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EFFECT OF MYCORRHIZAE TREATMENT ON SOME CHEMICAL PROPERTIES OF THE SOIL, ROOT COLONIZATION AND GROWTH OF RUBBER SAPLINGS

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ABSTACT

A field experiment was conducted at Rubber Research Institute of Nigeria, Edo state Iyanomo during the cropping season to determine the effect of different soil amendments on the chemical properties of the soil, root colonization and the growth of rubber saplings.. The experiment was a 3 x 4 factorial and arranged in a randomized complete block design (RCBD) with three replicates. The field was partitioned into plots with each measuring 1m x 1m and 1m apart between the plots giving rise to a total of 36 plots. 30 cmx 30 cm plant spacing was adopted. The materials used were three strains of the mycorrhiza *Glomus* (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 was also applied at the rate of 6000 kg/ha which gave rise to 12 treatments which is as follows: M_1F_0–*Glomus mosseae*, M_2F_0– *Glomus clarius*, M_3F_0–*Glomus deserticola*, M_0F_1– Chemical Fertilizer 15:15:15 (NPK), M_0F_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 and M_0F_0 which was the Control respectively. Plant data; girth and height were collected at monthly interval for seven (7) months. Soil samplings were obtained before and after application of soil treatment at 0-15cm depth. Also, the roots of *Hevea* saplings were also harvested and subjected to chemical analysis for root colonization. The result showed general improvements in the chemical properties after application of treatments in organic matter, nitrogen, pH, calcium, Avail phosphorus, ECEC and base saturation. The treatments of *Glomus clarius* + NPK 15:15:15 showed a higher root colonization than the other treatments with values of 38.70 arbuscules and 42.70 vesicles, invariably the same treatment recorded a higher growth response of rubber saplings height and girth than the other treatments with values of 45.1, 57.2, 78.3 and 140.3cm in the second, third, fourth and seventh month while 10.42 and 11.52cm on the sixth and seventh month respectively, which connotes that root colonization favours the growth of rubber saplings.

Keywords: Mycorrhizae, Root Colonization, Rubber Saplings

INTRODUCTION

Rubber tree *(Hevea brasiliensis* muell Arg) belong to the family of latex producing plants referred to as *Euphorbiaceae*. It could be propagated directly by seed or by budded stumps. Rubber was brought to African Countries including Nigeria in the early 1960 (Oyenuga, 1967). The boom in the rubber trade stimulated massive planting of natural rubber in Nigeria, some farmers were discouraged due to lack of technical knowhow in the agronomic practices required for the crop (Ogowewo, 1989). It has very high commercial and industrial valued in the manufacture of various articles used daily. One of the most important basis for increased rubber production lies in the development and

effective distribution of rubber planting materials (saplings) that are high yielding, disease and wind tolerant, early maturing and high field survival rate. The fertility management of rubber at the young 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 saplings are produced. Soil infertility is a common problem in the tropics especially the soils of the rubber belt of Nigeria with few exceptions 'has sub-optimal nutrient status. 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 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 deleterious effect on plant and soil quality (Asawalam and Ugwa, 1993). The negative consequences of the application of inorganic fertilizers have been shown in many studies (Eka *et al*, (2010). Ayoola and Adeniyan (2006) had reported that the use of inorganic fertilizer has not been helpful under intensive agriculture because it is often associated with reduced yield as a result of nutrient imbalance, leaching and pollution of groundwater, 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. This necessitates the need for an alternative source of nutrient that is readily available, relatively cheap and environmentally friendly. This 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 colonize roots of plants (Morera-Souze *et al*, 2003). Arbuscular Mycorrhizae are greatly implicated in nutrient uptake especially Phosphorus in most agricultural and native plants (Haridas, 1981). While poultry manure is a waste from 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. In addition, manure supply's other essential plants nutrients and serve as a soil amendment by adding organic matters (Waizah, (2011). Consequently, the aim of this study is to evaluate the effectiveness of mycorrhizal as tools to increase the productivity potential of improved *Hevea* saplings. 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 effect of these soil nutrients on the root colonization of *Hevea* sapling.

MATERIALS AND METHODS

The field experiment was carried out in 2015 early cropping season 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 site-area lies between latitude 6°00¹ and 7°00¹ North and longitude 5°00¹ and 6°00¹ East of the Equator. The rainfall pattern is bimodal with the peaks in the months of July and September but the highest in July and a trough in August, 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 sand stones 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), Orimoloye and Aikinbola (2013). The experiment was a 3 x 4 factorial and arranged in a randomized complete block design (RCBD) with three replicates. 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_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 manure was also applied at the rate of 6000 kg/ha which gave rise to 12 treatments which is 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. Plant data; girth and height were collected at monthly interval for seven (7) months. Soil samples were obtained before and after application of soil treatment from 0-15cm depth and were subjected to laboratory analysis (chemical and microbial analysis). Also, the roots of *Hevea* saplings were also harvested and subjected to chemical analysis for root colonization. All data sets were subjected to analysis of variance (ANOVA) using Genstat (2008) statistical package. The significant means were separated using Duncan Multiple Range Test (DMRT) at 5% level of probability.

RESULTS

Table 1 shows the some of the physical, chemical and biological characteristics of the soil before the application of treatments.

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

	Values
Parameter	**0 – 15 cm soil depth**
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 (Cmol/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

Effect of Treatment Application on some Soil Chemical Properties

Table 2 shows the effect of the soil amendment on some 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 the highest value of 98.70% base saturation, 9.36 Cmol/kg ECEC and 4.70 Cmol/kg Mg respectively. *Glomus clarius + 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 the highest value of 4.12 and 6.98 g/kg in Organic carbon and Organic matter when compared with other treatment. while *Glomus mosseae* + poultry manure (M_1F_2), *Glomus clarius* (M_2F_0), *Glomus deserticola* + NPK 15:15:15 (M_3F_1) and *Glomus clarius* + 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.

Table 2: Effect of Treatments on Soil properties seven months after planting

Treatment	pH	ORG. C	OM	Total N	Avail. P	K	Ca	Mg	EA	Na	ECEC	BS
	H2O	----------g/kg----------			mg/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_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_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_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_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_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_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_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_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_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_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**
LSD	**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

Effect of different Soil amendments on the Height and Girth of Rubber saplings

Table 3 and 4 shows the effects of the different treatments on the Height and Girth of rubber seedlings. In table 3, 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 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 showing a higher value of 85.50 and 101.1cm in the fifth and sixth months while M_2F_1 recorded a higher value of 140.3 cm than the other treatments in the seventh month. In table 4, 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 the treatments of M_2F_1 recording a higher value of 11.51cm than the other treatments including the control.

Table 3: Effect of the different Soil amendments on the Height of Rubber saplings

	MAA					
TRT	**2(cm)**	**3(cm)**	**4(cm)**	**5(cm)**	**6(cm)**	**7(cm)**
M_OF_O	42.6(3)	54.8(2)	55.0(5)	84.3	99.6(2)	106.0
M_OF_1	40.1(6)	52.6(3)	64.0(3)	76.3	88.4(5)	110.8
M_OF_2	40.6(4)	38.6(7)	54.3(6)	65.7	81.4(8)	101.2
M1FO	28.0(10)	34.5(10)	34.7(11)	51.1	52.0(12)	73.8
M1F1	28.5(9)	25.0(12)	41.7(10)	56.3	71.2(9)	85.7
M_1F_2	23.1(12)	36.5(9)	50.7(7)	77.8	83.6(6)	90.4
M2F0	36.8(7)	44.7(6)	55.0(5)	81.2	89.3(3)	94.7
M_2F_1	45.1(1)	57.2(1)	78.3(1)	79.2	89.1(4)	140.3
M_2F_2	30.9(8)	37.0(8)	43.1(9)	54.9	55.3(11)	80.1
M_3F_O	23.3(11)	31.8(11)	43.7(8)	52.0	64.8(10)	87.5
M_3F_1	40.2(5)	50.3(4)	64.7(2)	85.5	101.1(1)	111.4
M_3F_2	44.3(2)	47.6(5)	61.7(4)	74.5	83.2(7)	109.8
Mean	**35.29**	**42.55**	**53.91**	**69.9**	**80.75**	**98.45**
LSD	**13.87**	**24.62**	**26.69**	**NS**	**41.32**	**NS**

(1),(2)..., ranking order, NS= not significant, MAA= months after application

Table 4: Effect of the different Soil amendments on the Girth of Rubber saplings MAA

TRT	2(cm)	3(cm)	4(cm)	5(cm)	6(cm)	7(cm)
M_OF_O	4.81(3)	6.20(1)	7.98(1)	9.17(5)	9.65(3)	10.40
M_OF_1	3.76(7)	3.83(9)	5.78(10)	9.43(2)	9.53(5)	9.97
M_OF_2	5.01(2)	6.20(1)	7.51(3)	10.21(1)	10.34(2)	10.51
M_1F_O	4.60(5)	5.28(6)	6.24(8)	9.20(4)	6.83(11)	10.48
M_1F_1	3.76(7)	3.83(9)	5.78(10)	7.43(9)	8.47(7)	9.97
M_1F_2	3.72(8)	5.03(7)	5.80(9)	7.72(7)	8.40(8)	8.80
M_2F_0	4.60(5)	5.28(6)	6.24(8)	9.20(4)	9.52(4)	10.48
M_2F_1	5.01(2)	6.16(2)	7.01(5)	8.69(8)	10.42(1)	11.52
M_2F_2	4.62(4)	5.64(5)	6.34(6)	6.94(11)	8.15(9)	8.36
M_3F_O	3.69(9)	4.25(8)	6.27(7)	6.95(10)	7.44(10)	9.34
M_3F_1	5.54(1)	5.82(4)	7.85(2)	9.38(3)	9.05(6)	9.34
M_3F_2	4.11(6)	6.15(3)	7.39(4)	8.92(6)	9.52(4)	9.74
Mean	**4.44**	**5.31**	**6.68**	**8.94**	**8.63**	**9.36**
LSD	**1.52**	**1.93**	**2.16**	**3.08**	**2.56**	**NS**

(1),(2)..., ranking order, NS= not significant, MAA= months after application

Effect of different Soil Amendments on the Root Colonization of *Hevae* sapling

The Vescicle and the Hyphae showed a significant difference ($P<0.05$) among the treatments, with M_2F_1 (*Glomus clarius* + NPK 15:15:15) and M_3F_1 (*Glomus deseticola + NPK 15:15:15)* showing a higher value of 42.70 in vescicle, and 42.70 in hyphae among the treatments including the control (Table 5). While in Arbuscular in the root colonization there was no significant difference ($P<0.05$) among the treatments with M_2F_1 (*Glomus clarius* + NPK 15:15:15) also recording a higher value of 38.70 when compared with the other treatments respectively.

Table 5: Effect of soil amendments on the root colonization of *Hevae* sapling

Treatment	ABS	VES	HYP
M_0F_0	26.70	29.30(5)	21.30(7)
M_0F_1	22.70	22.70(8)	30.70(3)
M_0F_2	33.30	26.70(7)	25.30(6)
M_1F_0	30.70	30.70(4)	34.70(2)
M_1F_1	28.00	33.30(3)	29.30(4)
M_1F_2	22.70	21.30(9)	29.30(4)
M_2F_0	22.70	18.70(10)	21.30(7)
M_2F_1	38.70	42.70(1)	29.30(4)
M_2F_2	29.30	29.30(5)	28.00(5)
M_3F_0	34.70	28.00(6)	30.70(3)
M_3F_1	32.00	36.00(2)	42.70(1)
M_3F_2	26.70	26.70(7)	34.70(2)
Mean	**29.70**	**28.80**	**29.80**
LSD	**NS**	**16.88**	**17.70**

ABS= Arbuscular, VES= Vesicles, HYP= Hyphae, (1),(2)...= ranking order.

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. With regard to root colonization all sapling root segments analysed were colonized to AMF, with the occurrence of hyphae, vesicles and arbuscules in association with the roots. The results were similar to those found by Breuninger *et al.*, (2000) and Morera-Souze *et al.*, (2003). These symbiotic relationships were evident in the height and girth of rubber saplings that was investigated. It shows that the treatments with the highest root colony recorded the highest value in the girth and height of rubber sapling, which may be viewed that root colonization aided the growth response of rubber saplings. This agrees with the findings of Lambert *el al*, (1979) that fungi forms structures known as arbuscules and vesicles, which transfer and store nutrients to their host plant, that in both types of association, the host plant provides sugars and other food for the fungi while in return receives essential mineral nutrients that the fungi absorb from the soil. And also 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 important tree crops as cacao, coffee and rubber.

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. These symbiotic relationships were evident in the height and girth of rubber seedlings that was 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. However, it was noted that root colonization favours the growth parameters of rubber saplings that was investigated.

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