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# Effects of mycorrhizae, NPK 15:15:15 and poultry manure on some soil properties, microbial populations and growth of rubber *Hevea brasiliensis* seedlings.

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**ABSTRACT**

The study was conducted during the 2015 planting season at the Rubber Research Institute of Nigeria, Iyanomo, Edo state to determine the effects of different treatments on some chemical properties of the soil, microbial populations and growth of rubber seedlings. The treatments consisted of four strains of mycorrhizae ($M_0$, $M_1$, $M_2$ and $M_3$) applied at the rate of 5000 kg/ha each, NPK 15:15:15 at the rate of 112 kg/ha and poultry manure applied at the rate of 6000 kg/ha which gave rise to 12 treatment. The experimental design was a 3 x 4 factorial fitted into a Randomised Complete Block Design (RCBD) and replicated three times. Data collected on growth parameters were; plant girth and height at monthly intervals for seven months. Soil samples were obtained before and after treatment application at 0 - 15 cm depth. The microbial population was determined at the third and seventh month after treatment application. Genstat was used for statistical analysis (ANOVA). The result showed general improvements in the chemical properties after application of treatments in organic matter, nitrogen, pH, calcium, potassium, Avail phosphorus, ECEC and base saturation. Bacterial and Fungal-populations increased significantly as compared to control after three months with a value of 22.32 x $10^4$cfu and 12.45 x $10^4$cfu, respectively. Invariably the same treatment recorded a higher growth response of rubber seedlings on girth and height in the second, third, fourth, fifth, sixth and seventh month- respectively, which connotes that mycorrhizae support the growth of rubber seedlings.

## 1.0. Introduction

Rubber tree (*Hevea brasiliensis* muell Arg) belongs to the family of latex producing plants referred to as *Euphorbiaceae*. It could be propagated directly by seed or by budded stumps. (Oyenuga, 1967). Rubber was brought to African Countries, including Nigeria in early 1960 (Oyenuga, 1967). The boom in the rubber trade stimulated massive planting of natural rubber in Nigeria, and some farmers were discouraged due to lack of technical known-how in the agronomic practices required for the crop (Ogowewo, 1989). It has a very high commercial and industrial valued in the manufacturing of various articles used daily. One of the essential basis for increase rubber production lies in the development and effective distribution of rubber planting materials (seedlings) that are high yielding, disease and wind tolerant, early maturing and high field survival rate. The fertility management of rubber at the early stage is critical to the productivity of rubber at maturity. This can only be achieved among others through proper soil fertility management in the nursery, where seedlings are produced. Soil infertility is a common problem in the tropics, especially the soils of the rubber belt of Nigeria with few exceptions They are well known for their low available phosphorus (Uzu *et al*, 1985); their nitrogen content is also low as a result of low organic matter content. The available potassium content is invariably low, except in some soils in the north of Calabar (Onuwaje and Uzu, 1980); hence, the need for soil improvement using fertilizer. Fertilizer if use properly enhances the productivity of rubber and their overuse can have a deleterious effect on plant and soil quality (Asawalam and Ugwa, 1993). The negative consequences of the application of inorganic fertilizers have been shown over a period of time.

According to Eka *et al.,* (2010) and Ayoola and Adeniyan 2006 the use of inorganic fertilizer has not been helpful under intensive agriculture because it is often associated with reduced yield as a result of a nutrient imbalance, leaching and pollution of groundwater, Waizah 2018 therefore in Nigeria, most rubber growing soils are predominantly sandy to sandy-loam textured in the surface area and are, therefore, susceptible to nutrient losses. (Waizah 2018). This necessitates the need for an alternative source of nutrient that is readily available, relatively cheap and environmentally friendly. These alternative sources of soil nutrients for this study are Arbuscular Mycorrhizae and poultry manure, respectively. Arbuscular Mycorrhizae (AM) colonizes roots of more than 80% of higher plants due to their ubiquity and symbiotic capacity to roots of plants (Morera -Souze*et al*, 2003). Arbuscular Mycorrhizae is greatly implicated in nutrient uptake, especially phosphorus in most agricultural and native plants (Haridas, 1981). Poultry manure is a waste from the poultry industry, animal manures have been used effectively as fertilizers for centuries. Poultry manure has long been recognized as perhaps the most desirable of these natural fertilizers because of its high nitrogen content. Also, manure supplies other essential plant nutrients and serve as a soil amendment by adding organic matters. Hence, this study was conducted to determine: the effect of mycorrhizal, NPK and poultry manure on some chemical and biological properties of the soil and the influence of these soil nutrients on the Rubber seedlings.

Consequently, the specific objective is to evaluate the effectiveness of mycorrhizal as tools to increase the production and improved rubber seedlings.

**2.0. Materials and Methods**

*2.1. Description of the experimental site*

The field experiment was carried out in 2015 cropping season from October to April at the experimental site of the Soil and Plant Nutrition Division of the Rubber Research Institute of Nigeria, main station Iyanomo, Benin City, Edo State. The study area occupies a land area of 2070 hectares about 29 kilometres away from Benin City, Edo State, Southern Nigeria. The main access road is through Obaretin Village situated at KM 19, Benin- Sapele highway. The area is located within the co-ordinates of 5º34'E and 5º38'E Longitudes 6º08'N and 6º11'N Latitudes. The area lies within the humid rain forest agro-ecological zone. Mean annual rainfall goes above 2000 mm, distributed in a bi-modal pattern with peaks in July and September. The Soils of this humid forest belt are mainly ultisols with pH range between 4.0 and 5.5; the soil has been described as the acid sand derived from unconsolidated grits and sandstones containing clay peds of varying proportions, this area has deep, porous, non-mottled and non-concretionary red soils (sand and sandy clay), which are moderately acid in virgin forest land with strong acid sub-soil that is deficient in plant nutrient Orimoloye, (2011) and Orimoloye and Aikinbola (2013).

2.2. Experimental DesignThe experiment was a 3 x 4 factorial and arranged in a randomized complete block design (RCBD).

2.3. Field Operation

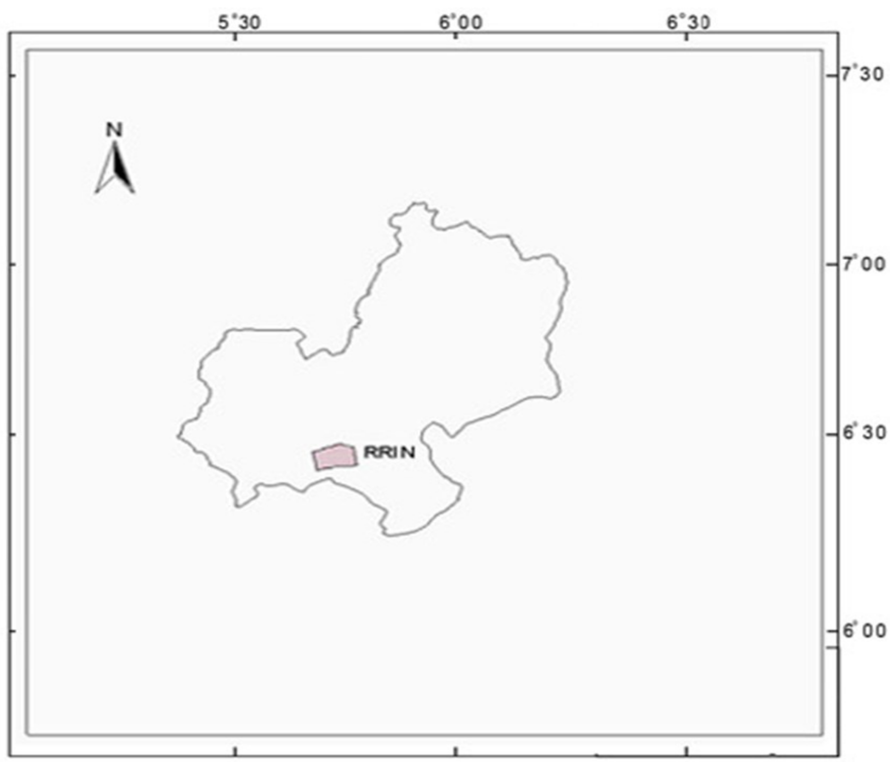



**Figure 1:** Map of Edo State showing the study location
**RRIN:** Rubber Research Institute of Nigeria

The field was partitioning into plots with each measuring 1m x 1m and 1m apart between the plots giving rise to a total of 36 plots. Each plot was pulverized and prepared into beds. The materials used were three strains of mycorrhizal ( $M_0$, $M_1$, $M_2$ and$M_3$) applied at the rate of 5000kg/ha each, NPK 15:15:15 at the rate of 112 kg/ha and poultry

------24m------------

| **REP1** | **Rep 2** | **Rep 3** |
|---|---|---|
| M0F0 | M0F0 | M0F0 |
| Control 101 | 201 | 301 |
| M1F0<br>102 | M0F2<br>202 | M1F2<br>302 |
| M2F0<br>103 | M1F0<br>203 | M3F0<br>303 |
| M3F0<br>104 | M3F2<br>204 | M3F1<br>304 |
| M0F1<br>105 | M1F2<br>205 | M3F2<br>305 |
| M0F2<br>106 | M2F0<br>206 | M2F1<br>306 |
| M1F1<br>107 | M2F2<br>207 | M0F1<br>307 |
| M2F1<br>108 | M0F1<br>108 | M2F2<br>308 |
| M3F1<br>109 | M3F1<br>109 | M2F0<br>309 |
| M1F2<br>110 | M3F0<br>210 | M1F1<br>310 |
| M2F2<br>111 | M1F1<br>211 | M0F2<br>311 |
| M3F2<br>112 | M2F1<br>212 | M1F0<br>312 |

------24m----------

**Figure 2:** A field plot design of experimental site measuring 24 x7 m

$M_0F_0$-control, $M_1$- *Glomus mosseae*, $M_2$-*Glomus clarius*, $M_3$ –*Glomus deserticola*, $F_1$ – NPK 15:15:15, $F_2$ – poultry manure, $M_1F_1$ – *Glomus mosseae*+NPK 15:15:15, $M_2F_1$ – *Glomus clarius*+NPK 15:`15:15, $M_3F_1$ – *Glomus deserticola*+NPK 15:15:15, $M_1F_2$– *Glomus mosseae*+poultry manure, $M_2F_2$ – *Glomus clarius*+poultry manure, $M_3F_2$- *Glomus deserticola*+poultry manure

manure was also applied at the rate of 6000 kg/ha which gave rise to 12 treatments- which are as follows: $M_1F_0$–*Glomusmosseae,* $M_2F_0$–*Glomusclarius,* $M_3F_0$–*Glomusdeserticola,* $M_0F_1$– Chemical Fertilizer 15:15:15 (NPK), $M_0F_2$– Poultry Manure, $M_1F_1$–*Glomusmosseae*+ NPK 15:15:15, $M_2F_1$–*Glomusclarius*+ NPK 15:15:15, $M_3F_1$–*Glomusdeserticola* + NPK 15: 15:15, $M_1F_2$–*Glomusmosseae* + Poultry Manure, $M_2F_2$–*Glomusclarius*+ Poultry Manure, $M_3F_2$–*Glomusdeserticola* +Poultry Manure and $M_0F_0$ which was the control respectively. The experimental design was a 3x4 factorial fitted into a Randomised Complete Block Design (RCBD) and replicated three times.

*2.4. Data Colloection*

Plant data; girth and height were collected at monthly interval for seven months. Soil samplings Soil samplings were carried out before and after application of soil treatments. Twelve (12) composite samples (0-15 cm depth) of the experimental area were collected by simple random sampling using soil auger and bulked to obtain a representative sample, and analysed at the pre-treatment stage. Similarly, soil samples from (0-15 cm depth) were collected from all the experimental plots at three and seven months in all the cropping seasons after the application of treatment to the soil. All samples collected were dispensed into poly bags and labelled appropriately.

They were all subjected to laboratory analysis (chemical and microbial analysis).

*2.5. Data Analysis*

All data sets were subjected to analysis of variance (ANOVA) using GENSTAT 2008 statistical software was used to analyzed the data.

**3.0. Results**

Table 1 shows some of the physical, chemical and biological characteristics of the soil before the application of treatments. 1n 2015 the soil was sandy in texture with base saturation of 80.57%. The soil pH was 4.80 and contained less amount of organic carbon (1.78 g/kg), organic matter (3.08 g/kg). It also composed of Total nitrogen (0.23 g/kg), available phosphorous 5.65 mg/kg, exchangeable calcium (1.23 cmol/kg), potassium (0.90 cmol/kg), sodium (0.30 cmol/kg), Magnesium (0.97 cmol/kg), ECEC (4.22 cmol/kg) and Exchangeable Acidity (0.82 cmol/kg).

*3.2. Effect of different soil amendments on the height and girth of rubber (Hevea brasiliensis) seedlings*

Table 2 and 3 show the effects of the different treatments on the height and girth of rubber seedlings. In Table 2, the results showed a significant difference ($P<0.05$) in the second, third, fourth and sixth months after application of treatments with $M_2F_1$–*Glomusclarius*+ NPK 15:15:15, having the highest value of 45.10, 57.20 and 78.30 cm than the other treatments including the control. In the fifth and seventh months, there was no significant difference ($P.>0.05$) with $M_3F_1$–*Glomusdeserticola* + NPK 15:15:15,showing a higher value of 85.50 and 101.1 cm in the fifth and sixth months while $M_2F_1$ *Glomusclarius*+ NPK 15:15:15 recorded a higher value of 140.3 cm than the other treatments in the seventh month.

**Table 1:** Pre cropping physical, chemical and biological properties of the soil

| **Parameter** | **Values** |
|---|---|
| | **0 – 15 cm** |
| Sand (g/kg) | 949.80 |
| Silt (g/kg) | 7.80 |
| Clay (g/kg) | 42.40 |
| Textural class | Sand |
| pH | 4.12 |
| Organic carbon (g/kg) | 3.45 |
| Organic matter | 5.95 |
| Total N (g/kg) | 0.21 |
| Available P (mg/kg) | 3.26 |
| Exch. Acidity ( C mol /kg) | 2.20 |
| K (C mol/kg) | 0.29 |
| Na (C mol/kg) | 0.04 |
| Ca (C mol/kg) | 1.60 |
| Mg (C mol/kg) | 0.08 |
| ECEC (C mol/kg) | 4.21 |
| Base Saturation (%) | 47.74 |
| Fungi (cfu) | 4.30 |
| Bacterial (cfu) | 6.20 |

N--- Nitrogen, Exch---Exchangeable, K--- Potassium, Na--- Sodium, Ca---- Calcium, Mg --- Magnesium, ECEC--- Effective cation Exchangeable Capacity

In Table 3, there was a significant difference ($P<0.05$) in almost all the months except in the seventh month were there was no significant difference ($P>0.05$) with recording a higher value of 11.51 cm than the other treatments including the control.

*3.3 Effect of different soil amendment on the bacterial count on the soil planted with Rubber (Hevea brasiliensis) seedlings*

The bacterial population on the soil after treatments application showed an increase in all the treatments including the control in the third month with poultry manure ($M_0F_2$) $F_1$–NPK 15:15:15, recording the highest value of 6.68 cfu. However, in the seventh month most of the treatments recorded a decrease in the bacterial population; **,** $M_2$-*Glomus clarius*, $M_2F_2$ – *Glomus clarius* + poultry manure, $M_3$–*Glomus deserticola*, $F_1$–NPK 15:15:15, $F_2$ – poultry manure, $M_3F_2$- *Glomus deserticola* + poultry manure – *Glomus clarius*+NPK 15:`15:15, $M_3F_1$ – *Glomus deserticola*+NPK 15:15:15, while the remaining treatments showed an increase with $M_0F_0$ control recorded a value of 6.87cfu as the highest among the other treatments.

*3.4 Effect of different soil Amendment on the Fungal count of soil planted with Rubber seedlings*

The fungal population showed an increase in the third month in most of the treatments when compared with the control, with *Glomusclarius* ($M_2F_0$) recording the highest value However, in the seventh month, there was a drastic decrease in fungal population in all the treatments including the control, with the soil treated with *Glomusclarius* + NPK 15:15:15 ($M_2F_1$) recording the lowest value among the other treatments including the control.

*3.5 Effect of Treatment Application on some Soil Chemical*

*Properties*

Table 4 shows the effect of the soil amendment on some

**Table 2:** Effect of the different Soil amendments on the Height of Rubber (*Hevea brasiliensis*) seedlings

**MAA**

| **TREATMENT (cm)** | **2** | **3** | **4** | **5** | **6** | **7** |
|---|---|---|---|---|---|---|
| $M_OF_O$ | 42.60 | 54.80 | 55.00 | 84.30 | 99.60 | 106.00 |
| $M_1F_O$ | 28.00 | 34.50 | 34.70 | 51.10 | 52.00 | 73.80 |
| $M_2F_0$ | 36.80 | 44.70 | 55.00 | 81.20 | 89.30 | 94.70 |
| $M_3F_O$ | 23.30 | 31.80 | 43.70 | 52.00 | 64.80 | 87.50 |
| $M_OF_1$ | 40.10 | 52.60 | 64.00 | 76.30 | 88.40 | 110.80 |
| $M_OF_2$ | 40.60 | 38.60 | 54.30 | 65.70 | 81.40 | 101.20 |
| $M_1F_1$ | 28.50 | 25.00 | 41.70 | 56.30 | 71.20 | 85.70 |
| $M_2F_1$ | 45.10 | 57.20 | 78.30 | 79.20 | 89.10 | 140.30 |
| $M_3F_1$ | 40.20 | 50.30 | 64.70 | 85.50 | 101.00 | 111.40 |
| $M_1F_2$ | 23.10 | 36.50 | 50.70 | 77.80 | 83.60 | 90.40 |
| $M_2F_2$ | 30.90 | 37.00 | 43.10 | 54.90 | 55.30 | 80.10 |
| $M_3F_2$ | 44.30 | 47.60 | 61.70 | 74.50 | 83.20 | 109.80 |
| Mean | 35.29 | 42.55 | 53.91 | 69.9 | 80.75 | 98.45 |
| 0.05% | 13.87 | 24.62 | 26.69 | NS | 41.32 | NS |

NS= not significant, MAA= months after application

$M_0F_0$-control, $M_1$- *Glomus mosseae*, $M_2$-*Glomus clarius*, $M_3$ –*Glomus deserticola*, $F_1$ –NPK 15:15:15, $F_2$ – poultry manure, $M_1F_1$ – *Glomus mosseae*+NPK 15:15:15, $M_2F_1$ – *Glomus clarius*+NPK 15:`15:15, $M_3F_1$ – *Glomus deserticola*+NPK 15:15:15, $M_1F_2$–*Glomus mosseae*+poultry manure, $M_2F_2$ – *Glomus clarius*+poultry manure, $M_3F_2$- *Glomus deserticola*+poultry manure

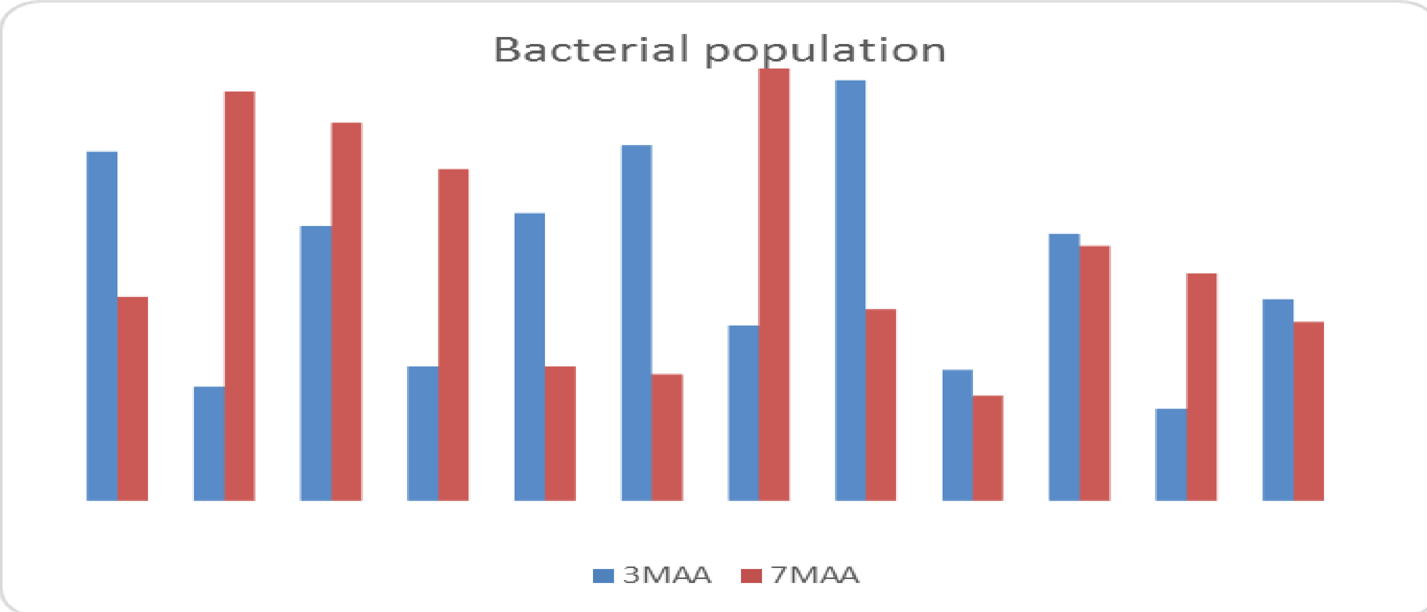
**Table 3:** Effect of the different Soil amendments on the Girth of Rubber (Hevea brasiliensis) seedlings

**MAA**

| **TREATMENT (cm)** | **2** | **3** | **4** | **5** | **6** | **7** |
|---|---|---|---|---|---|---|
| $M_OF_O$ | 4.81 | 6.20 | 7.98 | 9.17 | 9.65 | 10.40 |
| $M_1F_O$ | 4.60 | 5.28 | 6.24 | 9.20 | 6.83 | 10.48 |
| $M_2F_0$ | 4.60 | 5.28 | 6.24 | 9.20 | 9.52 | 10.48 |
| $M_3F_O$ | 3.69 | 4.25 | 6.27 | 6.95 | 7.44 | 9.34 |
| $M_OF_1$ | 3.76 | 3.83 | 5.78 | 9.43 | 9.53 | 9.97 |
| $M_OF_2$ | 5.01 | 6.20 | 7.51 | 10.21 | 10.34 | 10.51 |
| $M_1F_1$ | 3.76 | 3.83 | 5.78 | 7.43 | 8.47 | 9.97 |
| $M_2$F1 | 5.01 | 6.16 | 7.01 | 8.69 | 10.42 | 11.52 |
| $M_3F_1$ | 5.54 | 5.82 | 7.85 | 9.38 | 9.05 | 9.34 |
| M1F2 | 3.72 | 5.03 | 5.80 | 7.72 | 8.40 | 8.80 |
| $M_2F_2$ | 4.62 | 5.64 | 6.34 | 6.94 | 8.15 | 8.36 |
| $M_3F_2$ | 4.11 | 6.15 | 7.39 | 8.92 | 9.52 | 9.74 |
| Mean | 4.44 | 5.31 | 6.68 | 8.94 | 8.63 | 9.36 |
| 0.05% | 1.52 | 1.93 | 2.16 | 3.08 | 2.56 | NS |

NS= not significant, MAA= months after application

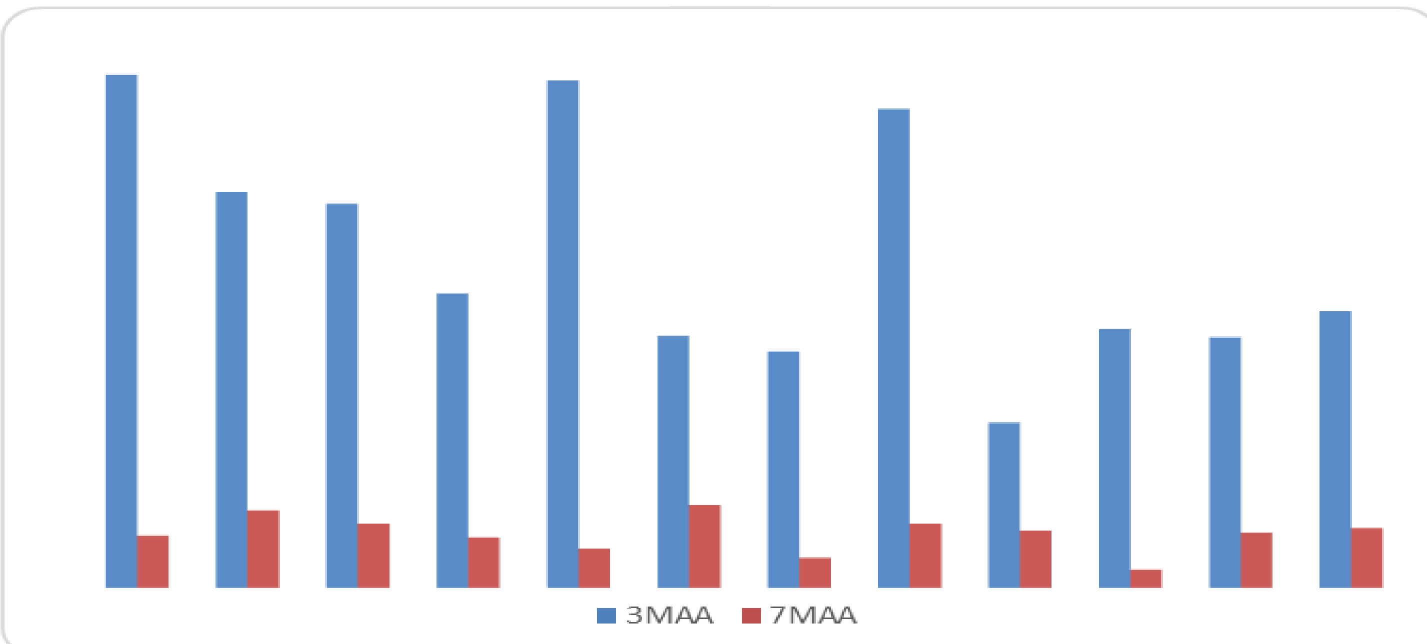
$M_0F_0$-control, $M_1$- *Glomus mosseae*, $M_2$-*Glomus clarius*, $M_3$ –*Glomus deserticola*, $F_1$ –NPK 15:15:15, $F_2$ – poultry manure, $M_1F_1$ – *Glomus mosseae*+NPK 15:15:15, $M_2F_1$ – *Glomus clarius*+NPK 15:`15:15, $M_3F_1$ – *Glomus deserticola*+NPK 15:15:15, $M_1F_2$–*Glomus mosseae*+poultry manure, $M_2F_2$ – *Glomus clarius*+poultry manure, $M_3F_2$- *Glomus deserticola*+poultry manure




MAA: Months after application

**Figure 3:** Effect of soil amendment on bacterial count

soil chemical properties (7MAA). There was a significant difference (P<0.05) among all the treatment in pH, organic carbon, organic matter, calcium, magnesium, exchangeable acidity, available phosphorus, potassium, sodium and ECEC. However, there was no significant difference (P<0.05) in Nitrogen and Base Saturation, with NPK 15:15:15 recording a higher value of 98.70% base saturation, 9.36 Cmol/kg ECEC and 4.70 Cmol/kg Mg respectively. *Glomusclarius+ NPK 15:15:15* ($M_2F_1$) showed a higher value of 5.10 in pH when compared to the other treatments, including control. The control ($M_0F_0$) showed a higher value of 4.12 and 6.98 g/kg in Organic carbon and




MAA: Months after application

**Figure 4:** Effect of soil amendment on fungal count

Organic matter when compared with other treatment. while *Glomusmosseae* +poultry manure ($M_1F_2$), *Glomusclarius*($M_2F_0$), *Glomusdeserticola*+ NPK 15:15:15 ($M_3F_1$) and *Glomusclarius*+ poultry manure ($M_2F_2$) showed a higher value of 36.40 mg/kg, 0.80 Cmol/kg, 8.00 Cmol/kg and 0.50 Cmol/kg in Avail.P, Potassium, Calcium and Exchangeable acidity than the other treatments including the control.

## 4.0. Discussion

The result of the soil chemical properties before and after application of the treatments showed improvement in the general soil chemical properties when compared with the values before application of treatments, which may be ascribed to the application of the different treatments. According to the report of Brady and Weil, (1999) that the addition of fertilizers, (organic and inorganic) increase the nutrient pool of the soil. The biological properties of the soil showed an increase in both bacteria and fungi population in the third month after application of treatments which may be due to the addition of the different soil amendment that was inoculated into the soil which might have increased the growth and activities of the micro-organisms. This conforms with the report of Bethlenfalvay and Linderman (1992) that the addition of almost any energy-rich organic substances including the compounds excreted by plant roots, stimulates microbial growth and activity and also, certain bacteria and fungi are stimulated by specific amino acids and other growth factors found in the rhizosphere or produced by other organisms; that is why the control also had an increase in the microbial growth. However, in the seventh month after treatment application, there was a sharp decline in the microbial population, especially in fungi. This might be due to the fluctuations in the moisture and temperature of the study area because, at the seventh month, there was a seasonal change that brought about an increase in soil temperature and a decrease in the soil moisture regime during the period of the experiment, which conforms to the findings of Hendrix *et al*., (1990) that high temperature and lower moisture in the soil tends to slow down or temporarily suppress microbial activities. The decline may also have been due to chemical alteration of the soil pH and the exchangeable calcium which may have been caused by some soil chemical reactions that affected the microbial population, this agrees with Eswaran*et al*, (1993) who noted that levels of exchangeable calcium and pH helps determine which specific organism thrive in a particular soil, that in some chemical conditions found in the soils, some organisms tends to thrive better while the activities of others are suppressed due to the unfavourable chemical conditions. These symbiotic relationships were evident in the height and girth of rubber seedlings that were investigated. Its shows that the treatments with the highest root colony recorded the highest value in the girth and height of rubber seedlings, which may be viewed that root colonization aided the growth response of rubber seedlings. The symbiotic provides sugars and other food for the fungi while in return, receives essential mineral nutrients that the fungi absorb from the soil. Moreover, Gilbert *et al.*, (1994) corroborated these findings that most species of fungi in soils from the tropics forms these endomycorrhizal associations on most roots of agronomic crops as well as essential tree crops as cacao, coffee and rubber.

**Table 4:** Effect of Treatments on Soil properties seven months after planting

| Treatment | Ph $H_2O$ | ORG. C | OM | Total N | Avail.P mg/kg | K | Ca | Mg | EA | Na | ECEC | BS % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | ------------------g/kg------------ | | | | ----------------------------Cmol/kg----------------------- | | | | | | |
| $M_0F_0$ | 4.44(6) | 3.77(1) | 6.98(1) | 0.22 | 19.60(4) | 0.22(6) | 5.00(3) | 0.30(6) | 0.17(6) | 0.65(1) | 5.75(8) | 98.6 |
| $M_1F_0$ | 4.13(11) | 3.86(5) | 6.64(7) | 0.21 | 17.30(7) | 0.79(2) | 7.00(2) | 0.80(3) | 0.28(3) | 0.65(1) | 8.82(4) | 96.8 |
| $M_2F_0$ | 4.51(5) | 3.91(2) | 6.73(4) | 0.22 | 13.00(9) | 0.80(1) | 7.00(2) | 1.70(2) | 0.24(5) | 0.62(2) | 9.07(2) | 97.4 |
| $M_3F_0$ | 4.92(3) | 3.91(2) | 6.74(3) | 0.22 | 12.60(10) | 0.24(4) | 2.00(6) | 0.60(4) | 0.16 | 0.44(5) | 2.94(11) | 94.6 |
| $M_0F_1$ | 4.53(4) | 3.62(7) | 6.23(9) | 0.21 | 17.80(5) | 0.79(2) | 3.00(4) | 4.70(1) | 0.11(9) | 0.65(1) | 9.36(1) | 98.7 |
| $M_0F_2$ | 4.22(10) | 3.88(4) | 6.68(6) | 0.22 | 13.30(8) | 0.25(3) | 7.00(2) | 0.50(5) | 0.28(3) | 0.51(4) | 8.04(7) | 96.5 |
| $M_1F_1$ | 4.00(12) | 3.90(3) | 6.71(5) | 0.22 | 12.57(11) | 0.23(5) | 2.52(5) | 0.80(3) | 0.16(7) | 0.65(1) | 8.64(5) | 98.2 |
| $M_2F_1$ | 5.10(1) | 3.86(5) | 6.64(7) | 0.22 | 13.30(8) | 0.24(4) | 3.00(4) | 0.10(9) | 0.24(5) | 0.52(3) | 4.12(9) | 94.2 |
| $M_3F_1$ | 4.93(2) | 3.86(5) | 6.64(7) | 0.22 | 20.50(3) | 0.21(7) | 8.00(1) | 0.13(8) | 0.12(8) | 0.40(6) | 8.88(3) | 98.6 |
| $M_1F_2$ | 4.37(8) | 3.95(1) | 6.81(2) | 0.22 | 36.40(1) | 0.23(5) | 1.00(7) | 0.30(6) | 0.45(2) | 0.44(5) | 2.09(12) | 94.3 |
| $M_2F_2$ | 4.38(7) | 3.91(2) | 6.74(3) | 0.22 | 17.50(6) | 0.79(2) | 7.00(2) | 0.40(7) | 0.50(1) | 0.65(1) | 8.34(6) | 97.6 |
| $M_3F_2$ | 4.26(9) | 3.85(6) | 6.63(8) | 0.22 | 34.70(2) | 0.21(7) | 2.00(6) | 0.80(3) | 0.27(4) | 0.65(1) | 3.50(10) | 97.7 |
| Mean | 4.53 | 3.85 | 6.68 | 0.22 | 19.07 | 0.42 | 25.00 | 0.93 | 0.12 | 0.57 | 6.63 | 96.93 |
| 0.05% | 0.59 | 1.10 | 0.12 | NS | 0.44 | 0.87 | 20.7 | 0.50 | 0.24 | 0.074 | 0.26 | NS |

NS= No significant, (1), (2)…= ranking order from the highest to the lowest

$M_0F_0$-control, $M_1$- *Glomus mosseae*, $M_2$-*Glomus clarius*, $M_3$–*Glomus deserticola*, $F_1$–NPK 15:15:15, $F_2$ – poultry manure, $M_1F_1$ – *Glomus mosseae*+NPK 15:15:15, $M_2F_1$ – *Glomus clarius*+NPK 15:`15:15, $M_3F_1$ – *Glomus deserticola*+NPK 15:15:15, $M_1F_2$–*Glomus mosseae*+poultry manure, $M_2F_2$ – *Glomus clarius*+poultry manure, $M_3F_2$- *Glomus deserticola*+poultry manure

## 5.0. Conclusion

There was a general improvement in the chemical and biological properties of the soil through the addition of the different soil amendment (organic and inorganic) fertilizer on the soil. The microbial population was increased in the third month and rapidly decline in the seventh month after treatments application.

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