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# Effects of Green Manure of *Gliricidiasepium* (JacqKunth) and *Leucaenaleucocephala* (Lam De Wit), Arbuscular Mycorrhizal Fungi, and soil Amendments on the Physiological and Yield Characters of White yam (*Dioscorearotundata* - Poir) under Nutrient-depleted Soil

**Dr. Afolayan Ezekiel Taiwo**
Senior Lecturer, Department of Biology, Federal College of Education, Osiele, Abeokuta, Ogun State, Nigeria

***Abstract:***
*Food shortage due to poor yield of food crops threatens the ever growing population in Africa and especially West African sub-region as a result of desertification, erosion over cropping, and land excavation. This present work intends to improve tuber yield in white yam under arbuscular mycorrhizal fungi, green manure of some leguminous (forage) trees and soil amendments in a nutrients-depleted soils. The study was carried out on a nutrients-depleted soil where land excavation had taken place behind the male hostel at the Federal College of Education, Abeokuta, Ogun State, South-West Nigeria. The land was cleared and heaped at 1mX1m and arranged in a completely randomized block design in three replicates. Data obtained were subjected to analysis of variance (ANOVA) and the means were separated using Duncan Multiple Range Test (DMRT). The results showed that green manure of Gliricidia sepium and Leucaena leucocephala enhanced chlorophyll production, water status and tuber weight in white yam. Other treatment that also enhanced white yam's physiological and yield characters are Glomus mosseae, G. etunicatum, poultry manure and NPK fertilizer. Though both organic and inorganic fertilizers enhanced tuber yield, the ecological hazards of inorganic fertilizers make organic fertilizers to be recommended for white yam's tuber yieldimprovement.*

***Keywords:*** *Tuber yield, Mycorrhizal fungi, green manure, Nutrients-depleted soils*

## 1. Introduction

White yam (*Dioscorearotundata),* which belong to the family Dioscoreaceae with about 600 species is a major food crop in Africa. It has about 50-60 species which are cultivated for food or pharmaceutical purposes. Among this family, *Dioscorea* is the largest genus of the family (Oyetunji *etal*., 2003; Behera*etal*., 2009). It thrives well on permeable soils of high fertility(from sea level up to 900 m) and requires a well distributed rainfall of 1,500mm per annum (Oyetunji *et al*., 2003).White yam is the major cultivated food crop that makes up the major food served in different forms in West African sub-region and an important source of income for a wide range of small holders, including women who are marketers of yam tubers and products before the introduction of exotic crops such as maize, rice, cassava and potato (Asuming-Brempong, 1994; IITA,1999).

Yam is sometimes used as feed for livestock. It is also used industrially for the production of alcohol, fuel for energy; manufacture of gums and adhesives, as foaming agent in brewing industries, manufacturing of drugs, insecticides, flavours, fragrances, drinks and cosmetics. It is also used for the production of birth control pills, sex hormones, anabolic steroids and treatment of asthma, rheumatoid arthritis and skin disorders. It is a source of proteins, fats and vitamins (Armstrong, 1996).Different workers compared income contributions of yam among other crops and found that yams constituted an average of 32% of farmers' gross income and that despite the high production cost its production is profitable (Lageman, 1977; Lyonga, 1981). It was also found that yam commands highest socio-cultural value among the people of Nigeria (Orkwor*etal*., 1998).

Despite this huge economic importance of yam its productions are in the hands of small-scale farmers. Sequel to this, the demand for yam tubers in Nigeria still exceeds its supply in nearest future.

Mycorrhizal benefits include greater yield, nutrient accumulation, and/or reproductive success (Lewis and Koide, 1990). Arbuscular mycorrhizal fungi (AMF) helps the plant in the uptake of some elements such as Phosphorus, Copper, Zinc, Manganese, Magnesium etc. which are considered to be relatively immobile (Oyetunji *et al*., 2003). Fagbola*et al.,* (1998)opined that arbuscular mycorrhizal fungi enhance greater contributions to cassava's growth, yield and nutrients uptake than the uninoculated plants.

*Gliricidia sepium* and *Leucaenaleucocephala* are leguminous trees used in many tropical and sub-tropical countries for various purposes such as live fencing, fodder, coffee shade, firewood, green manure and rat poison (Elevitch, 2004; Andrew *et al*., 2004). According to World Agroforestry Centre, this species is becoming an important part of farming practices in Africa. *G. sepium* has a combination of desirable properties in that it fixes nitrogen in the soil, it boosts crop yields significantly without the expense of chemical fertilizers (Dommergues, 1987; Oyetunji *et al.,* 2003). When *G. sepium* was used as green manure, yields of taro, yam and rice were increased (by 54 per cent) and reduce time to harvest (Budelman, 1988). Bindumadhava, (1966) and Patil, (1989) reported that one tonne dry weight of gliricidia leaves is equivalent to 27 kg N. Rajan and Alxander (1988) reported that when *G. sepium* is used as mulch in rice field, incidence of rice blight disease was reduced. There was greater availability of nutrients to cassava roots from *G. sepium* and Leucaena than from Senna plants under AM fungi inoculation (Osonubi*et al.,*1995).

## 2. Objectives

Sustainable food production in African is affected by infertile and unproductive land as a result of drought, desertification, erosion, land tenure system, overgrazing and over cultivation. Application of inorganic fertilizers increases the cost of production without commensurate increase in crop yield, kills soil humus and microorganisms, alters the soil biophysical properties, causes algal bloom and kills aquatic animals when washed into nearby streams and rivers. This had resulted in the declining food production and rising dependency on (food) importation which is now threatening the vast population with malnutrition, hunger and starvation (Yaker, 1993).

Low yield of some major food crops, like yam tubers as a result of limited and rapidly diminishing land (for food production), nutrients depletion and ecological hazards posed by the use of inorganic fertilizers necessitated in this study, the use of bio - fertilizers which are environmentally friendly to increase the yield of food cops (e.g. White yam) in nutrient-depleted soils in order to bridge the gap between demand and supply of food and ensure proper human nutrition.

The general aim of this work is to evaluate the yield potential of white yam under Arbuscular mycorrhizal fungi (AMF), green manure and soil amendments in nutrient-depleted soils. This on-going research aims at assessing the physiological and yield responses of cultivated white yam to symbiotic fungi (Arbuscular mycorrhizal fungi) and green manure of some leguminous tree like *Gliricidia sepium* and *Leucaenaleucocephala.*

## 3. Materials andMethods

### *3.1. SamplesCollection*

Viable seeds of *Dioscorea rotundata* (Efuru) were collected from Bodija Market, Ibadan, Oyo State.

### *3.2. BotanicalIdentification*

Botanical identification of seed yams, leaves of *G. sepium* and *L. leucocephala* were duly carried out.

### *3.3. Collection of Fungal Inoculum andTreatments*

AMF (*Glomus mosseae* - TH Nicolson &Gerd and *Glomus etunicatum* – WN Beckert&Gerd) were obtained from the Microbiology Laboratory, Department of Agronomy, University of Ibadan, Oyo state. Poultry manure was obtained from the poultry farm in Abeokuta, while NPK, fertilizers was purchased from Agbeni/Ogunpa market, Ibadan.
Leaves of *Gliricidia sepium* and L. *leucocephala* were collected from the University of Ibadan.

### *3.4. Determination of Biophysical Properties*

Prior planting of seed yams, soil samples were collected, biophysical and chemical analysis were carried out.

### *3.5. Land Preparation, Planting and TreatmentsApplication*

Heaping was done at 1m X 1m. Seed yams (250 -800 g) were planted on prepared heaps.Twenty gram (20 g) of sand containing the inoculum of *Glomusmosseae* and *Glomus etunicatum* were carefully measured into the dug hole and the seed yams carefully laid on it and then covered with sand.

For the Green manure treatment, the heaps were covered with 800 g of *Gliricidiasepium* and *L. leucocephala* leavesafter planting accordingly. Fifty gram (50 g) of poultry manure was also applied two weeks after sprouting as poultry manure (PM) treatment. While 200 kg/ha of NPK were applied two weeks after sprouting as NPK treatment.

### *3.6. Staking andWeeding*

Staking of each plant was done with bamboo trees and other trees while weeding and other agronomic practices were duly carried out.

*3.7. Determination of ChlorophyllContents*

Chlorophyll content of the leaves was determined by using pocket chlorophyll meter. This was done between 7.00am – 10.00 am before the photo assimilation of chlorophyll occurs.

*3.8. Determination of Relative WaterContent*

This was done by collecting fresh leaves from each treatment. Using cork borer, they were cut into small discsand weighed (sample's fresh weight W). The samples were then hydrated to full turgidity in distilled water for 4 hours under normal room condition. After this, the leaves were quickly dried off with filter paper and immediately weighed as the turgid weight (TW). Samples were then dried in an oven at 80°C for 24 hours, cooled in a desiccator and later weighed as the dry weight. Relative water content (R W C) was determined using this formula:

$$RWC\ (\%) = \frac{W - DW}{TW - DW} \times 100$$

Where W = sample fresh weight; DW = sample dry weight; TW = sample turgidweight.

### 4. Results andDiscussion

| Treatments | Weeks After Treatment (WAT) | | | |
|---|---|---|---|---|
| | 10 | 12 | 14 | 16 |
| GM | 43.70cd | 63.17g | 67.37ef | 77.71e |
| GE | 45.00c | 60.03h | 65.03f | 72.10g |
| PM | 43.53cd | 65.30f | 69.67e | 80.31c |
| NPK | 41.73d | 65.00f | 74.93b | 79.64d |
| GS | 44.20cd | 67.50e | 74.10b | 81.02c |
| LL | 47.27b | 65.03f | 69.90e | 72.00g |
| GM+GE | 49.70ab | 64.07f | 68.60e | 71.41h |
| GM+PM | 49.00ab | 67.0e | 70.93d | 82.30b |
| GM+NPK | 46.23c | 63.23g | 73.40bc | 74.21f |
| GM+GS | 49.67ab | 76.27b | 77.07a | 82.33b |
| GM+LL | 47.10b | 78.27a | 77.60a | 79.41d |
| GE+PM | 44.43cd | 62.03g | 74.80b | 81.23c |
| GE+NPK | 48.07b | 65.20f | 70.83d | 79.14d |
| GE+GS | 48.44b | 72.70cd | 75.40ab | 83.11b |
| GE+LL | 50.00a | 73.93c | 74.13b | 79.40d |
| PM+NPK | 48.30b | 70.77d | 71.97d | 80.43c |
| PM+GS | 46.30c | 71.43cd | 72.83c | 82.10b |
| PM+LL | 50.20a | 70.10d | 73.67bc | 80.22c |
| NPK+GS | 50.00a | 72.09cd | 74.00b | 82.52b |
| NPK+LL | 50.30a | 74.00c | 74.82b | 80.14c |
| GS+LL | 50.56a | 71.59d | 73.60bc | 85.41a |
| CTRL | 21.90e | 27.41i | 36.90g | 33.40i |

*Table 1: Chlorophyll contents of white yam treated with arbuscular mycorrhizal fungi, green manure of Gliricidiasepium and Leucaenaleucocephala and other soil amendments under nutrient-depleted soil*

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.

Table 1 shows the leaf chlorophyll synthesis of white yam treated with *Glomus mosseae, Glomus etunicatum*, green manure of *Gliricidia sepium* and *Leucaena leucocephala* and other soil amendments under nutrient-depleted soils. At 10 weeks after treatment (WAT), the combined treatments of GS+LL had the highest value for chlorophyll content but this value was not significantly different from NPK+LL, NPK+GS, PM+LL AND GE+LL treated plants. The untreated plants had the least values throughout the period of study.At 12WAT, the combined treatments of *Glomus mosseae* and leguminous plants – *Leucaena leucocephala* (GM+LL) had the highest value (78.27) which was significantly different from all the other treatments. It is of interest to observe that the combined treatments of *Glomus mosseae* and another species of leguminous tree –*Gliricidia sepium* (GM+GS) also had a very high value for chlorophyll synthesis (76.27). The combined treatments of *Glomusmosseae*and leguminous trees (GM+LL and GM+GS) had values which were significantly not different at 14WAT, but were higher than all the other treatments. But at 16 WAT, the GS+LL had the highest chlorophyll contents which was different statistically from all the other treatments. It was further observed that NPK+GS, PM+GS, GE+GS, GM+GS and GM+PM had higher chlorophyll contents, with values which were statistically not different (Oyetunji *et al*., 2009).

The relative water content of the leaves of white yam under arbuscular mycorrhizal fungi, green manure of some leguminous plants and other soil amendments was determined and the result was as presented in Table 2. It was observed that the combined treatments of the two mycorrhizal fungi –*Glomus mosseae* and *Glomus etunicatum* had highest water content at 10WAT (Oyetunji and Afolayan, 2007), which was not statistically different from GM+GS. This may be as a result of the numerous mycelia fragments of the mycorrhizal fungi. The untreated yam plants had the least. At 12WAT, enhanced relative water content was observed in plants treated with PM+LL, but was not statistically different from GS+LL treated plants. Other treatments with enhanced water contents were PM+GS, GM+LL and GM+GS. Similar results were obtained at 14WAT, with the combined treatments of the leguminous trees having highest relative water contents (67.9). At 16WAT, GM+GE enhanced higher relative water content which was significantly higher than all the other treatments. The results of this workcorroboratethereportofOyetunji*etal*, (2009)thatwaterstatusandchlorophyllsynthesisincreasewithplantage.

Table 3 shows the tuber weights of white yam as influenced by arbuscular mycorrhizal fungi, green manure of *Gliricidia sepium* and *Leucaena leucocephala* and other soil amendments under nutrient-depleted soil. Green manure of *Gliricidia sepium*combined with *Leucaena leucocephala* enhanced higher tuber weight (5.80 kg) at harvest. Higher tuber weights were also observed in NPK+GS and PM+GS. This shows that *Gliricidia sepium* is excellent organic manure that is rich in both macro and micro nutrients for the growth and productivity of plants ((Dommergues, 1987). The results also show that *Glomusmosseae* (GM) had greater potential to increase tuber yield than *G.* etunicatum (Oyetunji and Afolayan, 2007), likewise GS than LL. The higher chlorophyll synthesis and water contents in plants treated with *Gliricidia sepium* (GS) and *Leucaena leucocephala* (LL) singly or in combination may be responsible for the enhanced tuber weights in these treatments. This results corroborate the reports of Oyetunji *et al.,* 2003 who opined that *G. sepium* has a combination of desirable properties in that it fixes nitrogen in the soil, it boosts crop yields significantly without the expense of chemical fertilizers. The untreated plants had the least tuber weight. It was interesting to observe that organic and inorganic fertilizers influence yam tuber yield. This was similar to the findings of Oyetunji*et al.,* 2009 who reported that yams responded same way to organic manure and inorganic fertilizersapplications.

| Treatments | Weeks After Treatment (WAT) | | | |
|---|---|---|---|---|
| | 10 | 12 | 14 | 16 |
| GM | 23.50$^{h}$ | 37.21$^{f}$ | 57.30$^{g}$ | 67.50$^{c}$ |
| GE | 21.00$^{j}$ | 34.90$^{h}$ | 52.71$^{i}$ | 65.31$^{d}$ |
| PM | 24.31$^{g}$ | 41.04$^{c}$ | 55.35$^{h}$ | 56.14$^{h}$ |
| NPK | 24.30$^{g}$ | 36.31$^{g}$ | 47.80 | 50.62$^{i}$ |
| GS | 25.81$^{f}$ | 40.25$^{d}$ | 60.27$^{e}$ | 62.51$^{ef}$ |
| LL | 24.00$^{b}$ | 41.51$^{c}$ | 60.30$^{e}$ | 61,74$^{f}$ |
| GM+GE | 31.51$^{a}$ | 42.34$^{bc}$ | 59.00$^{ef}$ | 75.33$^{a}$ |
| GM+PM | 29.20$^{b}$ | 42.78$^{bc}$ | 59.20$^{ef}$ | 60.41$^{g}$ |
| GM+NPK | 29.30$^{b}$ | 40.20$^{d}$ | 50.00 | 57.03$^{h}$ |
| GM+GS | 30.61$^{a}$ | 45.28$^{ab}$ | 61.53$^{d}$ | 62.00$^{ef}$ |
| GM+LL | 28.11$^{c}$ | 45.00$^{ab}$ | 60.74$^{e}$ | 62.12$^{ef}$ |
| GE+PM | 26.22$^{cd}$ | 43.41$^{b}$ | 61.50$^{d}$ | 61.72$^{f}$ |
| GE+NPK | 25.25$^{f}$ | 40.30$^{d}$ | 56.70$^{g}$ | 60.52$^{g}$ |
| GE+GS | 26.94$^{de}$ | 41.63$^{c}$ | 62.00$^{cd}$ | 63.40$^{e}$ |
| GE+LL | 22.79$^{i}$ | 43.22$^{b}$ | 61.36$^{d}$ | 62.14$^{ef}$ |
| PM+NPK | 24.22$^{g}$ | 40.71$^{d}$ | 58.11$^{f}$ | 61.20$^{f}$ |
| PM+GS | 24.41$^{g}$ | 45.04$^{ab}$ | 65.80$^{b}$ | 64.30$^{d}$ |
| PM+LL | 23.40$^{h}$ | 46.81$^{a}$ | 63.19$^{c}$ | 63.55$^{e}$ |
| NPK+GS | 27.11$^{d}$ | 38.91$^{e}$ | 59.36$^{ef}$ | 62.31$^{ef}$ |
| NPK+LL | 25.29$^{f}$ | 39.62$^{e}$ | 58,93$^{f}$ | 61.47$^{f}$ |
| GS+LL | 28.17$^{c}$ | 46.03$^{a}$ | 67.90$^{a}$ | 68.26$^{b}$ |
| CTRL | 16.38$^{k}$ | 21.87$^{i}$ | 25.60$^{j}$ | 35.00$^{j}$ |

*Table 2: Influence of arbuscular mycorrhizal fungi, green manure of Gliricidiasepium and Leucaenaleucocephala and other soil amendments on white yams' Relative water contents (RWC) under nutrient-depleted soil*

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.

| Treatments | Tuber weight |
|---|---|
| GM | 2.50[j] |
| GE | 2.10[k] |
| PM | 3.60[f] |
| NPK | 3.10[i] |
| GS | 3.50[g] |
| LL | 3.20[h] |
| GM+GE | 3.10[i] |
| GM+PM | 4.00[d] |
| GM+NPK | 4.10[d] |
| GM+GS | 4.10[d] |
| GM+LL | 3.80[e] |
| GE+PM | 3.90[e] |
| GE+NPK | 3.70[f] |
| GE+GS | 3.90[e] |
| GE+LL | 3.60[f] |
| PM+NPK | 4.00[d] |
| PM+GS | 4.60[b] |
| PM+LL | 4.00[d] |
| NPK+GS | 4.55[b] |
| NPK+LL | 4.30[c] |
| GS+LL | 5.80[a] |
| CTRL | 0.40[l] |

*Table 3: Tuber weight of white yam as influenced by arbuscular mycorrhizal fungi, green manure of Gliricidiasepium and Leucaenaleucocephala and other soil amendments under nutrient-depleted soil*

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.

## 5. Conclusion

In the face of climate change, desertification, erosion and land excavation, poor yield of food crops threatens the ever growing population in Africa and especially the West African sub-region. To mitigate the effects of these climatic and other ecological problems, there is need to increase food production through bio agents which can remediate the soil, affordable and available. In this present study, green manure of *Gliricidia sepium* and *Leucaena leucocephala* enhanced the chlorophyll synthesis and relative water accumulation in yam, which in turn enhanced the tuber yield in white yam. Similarly, arbuscular mycorrhizae (*G. mosseae* and *G. etunicatum*) were also observed to enhance physiological and yield characters in yam when applied singly or in combinations.

In an abandoned land like the ones used in this study, animal remains or wastes, plants manure or plants remains can be used to remediate nutrient-depleted soil and also to improve yield of both cash and food crops.

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