	F	P
Number of flowers	Location	60.806	2	30.403	0.991	0.403
	Treat	168.883	6	28.147	0.843	0.537
	Location * Treat	154.660	12	12.888	0.386	0.968
	Error	9813.600	294	33.380		
	Total	101097.949	314			
Number of leaves	Location	665.073	2	332.537	6.443	0.002
	Treat	1356.641	6	226.107	4.381	0.000
	Location * Treat	1840.616	12	153.385	2.972	0.001
	Error	15172.800	294	51.608		
	Total	19035	314			

Table 5: Showing ANOVA test of location and Treatment for numbers of leaves and flowers.

Table 5 shows that there was no significant main effect of location on number of flowers [$F(2,294)=0.911$, $P>0.05$]. There is also no significant main effect of treatment on number of flowers [$F(6,294)=0.843$, $P>0.05$]. The table also shows no significant interactive effects of location and treatment on number of flowers [$F(12,294)=0.386$, $p>0.05$].

Table 4 however, shows a significant main effect of location on number of leaves [$F(2,294)=6.443$, $p<0.01$]. There is also no significant main effect of treatment on number of leaves [$F(6,294)=4.381$, $p<0.001$]. The table also shows significant interactive effects of location and treatment of leaves [$F9(12,294)=2.972$, $P<0.001$].

Location	N	Mean ± SEM Number of Leaves
Abeokuta	105	37.59 ± 0.67 b
Ibadan	105	39.07 ± 0.77 b

Lagos	105	41.13 ± 0.80 a

Table 6: Showing Duncan Multiple Range Test (DMRT) of location.

Means with the same letter along the column are not significantly different (DMRT at $p<0.05$).

Table 6 shows that there is no significant difference in number of flowers across locations ($p>0.05$). However, number of leaves value in Lagos is significantly higher than that of Ibadan and Abeokuta ($p<0.05$) but no significant difference was observes between Abeokuta and Ibadan location about number of leaves ($p>0.05$).

Treatment	N	Mean ± SEM	
		Number of flowers	Number of leaves
AMF	45	8.24 ± 0.80a	39.11 ± 1.24bc
AMF +NPK	45	8.36 ± 0.83a	40.62 ± 1.10bc
AMF +PM	45	9.56 ± 0.84a	39.78 ± 1.12bc
NPK	45	8.02 ± 0.81a	38.11 ± 1.03bc
PM	45	8.82 ± 0.83a	38.27 ± 1.03bc
NPK +PM	45	9.98 ± 0.97a	43.49 ± 1.36a
Control	45	7.93 ± 0.82a	37. 47 ± 0.99c

Table 7: Showing Duncan Multiple Range Test (DMRT) of Treatment.

Means with the same letter along the column are not significantly different (DMRT at $p<0.05$).

The effect of AMF and other soil amendment was measured and presented in Table 7. It shows that combined treatment of NPK+PM had the highest value (9.98) for the number of flowers and number of leaves (43.49) while the untreated (control) had the least value (7.93 and 37.47).

Parameters	Stem height	Leaf breadth	Leaf length	Number of flowers	Number of leaves
Stem height	1				
Leaf breadth	0.773**	1			
Leaf length	0.035**	0.044	1		
Number of flowers	0.339**	0.337	−0.064	1	
Number of leaves	0.265**	0.312**	−0.072	0.806**	1

Table 8: Showing inter-correlation between variables of the study.

Table 8 shows that stem height positively correlated with leaf breadth, number of flowers and number of leaves ($r=0.773$, $p<0.01$, $r=0.339$, $p<0.01$ and $r=0.265$, $p<0.01$). This implies that increase in stem height values leads to increase in leaf breadth, higher number of flower and leaves. Also, leaf breadth positively correlated with number of flower and leave ($r=0.337$, $p<0.01$ and $r=0.312$, $p<0.01$). This implies that increase in leaf breadth values leads to increase in higher number of flower and leaves ($r=0.806$, $p<0.01$). This implies that higher number of leaves leads to higher number of flowers.

The result of this work was who reported that the use of poultry manure as organic amendment significantly improved the physiochemical and morphological properties of the soil and that when it is added in combination with chemical fertilizer, supplemented all nutrients to crops and increases the productivity of crop. The higher values for number of leaves and flower in this work conform to the report of Olawuyi et al. who opined that AMF is an alternative to Inorganic fertilizer in soil amendment for crop growth and yield, He further explained that Plants utilize Arbuscular mycorrhizal fungi (AMF) to increase their growth and yield responses due to mobility of nutrient that is limited. It is reported that AMF showed increased productivity of a variety of agronomic crops including yam. It is suggested that in maize, the most widely recognized contribution of AM fungi to host-plant nutrition involves their ability to extract. Phosphorus from outside the Phosphorus depleted regions near the plant roots and non-AM-host weed suppression. The result also showed that the combined treatment of AMF+NPK and AMF+PM had an enhanced leave breadth and stem length. This was like the observation of an enhanced leaf length and flower production in plants inoculated with Arbuscular mycorrhizal fungi (AMF) combined with either NPK fertilizers and poultry manure. In general, it was observed from the result of this work that NPK+PM treated plant had a significantly higher value for all the traits assessed, this corroborate the findings of Daramola et al. reported that there is a synergistic effect of organic and Inorganic fertilizer on maize yield [15-18].

Conclusion

The effects of AMF, PM and NPK on the morphological features of different accessions of soybean showed a significant varying effect. Summarily, the higher values observed in AMF+PM, AMF and PM treatments over and above NPK can guarantee both sustainable food production and ecological friendliness in Nigeria specifically and Africa in general.

References

1. Blackman SA, Obendorf RL, Leopold AC (1992) Maturation proteins and sugars in desiccation tolerance of developing soybean seeds. Plant Physiol 100: 225-230.

2. Jordan DC (1982) Transfer of *Rhizobium japonicum* Buchanan 1980 to *Bradyrhizobium* gen. nov., a genus of slow-growing, root nodule bacteria from leguminous plants. Int J Syst Evol Microbiol 32: 136-139.
3. Olawuyi OJ, Odebode AC, Babalola BJ, Afolayan ET, Onu CP (2014) Potentials of arbuscular mycorrhiza fungus in tolerating drought in Maize (*Zea mays* L.). Am J Plant Sci 5: 779.
4. Olawuyi OJ, Odebode AC, Olakojo SA, Adesoye AI (2011) Host-Parasite Relationship of Maize (*Zea mays L.*) and *Striga lutea* (lour) as Influenced by Arbuscular Mycorrhiza Fungi. J Sci Res 10: 186-198.
5. Bolan NS (1991) A critical review on the role of mycorrhizal fungi in the uptake of phosphorus by plants. Plant and Soil 134: 189-207.
6. Barea JM, Azcon R, Azcon-aguilar C (2002) Mycorrhizosphere to improve Plant Fitness and Soil Quality. Antonie Van Leeuwenhoek Int J Gen Mol Microbiol 81: 343-351.
7. Sunassee S (2002) Use of poultry litter for vegetable production. In: Fifth Annual Meeting of Agricultural Scientists, p: 259.
8. Asiegbu JE (1987) Some biochemical evaluation of fluted pumpkin seed. Journal of the Science of Food and Agriculture 40: 151-155.
9. Husseib TO (1997) Effect of poultry manure on the growth of tomato. Proceeding of 15th Annual Conference of Horticultural Society of Nigeria (HORTSON), pp: 8-11.
10. Nwangburuka CC, Olawuyi OJ, Oyekale K, Ogunwenmo KO, Denton OA (2102) Growth and yield response of Corchorus olitorius in the treatment of Arbuscular mycorrhizae (AM), Poultry manure (PM), Combination of AM-PM and Inorganic Fertilizer (NPK). Adv Appl Sci Res 3: 1466-1471.
11. Kirk GJ (2001) Plant-mediated processess to acquire nutrients: nitrogen uptake by rice plants. Plant and Soil 232: 129-134.
12. Shen J, Yuan L, Zhang J, Li H, Bai Z, et al. (2011) Phosphorus dynamics: from soil to plant. Plant Physiol 156: 997-1005.
13. Hogan KP, Smith AP, Ziska LH (1991) Potential effects of elevated CO2 and changes in temperature on tropical plants. Plant, Cell & Env 14: 763-778.
14. Taiye F, Jonathan G, Ishola F (2007) Nutritional requirements of *Volvariella speciosa* (Fr. Ex. Fr.) Singer, a Nigerian edible mushroom. Food Chem 100: 904-908.
15. Olayinka A, Adebayo A, Amusan A (1998) Evaluation of organic carbon oxidation efficiencies of a modified wet combustion and Walkleyblack procedures in Nigerian soils. Comm in Soil Sci & Plant Anal 29: 2749-2756.
16. Olawuyi OJ, Ezekiel-Adewoyin DT, Odebode AC, Aina DA, Esenbamen GE (2012) Effect of arbuscular mycorrhizal fungi (*Glomus clarum*) and organomineral fertilizer on growth and yield performance of Okra (*Abelmoschus esculentus*). Afri J Plant Sci 6: 84-88.
17. Ismail AS, El-Sebaay AS, Saleh SA, Abd-El-Wahab AF (1996) Effect of application of mineral and organic amendments on nodulation, cowpea growth and certain chemical properties of calcareous soils. In Special Issue: Proceedings of the Sixth Conf. of Agri Develop Res.
18. Nwangburuka CC, Olawuyi OJ, Oyekale K, Ogunwwenmo KO, Denton O, et al. (2012) Effect of Arburscular mycorrhizea (AM), poultry manure (PM), NPK fertilizer and the combination of AM-PM on the growth and yield of okra (*Abelmoschus esculentus*). Nature and Sci 10: 35-45.