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RESEARCH ARTICLE

Influence of Arbuscular Mycorrhizal Fungi, Green Manure of *Leucaena leucocephala* and *Gliricidia sepium* on the Yield of White Yam (*Dioscorea rotundata*) and Soil Bioremediation in the Abandoned Quarry

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ABSTRACT

White yam (*Dioscorea rotundata*) was planted in the abandoned quarry to determine the growth and yield effects of mycorrhizal fungi, green manure, and other soil amendments. Seed yams were planted on the heaps (1 m × 1 m) in three replicates and three blocks. Data collected were analyzed using analysis of variance and Duncan multiple range test. The results showed that *Glomus mosseae, Glomus etunicatum,* green manure of *Gliricidia sepium* (GS), poultry manure, and NPK fertilizer influence yam's shoot, root, and tuber weights. It was further observed that the combined treatments of GS and *Leucaena leucocephala* had better enhancement of growth and yield characters of yam. Biofertilizers together with plant and animal remains are therefore recommended for the bioremediation of quarry and other areas affected by natural, human, or ecological activities.

Key words: *Gliricidia sepium, Glomus* sp., White yam, Yield

INTRODUCTION

White yams belong to the family Dioscoreaceae. It requires a nutrient-rich soil and a rainfall of over 1500 mm per year.[15] It is a major source of income and staple carbohydrate for large percentage of the people in Africa. Yam also contains a high value of protein (2.4%), vitamins, and some other minerals such as calcium, phosphorus, and iron than any other tuber crop.[2,3] Biofertilizers such as fungus and some bacteria are environment friendly; they are comparatively low in cost inputs with high soil enrichment quality.[11,20] Microorganisms convert complex organic materials into simple compounds so that the plant can easily take up the nutrients. These fertilizers harness atmospheric nitrogen and make it directly available to the plants. They increase the phosphorous content of the soil by solubilizing and releasing unavailable phosphorous to the plants. Biofertilizers improve root proliferation due to the release of growth promoting hormones. They help in increasing the crop yield by 10–25% (www.wikipedia.org). Chemical fertilizers have high nutrients contents which are rapidly absorbed by plants, but are expensive, can result in nutrient loss, contamination of water, soil acidification or basification, destruction of soil microorganisms, etc. The impact of human activities such as deforestation, mining, oil exploration and construction of house of roads, and industries has reduced the quality and quantity of agricultural lands. This work investigates the influence of biofertilizers and some other soil amendments on the growth and performance of white yam under nutrient-depleted soil.

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MATERIALS AND METHODOLOGY

This work was carried out at a (stone) quarry (behind male hall of residence at the Federal College of Education, Abeokuta, Ogun State, Nigeria). The land was cleared and heaped at 1 m × 1 m. Viable seeds (250–800 g) of *Dioscorea rotundata* (Efuru) were collected from the popular

Bodija Market, Ibadan, Oyo State, Nigeria. These (seed yams) were planted in May 2017. Prior planting of seed yams, soil samples were collected, biophysical and chemical analysis were carried out at the Soil Laboratory, Federal University of Agriculture, Abeokuta, Nigeria.

About 20 g of sand containing the inoculum of *Glomus mosseae* - TH Nicolson and Gerd and *Glomus etunicatum* - WN Beckert and Gerd obtained from the Microbiology Laboratory, Department of Agronomy, University of Ibadan, Oyo State, were carefully measured into the dug hole and the seed yams carefully laid on it and then covered with sand.

About 50 g of poultry manure (PM) obtained from the poultry farm in Abeokuta, 200 kg/ha of NPK fertilizer purchased from Agbeni/Ogunpa market, Ibadan, Oyo State, Nigeria, and 800 g of leaves of *Gliricidia sepium* (GS) and *Leucaena leucocephala* (LL) (identified at the Botany Department, University of Ibadan) were applied 2 weeks after sprouting. Staking of each plant was done with bamboo trees and other trees while weeding and other agronomic practices were duly carried out. Growth and yield characters were determined.

RESULTS AND DISCUSSION

Tables 1-3 showed the soil physical and chemical factors. The soil pH remained the same throughout the period of study. Soil's nitrogen increased by 0.28%, average phosphorus by 7.8 mg/kg, while potassium increased by 0.086 mol/kg. There were significant increases in the amount of all the other macroelements. Similarly, there were differences in the amount of trace elements before planting and after harvesting. Iron (Fe), zinc (Zn), and manganese (Mn) increased by 0.142, 0.335, and 0.1, respectively, while slight decrease was observed in other microelements. There was increase in the amount of silt fine sand. There was a reduction in the amount of clay, coarse particles, and gravel. These results support the findings of many workers who opined that lack of macronutrients and micronutrients in the soil can be corrected by the addition of PM which will promote and enhance the growth and yield of plants.[5,18] The use of organic manure has been reported to enhance soil productivity, increase the soil organic carbon content, soil microorganism, improves soil structure, the nutrient status of the soil, and enhance crop yield.[3,7,17,19]

PMs are good soil conditioners that should be incorporated into the soil to save nitrogen.[8] It was also reported that the use of PM as organic amendment significantly improved the physiochemical and morphological properties of the soil.[12] Another treatment that aid in bioremediation of the soil in this site is GS which fixes nitrogen into the soil.[4,6,15] GS and Leucaena were reported to release more mineral elements to the soil which are readily made available to the plants.[2,22] The results of this work might also be due to the influence of mycorrhizal fungi on the soil microbial populations and exudates in the mycorrhizosphere and hyphosphere.[1] Hyphae of AM fungi are considered to contribute

Table 1: Soil chemical analysis showing the major elements

Chemical properties	pH	N (%)	H	Ca (mol/kg)	Mg (mol/kg)	Av.P (mg/kg)	C (%)	Na (mol/kg)	K (mol/kg)
Before planting	7.2	0.531	0.4	0.284	0.361	42.57	1.733	0.581	0.624
After harvesting	7.2	0.811	0.6	0.431	0.597	50.37	2.061	0.824	0.710

Table 2: Soil micronutrients

Chemical properties	Fe (mg/kg)	Zn (mg/kg)	Mn (mg/kg)	Cu (mg/kg)	Pb (mg/kg)	Co (mg/kg)	Bo (mg/kg)	Mo (mg/kg)
Before planting	6.89	1.045	0.967	0.691	0.811	0.456	0.216	0.189
After harvesting	8.31	1.380	1.067	0.612	0.687	0.318	0.224	0.162

Table 3: Soil physical properties

Properties	Sand (%)	Clay (%)	Silt (%)	Coarse particles (%)	Fine (%)	Gravel (%)
Before planting	61.3	2.4	36.3	38.67	61.33	10.12
After planting	58.91	2.0	45.4	43.61	73.05	10.01

to soil structure. Hyphal mats produced by ectomycorrhizal fungi alter soil structure.[9] Mycorrhizal fungi contribute to carbon storage in soil by altering the quality and quantity of soil organic matter.[21]

The influence of organic and inorganic fertilizers applications on the shoot weight was examined and the result was presented in Table 4. The shoot weight was highly influenced by the combined treatments of GS and LL (GS+LL). Higher shoot weights were observed in PM+LL, GE+NPK, GM+GS, and GM+PM but were significantly different from one another. PM had higher shoot weight (768.14 g) but was not significant difference from NPK in their shoot weights. White yam treated with the green manure of GS had value that was significantly different from LL. Among the mycorrhizae used, *G. mosseae* had higher shoot weight which was significantly different from *G. etunicatum.* The untreated white yam had the least value.

The result of the root weight of white yam treated with AMF, green manure of some leguminous trees, and other soil amendments [Table 5] showed that yam treated with GS+LL had the highest value which was not significantly different from PM+GS but was different from all the other treatments. Root weight was influenced by NPK+LL, NPK+GS, PM+NPK, GE+GS, GM+LL, GM+GS, GM+PM, and PM. The least value was observed in the untreated yams. This enhanced growth in yams on different soil amendments might be because of the enhanced chlorophyll production, which promotes aerial growth, increase root, leaf area, number of branches, and height.[11,13]

The combined treatments of GS+LL enhanced higher tuber weight which was significantly different from all the other treatments [Figure 1]. It is noteworthy to observe that the two *Glomus* species and all the organic manure enhanced high tuber yield (above 2 kg) when compared with the untreated yams. This result was in tandem with 3.5 kg/plant and 2.41 kg/plant reported by some Shiwachi *et al.*, Law-Ogbomo and Remison, respectively[4,10,16]. This result showed enhanced performance in the root, shoot, and tuber weight of plants treated with AMF, GS, GE, PM, and GM applied singly or in combinations. This showed the effectiveness of arbuscular mycorrhizal fungi and organic manure in soil amendments. The enhanced performance in this research might be due to the ability of AMF to increase the absorptive surface area of the plants and the organic manure which enrich the soil.[16,14]

Table 4: Shoot weight of white yam treated with arbuscular mycorrhizal fungi, green manure of *Gliricidia sepium* and *Leucaena leucocephala*, and other soil amendments under nutrient-depleted soil

Treatments	Shoot weight
GM	522.71[j]
GE	505.37[jk]
PM	768.14[g]
NPK	760.50[g]
GS	793.00[e]
LL	709.61[h]
GM+GE	590.76[i]
GM+PM	810.32[c]
GM+NPK	795.71[e]
GM+GS	832.04[b]
GM+LL	769.28[g]
GE+PM	785.62[ef]
GE+NPK	804.00[d]
GE+GS	702.41[h]
GE+LL	792.11[e]
PM+NPK	575.08[i]
PM+GS	762.51[g]
PM+LL	802.33[d]
NPK+GS	722.04[h]
NPK+LL	780.31[ef]
GS+LL	877.11[a]
CTRL	110.20[l]

Means with same letter in each column are not significantly different at Duncan's multiple range test ($P<0.05$). GM: *Glomus mosseae*, GE: *Glomus etunicatum,* PM: Poultry manure, GS: *Gliricidia sepium,* LL: *Leucaena leucocephala*; their combined treatments and CTRL: Untreated yams

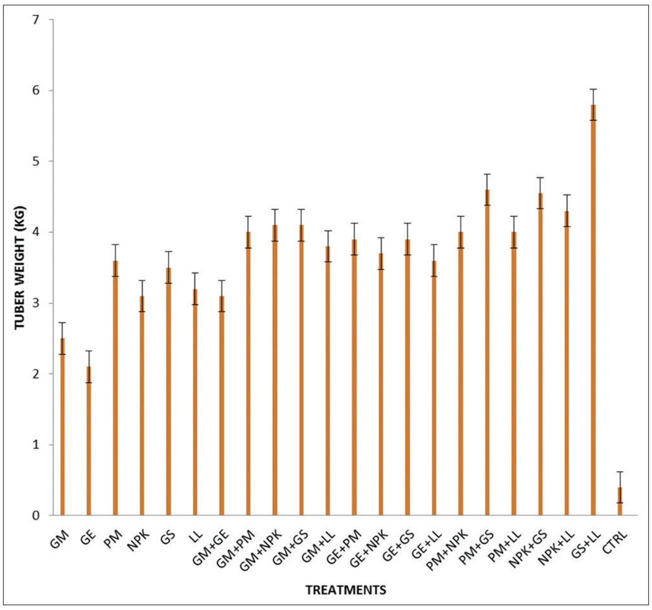

Figure 1: Tuber weight of white yam as treated with arbuscular mycorrhizal fungi, green manure of Gliricidia sepium and Leucaena leucocephala, and other soil amendments under nutrient-depleted soil

Table 5: Effect of arbuscular mycorrhizal fungi, green manure of *Gliricidia sepium* and *Leucaena leucocephala*, and other soil amendments on the root weight under nutrient-depleted soil

Treatments	Root weight (g)
GM	15.03[h]
GE	15.31[h]
PM	18.75[d]
NPK	15.06[h]
GS	17.35[f]
LL	17.61[f]
GM+GE	17.97[e]
GM+PM	19.66[c]
GM+NPK	17.37[f]
GM+GS	19.06[c]
GM+LL	18.22[d]
GE+PM	16.51[g]
GE+NPK	17.93[e]
GE+GS	18.47[d]
GE+LL	16.02[g]
PM+NPK	20.40[b]
PM+GS	22.18[a]
PM+LL	18.71[d]
NPK+GS	19.30[c]
NPK+LL	18.00[de]
GS+LL	22.91[a]
CTRL	8.74[i]

Means with same letter in each column are not significantly different at Duncan's multiple range test ($P<0.05$). GM: *Glomus mosseae*, GE: *Glomus etunicatum*, PM: Poultry manure, GS: *Gliricidia sepium,* LL: *Leucaena leucocephala*; their combined treatments and CTRL: Untreated yams

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