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(Research Article)

The efficacy of *Mycorrhizae*, poultry manure and inorganic fertilizer in improving soil fertility and growth of rubber saplings in Iyanomo Southern Nigeria

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Abstract

Screen house trials were conducted in Soil and Plant Nutrition Division in Rubber Research Institute of Nigeria. In Screen house four rate of *Mycorrhizae* was used (M0, M1, M2 and M3), NPK and Poultry manure was three rate (0, F1 and e rate F2) giving a total of twelve (12) treatment combination. Each treatment was replicated three times. The rates used in the Screen house are equivalent to 0, 500 g, 0.83 g and 600 g/polybag in 5 kg of soil. The experiment was laid out in a completely randomized design in 2014 cropping season.

which gave rise to 12 treatments which is as follows: M1F0–Glomusmosseae, M2F0–Glomusclarius, M3F0–Glomusdeserticola, M0F1– Chemical Fertilizer 15:15:15 (NPK), M0F2– Poultry Manure, M1F1–Glomusmosseae+ NPK 15:15:15, M2F1–Glomusclarius+ NPK 15:15:15, M3F1–Glomusdeserticola + NPK 15: 15:15, M1F2–Glomusmosseae + Poultry Manure, M2F2–Glomusclarius+ Poultry Manure, M3F2–Glomusdeserticola +Poultry Manure and M0F0 which was the Control respectively. Soil samplings were obtained before and after application of soil treatment at 0-15cm depth. Plant data; height, girth leaf area and number of leaves were collected at monthly interval for seven (7) months, The result showed general improvements in the chemical properties after application of treatments. In all the cropping seasons, seven months recorded a higher growth response of *Hevea brasiliensis* saplings plant height, girth, leaf area and number of leaves with values of (140.3, 133.0, 90.1, 81.2, 68.9 and 56.6 cm), (11.9, 10.5, 9.4, 9.1, 7.2 and 7.1 cm), (69.9, 50.7, 45.6, 32.8, 29.8 and 26.3 cm) and (25.3, 20.0, 15.3, 15.3, 14.0 and 13.3) respectively. The result obtained showed that at 7 months after treatment application there were significant difference (P<0.05) in Organic matter, Nitrogen, Magnesium, Calcium and Sodium with the highest value 6.74, 0.22, 6.40, 2.60 and 0.25 respectively in *Glomus deserticola* +Poultry Manure.

Keyword; *Mycorrhizae*; Hevea brasiliensis; Poultry manure; Lyanomo

1. Introduction

Rubber (*Hevea brasiliensis* Muell Arg.) belongs to the family of latex producing plants referred to as *Eurphorbiaceae*. 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 during and after the Second World War but soon, some farmers were discouraged due to lack of technical knowhow in the agronomic practices required for the cultivation of the crop (Ogowewo, 1989). However the efforts of few farmers who remained in the system motivated the government to invest in the rubber industry.

Rubber latex is the major component of the tree and has greatest economic importance relative to the wood, seed, seed cake and seed oil. It has very high commercial and industrial value in the manufacture of various articles used daily.

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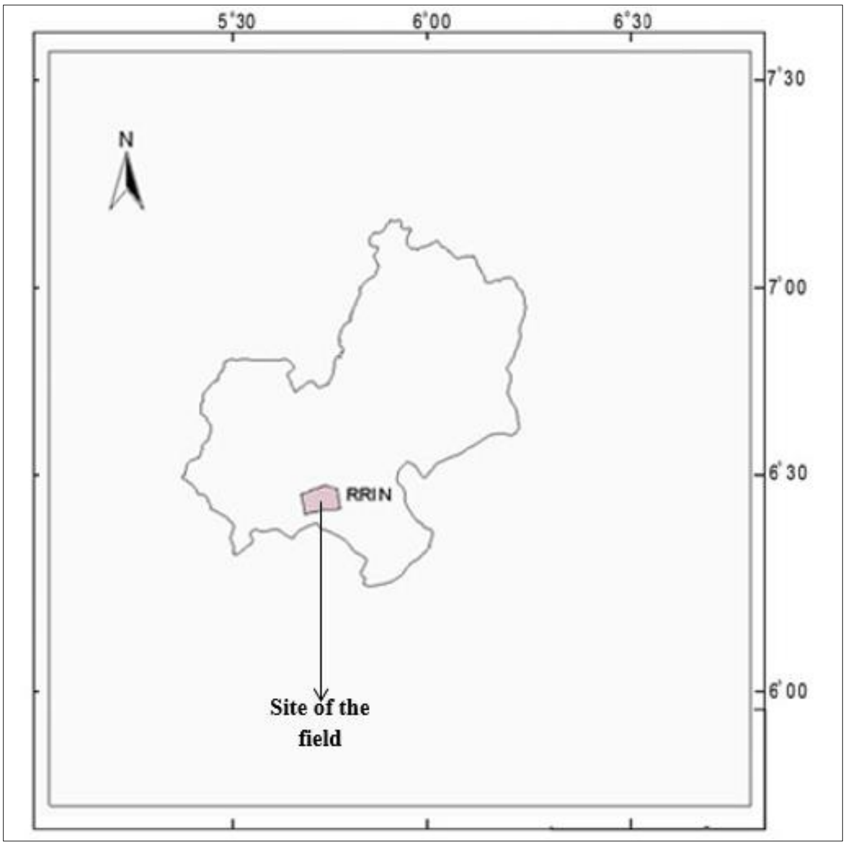
Commercially, it is used for making automobile, bicycle and aircraft tyres. Its industrial products include transmission and elevator belts, hoses and tubes, industrial lining, and bridge bearing. It is also used in consumer products such as golf or football balls and recreational and sports goods, erasers and footwear and on the other apparels. In medical and health sector, it is used in the production of condom catheters, surgical gloves. One of the most important basis for increased rubber production lies in the production and effective distribution of rubber planting materials (saplings). That are high yielding, disease and wind tolerant, early maturing and high field survival rate for plantation establishment. This can be achieved through proper soil fertility management among other factors in the nursery and in plantations.

Animal manures have been used effectively as fertilizers for centuries. Among these is Poultry manure, which is a waste from poultry industry and has long been recognized as the most desirable of these natural fertilizers, because of its high nitrogen content. In addition, manure supplies other essential plant nutrients that serve as a soil amendment by way of adding organic matters..

Thus, this research work focused on strategy that would generate higher and sustainable yield of *Hevea brasiliensis* saplings as well as improving the soil fertility status. Consequently, the aim of this study was to evaluate the effectiveness of *mycorrhizae* as tools to increase the production of improved *Hevea brasiliensis* saplings in the rootstock nursery.

Mineral fertilizers are very costly and inadequately available for farmers use .Therefore, there is the need to solve this problem by the use of bio fertilizer which is cheap, readily available and environmental friendly. The use of bio fertilizer will ensure 'friendly association' with *Hevea brasiliensis* saplings and soil environment thereby promoting crop yield and healthy environment. general objective of the study is to examine the effect of *mycorrhizae*, NPK 15;15:15 and poultry manure on some soil properties and growth of rubber (*Heveabrasillensis)* saplings.

2. Material and methods



RRIN: Rubber Research Institute of Nigeria

Figure 1 Map of Edo State showing the study location

This study was conducted in the Screen house

The screen house experiment was carried out in 2014 cropping the experimental site of the Soil and Plant Nutrition Division of the Rubber Research Institute of Nigeria (RRIN), 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 zones. The annual rainfall is above 2000 mm, distributed in a bi-modal pattern with peaks in the month of July and September.

The soils of this rain forest belt are mainly leached Ultisols with pH range between 4.0 and 5.5, described as the acid sand derived from unconsolidated grits and sand stones containing clay peds of varying proportions. The soils were deep, porous, non-mottled and non-concretionary red soils with textures ranging from loamy sand at the surface to sandy clay in the sub-soils. The detailed characteristics and classification of the soils in this area have been reported (Orimoloye, 2011;Orimoloye and Akinbola, 2013).

Materials used for this study include compound fertilizer NPK 15-15-15,poultry manure, Rubber seeds of NIG. 804 clone and three species of *mycorrhizae* namely, *Glomus mosseae, Glomus clarus and Glomus deserticola*

2.1. Experiment Design and Treatments

Screen house study involved the heating of top soil for 3 days in a fire stall to sterilizer the soil and sieve. Five kilograms of sterile soil was mixed with each treatment. *Mycorrhizae* and poultry manure were applied two week before transplanting of the Nig 804 pre-germinated seeds while NPK 15:15:15 was administered two weeks after transplanting and watered every other day.

Three strains of mycorrhizae designated M0, M1, M2 and M3, *(M1Glomus mosseae M2Glomus clairus* and *Glomus deserticola* was applied at the rate of 500g/ 5kg sterile soil.

NPK 15:15:15fertilizer was applied at the rate of 0.83g/poly bag, and the application was done two weeks after planting.

Poultry manure was also applied at rate of 500 g/soil.

After planting, saplings were allowed to grow in ploy bags for two weeks before cutting back to allow for new growth and on which parameter assessment was carried out on the sapling at a month interval for seven months..

2.2. Data Collection

Soil samples were collected before and after treatments application followed by another 3 months and 7 months for soil analysis.

2.3. Data Analysis

All data collected were subjected to statistical analysis using Genstat release 8.1 (2008) statistical package and measurable variables were tested for significance with one way analysis of variance (ANOVA) procedure in a completely randomized design (CRD). The treatment means comparison was done using least significant difference (LSD) and all pair wise comparison was done using Duncan multiple range test (DMRT) at 5% level of significance.

The *mycorrhizae* treatment(M0, M1,M2 and M3) were applied at the rate of 500 g/plot, NPK 15.15.15 at the rate of 11.2 g/plot equivalent to 112 kg/ha and poultry manure was also applied at the rate of 600 g/plot which is equivalent to 6000 kg/ha.

Saplings were cut back at a height of 20cm above the ground of the rubber after a period of two weeks for fresh shoot growth for initial determination on growth parameters at the late season which was planted in August and also in early season planted in the month of April.

2.4. Soil Sampling

Soil samplings were carried out before and after application of soil treatments. Twelve (12) composite samples (0-15cm depth) of the experimental area were collected by simple random sampling using soil auger and bulked to obtain a representative sample, and analyzed at the pre-treatment stage.

Figure 2 *Hevea brasiliensis* saplings growing in the experimental screen house in 2014 cropping season

Figure 3 *Hevea brasiliensis* saplings growing in the experimental screen house in 2014 cropping season

2.5. Laboratory Analysis

Soil samples were air dried for two week in an ambient laboratory temperature. Soil sample were sieved through 2 mm (Endecott, England) mesh before being subjected to laboratory analysis. And also, plant saplings were oven dried at 70 °C for 3-4 days until the moisture was completely removed, then it was grinded into powdery form before it was also subjected to laboratory analysis.

3. Results

Table 1 Pre cropping soil physical and chemical properties in 2014

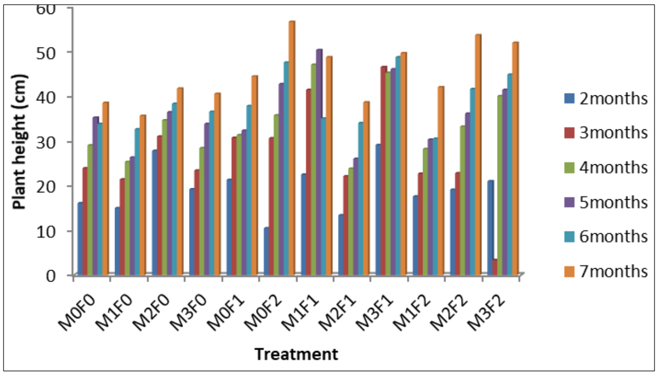
Soil properties	**Values (0- 15cm)**
	2014
Partical size (g/kg)	
Sand	949.80
Silt	7.80
Clay	42.40
Textural class	Sand
pH	4.12
(g/kg)	
Organic carbon	3.45
Organic matter	5.96
Total N	0.21
Available P (mg/kg)	3.26
Exch. Acidity (cmol/kg)	2.20
Exchangeable Cation (cmol/kg)	
K	0.29
Na	0.04
Ca	1.60
Mg	0.08
ECEC (cmol/kg)	4.21
Base Saturation (%)	47.74

Table 2 Effect of *mycorrhizae*, NPK 15:15:15 and poultry manure on soil chemical properties at 7 months after planting in 2014

Treatment	pH 1:2 ((H2O))	Org. C	Org.M	Total N	Avail.P	Exchangeable cation				EA	ECEC	%BS
						K	Mg	Ca	Na			
		→	g/kg	←	mg/kg	→			cmol/kg	←		
M0F0	6.53	3.74	6.46	0.22	5.85	0.08	1.70	1.60	0.18	0.03	2.15	99.85
M1F0	3.87	3.36	5.81	0.20	5.48	0.04	1.80	0.20	0.07	0.12	2.23	94.66
M2F0	5.33	1.40	2.42	0.17	5.27	0.03	3.00	1.80	0.07	0.06	4.96	98.81
M3F0	5.99	3.84	6.64	0.22	7.11	1.50	6.40	2.00	0.25	0.18	10.68	98.34
M0F1	4.98	3.28	5.67	0.20	5.39	0.11	1.40	0.20	0.11	0.18	2.00	98.80
M0F2	5.60	3.77	6.51	0.22	8.62	0.07	3.00	2.60	0.11	0.03	5.22	99.33
M1F1	4.75	3.43	5.93	0.20	5.79	0.03	3.60	1.00	0.07	0.21	4.91	95.08
M2F1	5.49	3.84	6.64	0.22	7.29	0.08	3.40	0.60	0.11	0.33	4.52	92.59
M3F1	5.37	2.74	4.74	0.18	7.52	0.06	2.80	1.60	0.07	0.07	4.65	97.46
M1F2	5.65	3.49	6.03	0.20	5.51	0.09	4.60	1.40	0.15	0.12	6.36	98.07
M2F2	5.90	3.06	5.29	0.19	5.37	0.10	1.30	2.00	0.18	0.02	9.51	99.71
M3F2	5.21	3.90	6.74	0.22	5.67	0.13	5.20	2.60	0.18	0.26	8.19	99.21
LSD(0.05)	ns	ns	ns	0.02	ns	Ns	0.27	0.02	0.03	Ns	ns	ns

ns= not significantM0F0-control, M1- Glomusmosseae, M2-Glomus clarius, M3 –Glomusdeserticola, F1 – NPK 15:15:15, F2 – poultry manure, M1F1 – Glomusmosseae+NPK 15:15:15, M2F1 – Glomusclarius+NPK 15:`15:15, M3F1 – Glomusdeserticola+NPK 15:15:15, M1F2– Glomusmosseae+poultry manure, M2F2 – Glomusclarius+poultry manure, M3F2- Glomusdeserticola+poultry ma

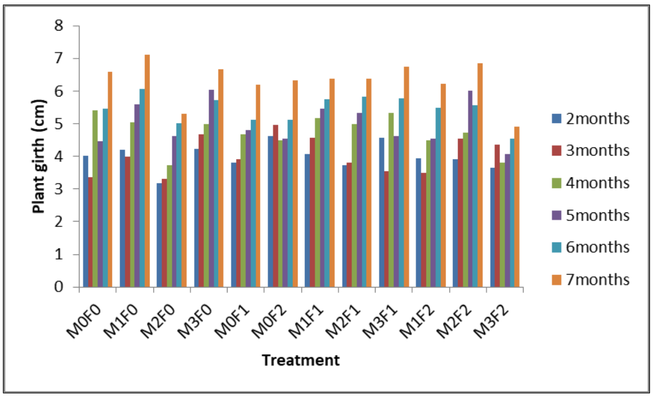
4.1 Plant height



M_0F_0-control, M_1- *Glomusmosseae*, M_2-*Glomus clarius*, M_3 –*Glomusdeserticola*, F_1 – NPK 15:15:15, F_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*+poul

Table 4 Effect of *mycorrhizae,* NPK 15;15:15 and poultry manure in *Hevea brasiliensis* saplings height in 2014

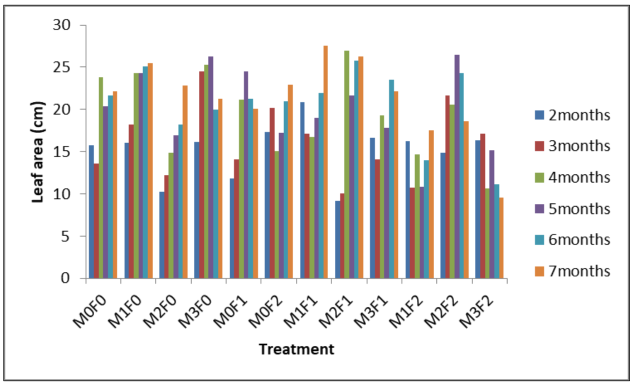
4.2 Plant girth



M_0F_0-control, M_1- *Glomusmosseae*, M_2-*Glomus clarius*, M_3 –*Glomusdeserticola*, F_1 – NPK 15:15:15, F_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

Table 5 Effect of *mycorrhizae*, NPK 15;15:15 and poultru manure in *Hevea brasiliensis* saplings plant girth in 2014

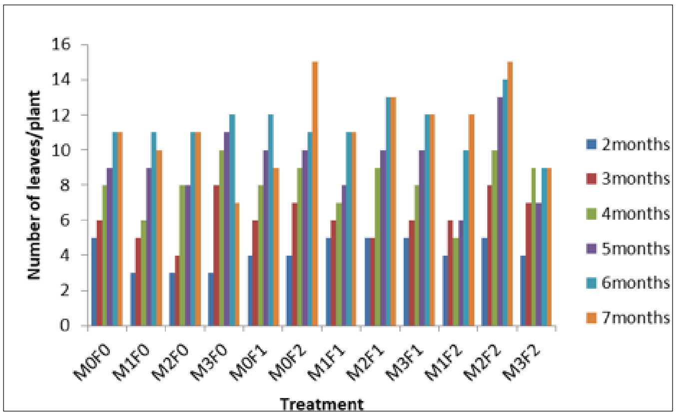
4.3 Leaf area



M_0F_0-control, M_1- *Glomusmosseae*, M_2-*Glomus clarius*, M_3 –*Glomusdeserticola*, F_1 – NPK 15:15:15, F_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

Table 6 Effect of *mycorrhizae*, NPK 15;15:15 and poultry manure in *Heveabrasiliensis* saplings leaf area in 2014

4.4 Number of leaves



M0F0-control, M1- Glomusmosseae, M2-Glomus clarius, M3 –Glomusdeserticola, F1 – NPK 15:15:15, F2 – poultry manure, M1F1 – Glomusmosseae+NPK 15:15:15, M2F1 – Glomusclarius+NPK 15:`15:15, M3F1 – Glomusdeserticola+NPK 15:15:15, M1F2– Glomusmosseae+poultry manure, M2F2 – Glomusclarius+poultry manure, M3F2- Glomusdeserticola+poultry manure

Figure 7 Effect of *mycorrhizae*, NPK 15;15:15 and poultry manure in *Heveabrasiliensis* saplings number of leaves in 2014

4. Discussion

In screen house, the result of the soil chemical properties after application of these treatment showed improvement in the soil chemical properties in the two cropping seasons when compared with the value before application of treatments. This could be ascribed to the application of different *mycorrhizae*, NPK and poultry manure treatments. Brady and Weils (1999) reported that the addition of fertilizer increased the nutrient pool of the soil. In the screen house the pH of the soil in both seasons which corroborate with the report of Yogaratnam and Silva (1987) that when NPK 15:15:15 is applied to acid soil, which are usually acidic, the initial hydrolysis of ammonium carbonate result in an increase in pH. The organic carbon in the *Glomusmosseae* and poultry manure treated plants was higher in all the seasons which may be due to the higher activities of soil micro-organisms which aided in the mineralization of poultry manure thereby increasing the soil organic matter status. The *mycorrhizae* and poultry manure treated plant responded better than the NPK treated plants in all the growth characteristics. This can be attributed to the loss of nitrogen either through volatilization and leaching of the NPK treated plant as reported by (Thorup, 1984) who stated that volatilization loss from NPK can occur in both acid and basic soils within 24hours after surface application and that the extent of loss can account for 50%. Keller and Mendel, (1986) also stated that N-volatilization in NPK is almost three times higher in a sandy soil with a CEC of 7 cmol/kg than in a silt loam with a higher CEC. The *Glomusmosseae* and poultry manure performed better due to the gradual mineralization of organic manure. The mineralized nutrients were not easily released thereby making nutrients readily available for crop uptake as reported by Brady and Weil, (1999). Brady and Weil (1999) also reported that organic colloids hold nutrient cations (K, Ca and Mg) in places where easily they can be used by plants. The ECEC and percentage base saturation increased in the screen house studies of the two cropping season, this may be due to the effect of soil treatments. This agrees to the report of Knoeep and Swank (1994) which state that the nutrient of the base cation react differently and distinctively.

Two months after application of the treatments, the mean plant height, plant girth, leaf area and number of leaves were almost the same in all the treatments. This may be attributed to the low inherent soil nutrient as the treatments applied were slow in releasing plant nutrient, especially the *mycorrhizae* and poultry manure. The increase in the mean plant height, plant girth, leaf area and number of leaves in the screen house in the cropping season revealed that the plant treated with *mycorrhizae* and NPK 15:15:15 performed better in the early stage. This is loss of nitrogen through volatilization and leaching as reported by Yogaratnam (1980) who noted that there is a reduction of nitrogen loss by volatilization and leaching when NPK is applied to soil. The gradual mineralization of organic manure were not easily leached out thereby making nutrients readily available for crop uptake as earlier reported by (Brady and Weils, 1999).

5. Conclusion

There was a general increase in the chemical properties of the soil through the addition of the different soil amendments (organic and inorganic fertilizer).

There is therefore need to formulate and improve on the organic fertilizers to suit various soils, since Nigerian soils vary in their characteristics with respect to pH, organic matter, availability of plant nutrients, and erosion related problems.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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