Original research papers

Effects of Arbuscular Mycorrhiza Fungi (*Glomusmossae*) and Compost on early growth performance of *Parkiabiglobosa*

Abstracts

One of the biggest challenges to sustainable global food security is the need to find suitable replacements for inorganic fertilizer. This is because inorganic fertilizers production consumes an increasing proportion of the global energy budget and the supply of key raw materials, primarily phosphorus is becoming more limited. Therefore, this study was conducted to evaluate the effect of Arbuscular Mycorrhiza Fungi, AMF (*Glomusmossae*) and compost on soil properties and early growth response of *Parkiabiglobosa*. The experiment was set up at the screen house of the Department of Bioscience, Forestry Research Institute of Nigeria. The experimental design was a 2 x 5 factorial, laid in a Completely Randomized Design (CRD) with four replicates. The treatments used were compost at five (5) levels: 10t/ha, 20t/ha, 30t/ha, 40t/ha, no amendments; and two (2) levels of AMF inoculation (with and without). Data on plant height, number of leaves, collar diameter and dry matter yields were generated and subjected to analysis of variance, and significant means were separated using Duncan's Multiple Range Test at 5 % level of significance. The result shows that mycorrhizal inoculation significantly increased ($p < 0.05$) plant height, stem diameter and leave numbers when compared with the non-mycorrhizal plants. There was no variation in number of leaves and height among the inoculated treatments as compared with the un-inoculated treatments which are significantly different from each other at -AMF 0 and –AMF 10 respectively. Interaction of AMF and compost at 40 t ha^{-1} had the highest plant height with a value of 35.06 cm. Application of 40 t ha^{-1} of compost with inoculation significantly increased ($p < 0.05$) the root dry matter yields while no significant differences were observed in leaves and stem dry matter yield for both inoculated and un-inoculated. The analysis of the soil before and after the experiments could also be comparable to one another as no variation was observed. From the results obtained, it can be concluded that AMF can successfully be inoculated into compost amended soil to improve the performance of *Parkiabiglobosa*.

Keywords: Compost; AMF; inoculation; *Parkiabiglobosa*; growth response.

Introduction

Land degradation refers to the reduction in the quality and productive capacity of the soil which involves physical, chemical and biological deterioration such as decline in soil fertility, organic matter, vegetation cover and biodiversity (Eswaran*et. al.*, 2001). Losses of plant nutrients from the agricultural system can be in the form of harvested product, soil erosion, gaseous losses, and leaching(Omoti*et. al.*,1983). The major losses of nutrients are from harvested products, and soil erosion. To maintain a sustainable cropping system where there is high rate of soil degradation due erosion, continuous cropping as well as the cultivation of marginal land then the issue of fertility management cannot be neglected.

Soil micro-organisms, especially arbuscularmycorrhizal fungi (AMF), in addition to ecto-mycorrhizal fungi (ECM) and ericoid mycorrhizal fungi (ERM), have well-recognized roles in terrestrial ecosystems (Zhu and Miller 2003; Rillig 2004; Read et al. 2004). Mycorrhizal fungi are frequently included in management, since they are widely used as soil inoculum additives (Schwartz et al. 2006). Vesicular ArbuscularMycorrhizal (VAM) symbiosis is a complex mutualistic association between a unique group of soil fungi and higher plants, in which a balance is maintained in allocation of carbon and other host derivatives to the fungus and supply of soil-derived nutrients mainly phosphorus to the host plant through their hyphae (Read *et al*., 2004). The effectiveness of this association is known to be determined by soil, fungal as well as plant factors (Smith and Jakobsen, 2004). Among soil factors, nutrient status is considered to be most important because the extent of root colonization by VAM fungi and their effectiveness is known to be inversely proportional to nutrient status of soil because soil nutrient availability status is modulated by biochar amendment (Glaser *et al.,* 2002). It is expected that the application of manure will influence VAM colonization levels and the magnitude of benefit derived from VAM symbiosis (Warnock *et al*., 2007).

In the arid and semi-arid regions of Africa, *Parkiabiglobosa*(African locust bean) is very important for food security particularly during food shortage and drought periods (Kourouma*et al,* 2011). They added that it is a food species whose importance is recognized both regionally and internationally because in some societies on the African continent it is not an ordinary food item but a therapeutic food and a source of income. *P. biglobosa*(named after the famous Scottish botanist and surgeon Mungo Park by Robert Brown in 1926) has long been widely recognized as an important indigenous multipurpose fruit tree whose uses include food, medicine, manure, tannin, shade, wind-breaks, bee food, stabilization of degraded environment, livestock feeds, fuel, fibre, fish poison and several other domestic uses (Sadiku, 2010). High rate of nutrient depletion resulting from soil degradation is the major factor affecting crop production among tropical farmers. However, knowledge of the effect of compost application and mycorrhizal inoculation on plant growth is scarce as both may adversely affect plant performances (Warnock *et al.*, 2007). Therefore, this experiment determine the growth response of *Parkiabiglobosa*to AMF (*Glomusmossae*)under the application of organic amendments at different level and also to evaluate the soil properties of *Parkiabiglobosa*in soils as influenced by organic amendments at different levels of application.

MATERIALS AND METHOD

The study was carried out at the screen house and laboratory of the Department of Bioscienceof the ForestryResearch Institute of Nigeria Ibadan (FRIN) to investigate the effects of Arbuscula Mycorrhiza Fungi (*Glomusmossae*) and compost on the growth and Soil Properties of *Parkiabiglobosa*.The study site is located on longitude 07^{o}23'18" N to 07^{o}23'43"N and latitude 03^{o}51'20"E to 03^{o}23'43"E. The climate of the area is West African monsoon with dry and wet seasons. The mean maximum temperature of the area at the period of the study was 31.11 ^{o}C, minimum 22.76 ^{o}C while the mean daily relative humidity was about 71.8% (Anonymous, 2018).

Collection of soil samples

The soil samples was collected from farm practical area (FAP), Federal College Forestry, Ibadan. Top soil of 0 – 20 cm depth was be used for the experiment. The soil was air dried; grounded and sieved using 2mm sieve to remove gravel and large plant roots. The soil samples were chemically analyzed for nitrogen and other nutrient content. Two kilogram soil was weighed in a polythene bag and incorporated with organic manure at different levels and mycorrhizal (*Glomusmossae*) as appropriate. *Glomusmossae*was supplied by Department of Agronomy, University of Ibadan. It was propagated in a sterile potted soil cropped with maize. The inoculant consists of a root-soil –fungus spore mixture inoculated at an appropriate rate using subsurface application method of depth between 0 – 5cm before planting.

Organic Amendments

Compost was analyzed to determine the NPK content of each amendment. The phosphorus content was used to determine the quantity of fertilizer to apply to *parkiabiglobosa*. The organic fertilizers were incorporated into the soil, two weeks before planting at different levels.

Experimental design

The experimental design was a 2 x 5 factorial in a Completely Randomized Design (CRD) with four replicates making a total of 40pots. The treatments used were as follows.

Organic amendments at 5 levels: 10t/ha, 20t/ha, 30t/ha, 40t/ha and no amendments (0).

Mycorrhizal (20g) flat rate applied to pots.

Data collection

Number of leaves was determined through physical counting of the number of leaves per plant. The plant height was measured from soil surface with the aid of a meter rule while Venire caliper was used to measure the diameter at breast height and recorded in millimeter. The plant Dry matter yield (g/plant) data was also determined for stem, root and leaf portions of the seedlings at the end of the experiment.

Soil analysis

The soil pH was determined with the pH meter (SM-3H Microfield England) using glass electrode in 1:2soil to water ratio. The organic carbon of the soil was determined using the Walkley Black wet oxidation method. Total nitrogen was determined using micro-*Kjeldahl method.* Available P was determined using Bray-1 method. Likewise, the soil was extracted with 1N HCl and Iron , Copper and Manganese concentrations were determine with atomic absorption spectrophotometer

Statistical Analyses

Quantitative data will be analyzed using the ANOVA procedure and means separated using the Duncan Multiple Range Test (DMRT) at 5% probability (SAS Institute, 2002).

Results and Discussion

Table 1: The chemical properties of the initial soil and compost used in the study

Properties	Soil	Compost%
pH (1:1)	6.5	5.9
T.N g/kg	0.27	0.93
Available P mg/kg	19.4	0.02
K cmol/kg	0.06	0.0004
Fe mg/kg	269	3.53
Mg cmol/kg	0.76	0.33
O.C g/kg	1.34	10.97
Na cmol/kg	3.19	0.014

Key: OC = Organic carbon, N = Nitrogen, P = Phosphorous, K = Potassium and Mg = Magnesium, Fe = iron.

For the pre soil, pH value was slightly acidic, soil was moderately furnished with P content since the critical value of 8-20mg/kg (Sobulo*et al*., 1981). The soil was deficient in both potassium (K) and Nitrogen (N) content compared to the critical value of soil required which is at least 1.5g/kg for N (Adeoye and Agboola., 1985) and 0.20-0.40cmol/kg (Adeoye and Agboola., 1985).

Table 2: Effects of Arbuscular Mycorrhiza Fungi (*glomusmossae*) and Compost on the plant height of *Parkiabiglobosa*

treatments	2wat	4wat	6wat	8wat	10wat	12wat	14wat	16wat
+Amf 0	21.38^{abc}	23.62^{abc}	23.67^{ab}	24.03^{abc}	24.25^{cd}	24.33^{ab}	27.83^{abc}	30.98^{abc}
-Amf 0	15.03^{bc}	15.25^{cd}	16.12^{bc}	18.17d	19.00^{d}	19.00^{b}	20.17^{bc}	23.00^{abc}
+Amf 10	20.25^{abc}	21.62^{bcd}	25.67^{ab}	25.60^{abc}	28.67^{abc}	30.67^{a}	32.22^{b}	33.33^{abc}
-Amf 10	18.80^{a}	20.12^{bcd}	26.82^{a}	29.67^{ab}	28.33^{abc}	29.00^{ab}	29.67^{abc}	29.67^{abc}
+Amf 20	19.00^{abc}	21.5^{bcd}	22.25^{ab}	22.05^{abc}	25.75^{abc}	26.83^{ab}	27.33^{abc}	27.25^{abc}
-Amf 20	20.73^{abc}	21.10^{bcd}	20.32^{ab}	22.88^{abc}	24.21^{abc}	21.38^{ab}	22.38^{abc}	26.00^{abc}
+Amf 30	19.88^{a}	21.75^{bcd}	22.83^{ab}	22.83^{abc}	23.10^{abc}	26.22^{ab}	28.21^{abc}	28.69^{abc}
-Amf 30	21.00^{abc}	21.25^{bcd}	23.15^{abc}	24.58^{abc}	26.15^{abc}	27.67^{ab}	28.5^{abc}	28.5^{abc}
+Amf 40	25.12^{a}	25.50^{ab}	25.83^{ab}	26.67^{ab}	30.43^{ab}	31.14^{b}	31.33^{a}	35.06^{a}
-Amf 40	20.23^{abc}	20.88^{bcd}	21.88^{abc}	23.60^{bcd}	23.10^{cd}	23.00^{a}	23.19^{abc}	24.88^{bc}
s.e.d	4.669	5.075	4.937	5.579	4.882	6.136	5.982	6.434

+AMF (inoculated with *Glomusmossae), -AMF (*un-inoculated), *compost (0, 10* t ha-^{1},*20* t ha-^{1},*30* t ha-^{1},*40* t ha-^{1}, wat (weeks after transplanting)

Plant Height

There was no significant difference (*p<0.05*) in the plant height of *parkiabiglobosa* between mycorrhizal and non-mycorrhizal plants across the first 6weeks (2WAT-6WAT). However, at 8WAT to 16WAT, there was significant difference among some treatments used. At 8WAT, the non-mycorrhizal plants were significantly different from each other (p<0.05) when –Amf 0 and –Amf 10 was used as an amendment with a value of 18.17cm and 28.67cm respectively. At 16WAT, there was increase among the treatments used as +Amf 40 t ha-^{1}had the highest plant height with a value of 35.06cm as compared to -Amf 0 which had the lowest with value 23.00cm throughout the experiment.Application of compost at 30 t ha-^{1} with or without inoculation were comparable to each other as they both produced significantly higher plants at 16WAT.Non-significant effect (*p<0.05*) of mycorrhizal inoculation towards plant height may be attributed to the incorporation of compost which has high phosphorus content- a limiting factor in the functions of AMF. This agrees with the results of Abbott and Robson (1991) who reported that mycorrhizal colonization in peanut plants was significantly depressed by adding Phosphorus. Sanchez and Salinas (1981) related the reduction in AM root colonization probably to high soil fertility level, which reduced the dependence of the plants on mycorrhizal and therefore restricted the development of these fungi to the root cortex.

Table 3: Effects of ArbuscularMycorrhizal Fungi (*glomusmossae*) and Compost on the collar diameter of *Parkiabiglobosa*

treatments	2wat	4wat	6wat	8wat	10wat	12wat	14wat	16wat
+Amf 0	2.13^{ab}	2.22^{abc}	2.47^{abc}	2.53^{abc}	2.93^{b}	3.37^{abc}	3.42^{abc}	3.72^{abc}
-Amf 0	2.01^{ab}	2.62^{abc}	2.76^{abc}	2.67^{abc}	2.67^{ab}	2.89^{abc}	3.11^{abc}.	3.64^{abc}
+Amf 10	1.96^{ab}	2.03^{abc}	2.22^{abc}	2.57^{abc}	2.57^{ab}	3.45^{abc}	3.44^{abc}	3.83^{abc}
-Amf 10	1.78^{ab}	2.22^{abc}	2.69^{abc}	2.76^{abc}	3.45^{ab}	3.69^{abc}	3.69^{abc}	3.73^{abc}
+Amf 20	1.66^{a}	1.74^{bc}	2.46^{abc}	1.78^{ab}	1.94^{c}	2.36^{abc}	2.71^{abc}	3.31^{abc}
-Amf 20	1.38^{ab}	1.86^{bc}	2.07^{abc}	2.11^{abc}	2.65^{b}	3.00^{abc}	3.04^{abc}	3.22^{abc}
+Amf 30	1.75^{ab}	1.87^{bc}	2.43^{abc}	2.41^{abc}	2.79^{b}	2.72^{abc}	2.77^{abc}	2.83^{ab}
-Amf 30	1.25^{ab}	1.25^{bc}	1.45^{bc}	1.61^{ab}	1.99^{bc}	2.54^{abc}	2.63^{abc}	2.97^{abc}
+Amf 40	2.48^{b}	3.15^{abc}	3.22^{abc}	3.35^{abc}	3.35^{a}	3.67^{abc}	4.02^{abc}	4.15^{abc}
-Amf 40	2.17^{ab}	2.43^{abc}	2.79^{abc}	2.45^{abc}	2.95^{c}	3.11^{abc}	3.13^{abc}	3.49^{abc}
s.e.d	0.5728	0.7266	0.7584	0.842	0.7131	1.023	1.031	1.104

+AMF (inoculated with *Glomusmossae), -AMF (*un-inoculated), *compost (0,10* t ha^{-1},*20* t ha^{-1},*30* t ha^{-1},*40* t ha^{-1}, wat (weeks after transplanting)

Collar Diameter

Mycorrhizal inoculation does not have significant effect on the collar diameter at 2, 4, 6, 8, 12, 14 and 16 except at 10 WAT, when mycorrhizal plants had significantly ($p<0.05$) higher collar diameter compared to non mycorrhizal plants. Application of compost at +Amf 40 t ha^{-1}produced significantly higher collar diameter when compared -Amf 30 t ha^{-1}with a mean value of 3.35mm and 1.99mm respectively. However, at 16WAT all the treatments are comparable to one another except + AMF 30t/ha which produced the lowest collar diameter

Table 4: Effects of Arbuscular Mycorrhiza Fungi (*glomusmossae*) and Compost on the number of leaves of *Parkiabiglobosa*

treatments	2wat	4wat	6wat	8wat	10wat	12wat	14wat	16wat
+Amf 0	11.75^{abc}	9.60^{a}	10.44^{a}	10.67^{b}	13.67^{bc}	14.44^{bc}	15.01^{bc}	15.75^{abc}
-Amf 0	10.5^{abc}	8.75^{a}	10.01^{a}	11.02^{b}	11.0^{bc}	11.33^{bc}	15.15^{abc}	15.05^{abc}
+Amf 10	11.72^{abc}	11.65^{a}	11.65^{a}	12.09^{b}	14.33^{abc}	16.33^{abc}	19.67^{abc}	20.75^{abc}
-Amf 10	10.05^{abc}	8.09^{a}	11.15^{a}	13.33^{b}	13.33^{abc}	14.1^{bc}	22.33^{abc}	17.70^{abc}
+Amf 20	11.95^{abc}	11.75^{a}	12.25^{a}	13.09^{b}	14.67^{abc}	19.22^{abc}	20.33^{abc}	20.75^{abc}
-Amf 20	11.75^{abc}	10.75^{a}	11.25^{a}	13.75^{b}	13.75^{bc}	12.25^{bc}	14.5^{bc}	18.75^{ab}
+Amf 30	11.92^{abc}	12.11^{a}	13.67^{a}	18.33$^{a\ b}$	18.95^{abc}	21.67^{abc}	26.75^{abc}	28.31^{abc}
-Amf 30	10.75^{abc}	10.25^{a}	11.01^{a}	16.50$^{a\ b}$	16.19^{bc}	23.33^{ab}	23.67^{abc}	27.98^{abc}
+Amf 40	12.50^{a}	12.75^{a}	17.33^{a}	25.67^{a}	25.99^{a}	31.67^{a}	30.48^{a}	34.50^{abc}
-Amf 40	10.75^{abc}	11.98^{a}	13.66^{a}	13.87^{b}	16.70^{c}	22.25^{c}	25.10^{c}	29.75^{abc}
s.e.d	4.895	4.677	4.500	6.551	6.242	8.13	8.74	7.236

+AMF (inoculated with *Glomusmossae), -AMF (*un-inoculated) , *compost (0,10* t ha-^{1},*20* t ha-^{1},*30* t ha-^{1},*40* t ha-^{1}, wat (weeks after transplanting)

Number of leaves

Mycorrhizal inoculation has significant effect on the number of leaves at 2, 8, 10, 12 and 14 WAT and mycorrhizal plants had significantly ($p<0.05$) higher number of leaves compared to non- mycorrhizal plant. However, at 4 and 6 WAT there was no signicant difference in all the treatments used. All treated pots were comparable to one another. This is similar to the results reported by Abdullahi and Sheriff (2013) that no significant difference ($p>0.05$) in number of leaves per plant due to mycorrhizal inoculation at 4 weeks after transplant (WAT) was observed. There was no significant difference ($p>0.05$) in number of leaves due to the compost application.

However, at 4 WAT, 40 t ha-1 of compost produced significantly (*p<0.05*) higher number of leaves with a mean value of 17.33when compared with control at –AMF 0 t ha-[1] (8.75)and –AMF 10 t ha-[1](8.09) but comparable with other treatments of compost rates. The 40 t ha-1 of compost also produced significantly (*p<0.05*) higher number of leaves when compared with the control (-AMF 0 and +AMF 0) but comparable with other treatments of compost rates at 6 WAT. Similar result was reported by Yusif*et al*. (2016) who found no significant difference (*p>0.05*) in number of leaves among compost rates.

Table 5: Dry matter yield of the plant after harvesting

TREATMENT	LEAVES	STEM	ROOT
+Amf 0	1.46 [a]	0.73 [a]	1.07[ab]
-Amf 0	1.43 [a]	0.69 [a]	1.19[ab]
+Amf 10	1.83 [a]	1.10 [a]	1.42[ab]
-Amf 10	0.85 [a]	0.49 [a]	1.69[ab]
+Amf 20	1.22 [a]	0.74 [a]	1.54[ab]
-Amf 20	1.41 [a]	0.67 [a]	1.38[ab]
+Amf 30	1.58 [a]	1.01 [a]	1.55[ab]
-Amf 30	1.53 [a]	0.59 [a]	0.94 [a]
+Amf 40	2.25[ab]	1.42 [a]	2.86 [c]
-Amf 40	1.15 [a]	0.31 [a]	1.61[ab]
s.e.d	0.4907	0.3752	1.132

+AMF (inoculated with *Glomusmossae)*, *-AMF (*un-inoculated, *compost (0,10* t ha-[1]*,20* t ha-[1]*,30* t ha-[1]*,40* t ha-[1]

Dry matter yield

There was no variation in the dry matter yield of leaves and stem presented in table 4 above, however there was significant difference between -Amf 30 t ha-[1]and Amf 40 t ha-[1]at the root with a mean value of 0.94g and 2. 86g respectively.The highest dry matter yield was recorded when Amf 40 t ha-[1]was used as an amendment for the leaves, stem and root while the lowest dry matter yield was observed in -Amf 10 t ha-[1]for leaves with a mean value of 0.85g, -Amf 40 t ha-[1]for stem with a mean value of 0.31 and -Amf 30 t ha-[1]for roots with a mean value of 0.94g.

Mycorrhizal plants had significantly (*p<0.05*) higher shoot and leaves dry matter yields compared to non-mycorrhizal plants (Table 4). This could be attributed to the ability of mycorrhizal to improve absorption of nutrients. The result agrees with the findings of previous researchers including Al-Karaki*et al.* (1998) who reported increase shoot dry matter yields with mycorrhizal inoculation in wheat plants(*Triticumaestivum*L.). However, significant difference (*p<0.05*) was observed in root dry matter yields due to mycorrhizal inoculation, this result was contrary to Ebrahim and Nasser (2013) that mycorrhizal treatments had no significant effect (*p<0.05*) on root dry matter yield of tomato plants. Shoot dry matter yields increased with increasing rate of compost application, with +Amf 40 t ha-1 of compost producing significantly (*p<0.05*) higher shoot dry matter yields. However, +Amf 40 t ha-1 of compost application rate was found to be comparable with +Amf10 and +Amf30 t ha-1 of compost application rates in shoot dry matter yields.

Table 6: Physical and chemical properties of the Postharvest soil.

Treatment	**N (g/Kg)**	**P (mg/Kg)**	**K (cmol/Kg)**	**Ca (cmol/Kg)**	**Mg (cmol/Kg)**	**Na (cmol/Kg)**	**Cu (mg/Kg)**	**O.C (%)**	**O.M (%)**	**Mn (mg/Kg)**
+Amf 0	0.12	3.52	0.002	11.58	0.96	2.89	3.7	1.44	2.48	388
-Amf 0	0.15	3.85	0.002	14.17	1.11	3.13	3.7	1.78	3.06	316
+Amf10	0.11	2.32	0.002	13.17	0.85	2.74	3.4	1.30	2.24	376
-Amf 10	0.08	1.14	0.002	13.97	1.43	2.86	4.4	0.94	1.62	340
+Amf 20	0.15	11.10	0.002	11.57	1.12	2.67	4.7	1.74	2.99	336
-Amf 20	0.17	12.40	0.002	9.58	1.29	2.87	4.3	1.94	3.34	372
+Amf 30	0.15	0.75	0.002	10.18	0.75	3.11	4.4	1.49	2.58	396
-Amf 30	0.11	1.46	0.003	15.76	1.23	3.11	4.3	1.72	2.96	408
+Amf 40	0.08	2.13	0.002	10.18	0.75	2.88	5.1	0.99	1.71	408
-Amf 40	0.11	4.54	0.003	13.37	0.95	3.10	3.80	1.28	2.20	312

The analysis of the soil before and after the experiments could also be comparable to one another as no variation was observed. The application of mycorrhizal and compost boosted the mineralization of the soil after the amendments.

Conclusion and recommendation

This study reveals that the inoculation of AMF into soil amended with compost at 40 t ha^{-1} and 20 t ha^{-1} had a more synergetic interaction between AMF and compost in the soil with resultant higher growth performance of *Parkiabiglobosa* when compared with other combinations in the study.The higher nutrient content of the compost could also be identified as one of the factors increasing root dry matter yield and the growth parameter while AMF inoculation significantly improved plant root dry matter yield.Inoculated soils generally performed better than un-inoculated ones in almost all the growth parameters examined in this study showing that AMF inoculation actually influenced the growth of *Parkiabiglobosa*in this sudy area. It is therefore recommended that AMF can successfully be inoculated into compost (40 t ha-1 and 20 t ha-1) amended soil for improved performance of *Parkiabiglobosa* in the study area.

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