THE EFFICACY OF POULTRY MANURE AND INORGANIC FERTILIZERS IN IMPROVING SOIL FERTILITY AND GROWTH OF RUBBER SEEDLINGS IN IYANOMO SOUTHERN NIGERIA

***Waizah Y., Anegbeh P.O., Orimoloye, J.R., Eguavoen, O.I., Idoko, S.O. and Izevbigie, F.C.**

Rubber Research Institute of Nigeria, Iyanomo, P.M.B 1049, Benin City, Nigeria.

**Corresponding author:* waizahyakub@gmail.com +2348038223360

ABSTRACT

A field trail was conducted in Rubber Research Institute of Nigeria, Iyanomo to examine the influence of poultry manure, urea and rock phosphate on the soil chemical properties in an Ultisol using rubber seedling as a test crop. A randomized complete block design was adopted with three treatments that were replicated three times. Treatment 1 received no soil amendment and served as the control, treatment 2 received 30 tons/ha of poultry manure and treatment 3 received 30 kg ha^{-1} P_2O_5 *as rock phosphate and 112 kg N* ha^{-1} *urea. Chemical analysis of poultry manure revealed that it is rich in some plant nutrients and the manure also had effect on some soil chemical properties as well as the growth of rubber seedlings. Pre-cropping soil analysis showed that the area was loamy sand characterised by low pH, Effective Cation Exchange Capacity (ECEC) and water holding capacity. There were no significant differences in the vegetative growth parameters measured (height, leaf area, leaf number and girth) on the seedlings among the treatments at early growth stage but at a later stage of growth, seedlings treated with poultry manure performed better than seedlings grown on soils without amendment and those amended with inorganic fertilizers. Therefore, the use of poultry manure should be encouraged, because of its low cost and availability over inorganic fertilizers.*

Key word: Fertilizer, Poultry manure, Soil properties, Seedling growth

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INTRODUCTION

Rubber tree (*Hevea brasiliensis*) is an industrial cash crop that serves as the major source of Natural Rubber (NR). The tree could be propagated by seeds (seedlings) or vegetatively (mainly by budding). However, lack of genetic uniformity among trees raised through seed germination made vegetative propagation the preferred method of propagating *Hevea* (Chandrasekhar *et al* 2005) and other high-value tree crops (Anegbeh *et al*., 2005). One of the most important bases for increased rubber production lies in the development and effective distribution of rubber planting materials (budded stumps) that are high yielding, disease and wind resistant, early maturing and adapted to field conditions (high field survival rate). This can only be achieved through proper soil fertility management in the nursery where these seedlings are produced. In the past, rubber plantations were raised mostly in newly cleared forests, rich in plant nutrients but over a period of time the situation changed, new forests became unavailable and rubber cultivation had to be taken up on denuded and less fertile crop lands.

In Nigeria, most rubber growing soils are predominantly sandy to sandy-loam, textured in the surface layer and are therefore, susceptible to leaching, erosion and nutrient losses. The fertility management of rubber at the juvenile stage is critical to the productivity of rubber at maturity. The soils of the rubber belt of Nigeria with few exceptions have sub-optimal nutrients status. They are well known for their low available phosphorus-P (Juo and Uzu, 1977). Their nitrogen content is also low as a result of low organic matter content. The potassium (K) content is invariably low except in some soils North of Calabar (Onuwaje, and Uzu, 1980). While fertilizers are essential to modern agriculture, their overuse can have harmful effect on plant and soil quality. However, the acquisition and distribution of fertilizer in Nigeria remains a challenge to the government and farmers. Fertilizer distribution over time has been ineffective, and even when made available, are very expensive for farmers to buy (Lal and Kang, 1982; Ugwa *et al* 2002), hence, the need for soil amendment using fertilizers. This necessitates the need for an alternative source of soil nutrients. Poultry manure which is considered in this study is a waste product from poultry industry. Its uses therefore, will go a long way in reducing the cost of raising rubber seedlings. This study was conducted to determine the potential of poultry manure in raising rubber seedlings and improving soil fertility.

MATERIALS AND METHODS

This study was conducted from August 2008 to April 2009 at Rubber Research Institute of Nigeria, Iyanomo main nursery near Benin City, Edo State. The study 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 month of July and September but the highest in July and a short dry spell in August (Fig. 1). The soils of the study area have pH that ranged from 4.0 to 5.5, and have been described as acid soils (Vine, 1956)

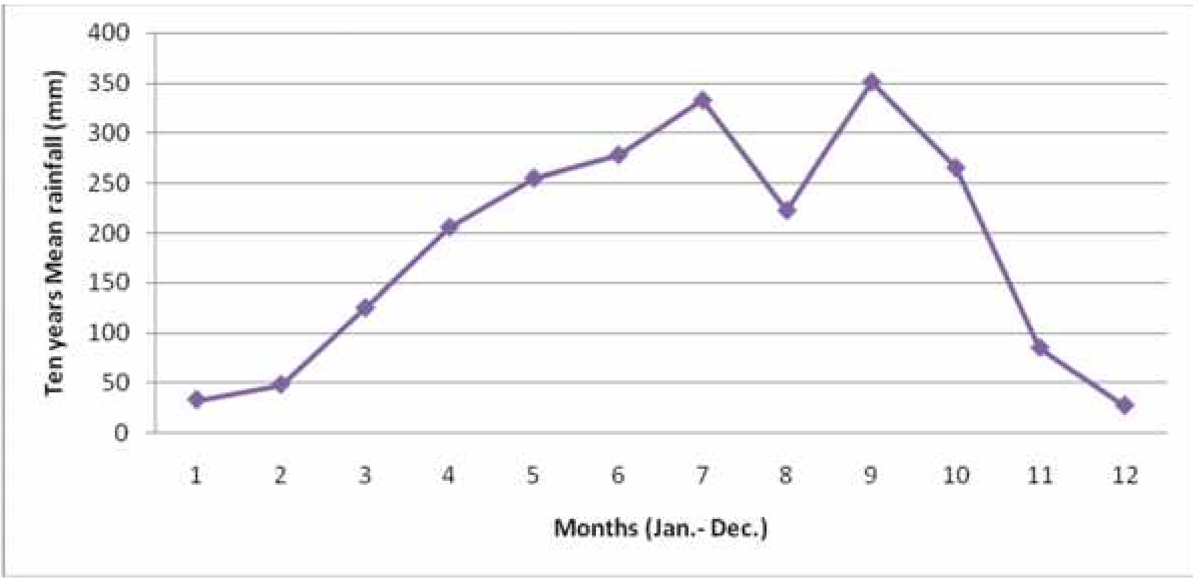

Figure 1: Ten years (2000-2010) mean annual rainfall (mm) of the study area

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three treatments and five replicates. Each plot measured 1.5 by 1 m with 1 m furrows in between the plots. The treatments are referred to as T_1 (control), T_2 (urea + rock phosphate) and T_3 (poultry manure). Treatment 1 received no soil amendment and served as the control, T_2 received 30 kg P_2O_5 as rock phosphate and 112 kg N ha^{-1} as urea and T_3 received 30 kg tons ha^{-1} of poultry manure. The rates of application were based on the concentration of nutrients in the soil amendment and applied at the rates recommended by previous studies (Onuwaje and Uzu, 1982; Ugwa and Orimoloye, 2001). Seedlings were planted at a spacing of 30 cm by 30 cm on the beds.

Growth data (stem girth, plant height, number of leaves and leaf area) of the rubber seedlings were taken at monthly interval. Five seedlings, devoid of diseases and border effects, were carefully selected per plot.

Soil sampling was carried out before and at the end of the experiment. Soil particle size was determined using the hydrometer method of (Bouyoucous, 1951). The soil pH was determined in a 1:1 soil to water ratio using the glass electrode pH meter while the organic carbon was determined using the chromic acid wet oxidation procedure as described by Jackson (1962). The total nitrogen was determined by micro-Kjeldal method as described by (Bray and Kurtz, 1945). Available phosphorus (P) was extracted using Bray No. 1 P solution (Bray and Kurtz, 1945). Phosphorus (P) in the extract was assayed calorimetrically by the molybdenum blue colour method (Murphy and Riley, 1962). The exchangeable bases were extracted using l N neutral ammonium acetate solution. Calcium and magnesium contents of the extract were determined volumetrically by EDTA titration procedure (Black, 1965). The calcium, potassium and sodium were determined by flame photometry. Magnesium content was obtained by the difference. The exchangeable acidity was determined by the KCl extraction and titration method of Mclean (1965). The Effective Cation Exchange Capacity (ECEC) was calculated as the sum of exchangeable bases and exchangeable acidity.

RESULTS

Some of the physico-chemical properties of the soil before the study was conducted are as shown in Table 1. The soil was loamy sand in texture with base saturation of 467.2 g kg^{-3}. The soil acidity was moderate with pH value of 5.7 and contained low amount of organic carbon, total nitrogen, available phosphorus, exchangeable calcium, magnesium, sodium, and potassium. The exchangeable acidity and ECEC values and micro element contents were Fe, Zn, Cu and Mn were indicated in Table 1. Results of the chemical properties of the poultry manure are indicated in Table 2.

The effect of soil amendment on height of *Hevea* seedlings is presented in Table 3. Significant differences ($p < 0.05$) were shown in plant height of rubber at 4, 5, 6 and 7 months after application (MAA) of treatments. At 4, 5, 6 and 7 MAA, poultry manure had the highest means of 105.8, 138.7, 162.3, and 183.9 cm respectively which were significantly different from urea + rock phosphate (105.6, 138.5, 161.7, and 183.4 cm respectively, while the control had 98.9, 124.2, 137.4, and 147.4 cm respectively. The treatments did not show significant effect on the mean height of rubber seedlings ($p < 0.05$) in the second and third MAA of soil amendments.

Table 1: Physico-chemical properties of the soil used for the experiment before cropping

Soil Properties	Characteristics
Sand (g kg^{-1})	880.4
Silt (g kg^{-1})	19.6
Clay (g kg^{-1})	100.0
Texture (g kg^{-1})	LS
pH (H_20)	5.7
Organic. Carbon (g kg^{-1})	13.8
Total Nitrogen (g kg^{-1})	3.3
Available Phosphorus (mg kg^{-1})	8.03
Exchangeable Calcium (cmol kg^{-1})	1.15
Exchangeable Magnesium (cmol kg^{-1})	0.85
Exchangeable sodium (cmol kg^{-1})	0.1
Exchangeable Potassium (cmol kg^{-1})	0.18
Exchangeable Acidity (cmol kg^{-1})	2.6
ECEC (cmol kg^{-1})	4.88
Base sat. (%)	46.72
Manganese (mg kg^{-1})	121.08
Iron (mg kg^{-1})	70.25
Copper (mg kg^{-1})	6.96
Zinc (mg kg^{-1})	17.32

ECEC = Effective Cation Exchange Capacity.

Table 2: Chemical properties of poultry manure

Properties	Characteristics
P^H	6.19
Nitrogen (%)	3.68
Phosphorus (%)	1.57
Organic carbon (%)	8.29
Potassium (%)	0.81
Calcium (%)	2.62
Sodium (%)	0.07
Magnesium (%)	0.48

The result of the effect of soil amendments on girth of *Hevea* seedlings is as shown in Table 4. At 5, 6 and 7 MAA there were significant differences ($p < 0.05$) among the treatment means. The highest girth (5.21 cm) was obtained for seedlings grown on poultry manure at 5 MAA followed by those grown on urea + rock phosphate treated soil (5.11 cm). The least value (4.34 cm) was obtained for those on control treatment. . The mean plant girths at 6 MAA were 5.86 cm, 5.76 cm, and 4.71 cm for urea + rock phosphate, poultry manure and control treatments respectively. At 7 MAA the plant girth of 6.86 cm was recorded for poultry manure, 6.85 cm for urea + rock phosphate and the control had the mean plant girth of 5.45 cm. The results indicated that at 2, 3 and 4 MAA, the treatments showed no significant effects ($p > 0.05$) on the girth of rubber seedlings.

Table 5 shows the effect of soil amendments on the leaf area of *Hevea* seedlings. The result showed that there was no significant ($p > 0.05$) effect of the treatments at 2 MAA on the leaf area of the rubber seedlings. However, at 3, 4, 5, 6 and 7 MAA the seedlings treated with soil amendments (T2 – T4) had larger leaf area than the control. At 3, 4 and 5 MAA, the leaf area of 34.48, 34.90 and 39.32 cm^2 respectively was obtained for rubber seedling plots treated with urea + rock phosphate while 33.17, 32.96 and 39.34 cm^2 leaf area was obtained for plots treated with poultry manure and the control had 28.93, 27.18

and 31.23 cm^2 in that order. At 6 MAA, a decrease in the leaf area was noticed, however, the plot treated with poultry manure had the largest leaf area of 37.02 cm^2 and 36.35 cm^2 was recorded for the plot treated with urea + rock phosphate while the control had the leaf area of 30.75 cm^2. At 7 MAA, leaf areas of 37.58, 36.89 and 30.73 cm^2 were recorded for urea + rock phosphate, poultry manure and the control respectively.

Table 6 shows the average number of leaves on rubber seedlings at different sampling periods with respect to the application of different soil amendments applied. There were no significant differences in leaf numbers during the second and third MAA of soil amendments. However, 4, 5, 6 and 7 MAA showed significant effects. At 4 MAA, the highest value was obtained for plots treated with poultry manure that had 20.53 leaf numbers while 19.00 and 16.40 were obtained for plots treated with urea and rock phosphate and the control treatment respectively. At 5, 6 and 7MAA, plot treated with poultry manure 24.73, 26.73 and 29.90 leaf numbers respectively while plot treated with urea + rock phosphate had 23.40, 26.80 and 29.90 leaf numbers and the control had average leaf number of 18.93, 20.40 and 23.20 in that order.

Table 3: Effects of Soil amendments on *Hevea* seedlings plant height (cm) at different months after treatments application

Treatments	Months After Treatment Applications (MAA)					
	2	**3**	**4**	**5**	**6**	**7**
Control	68.1	82.2	98.9^{b}	124.2^{b}	137.4^{b}	147.4^{b}
Urea + Rock P	68.6	86.5	105.6^{ab}	138.5^{a}	161.7^{a}	183.4^{a}
Poultry manure	71.1	83.8	105.8^{ab}	138.7^{a}	162.3^{a}	183.9^{a}
SE ±	2.83	2.79	3.97	3.92	4.42	4.76

^{ab}Means along the same column with different superscripts are significantly ($p < 0.05$) different.

Table 4: Effects of soil amendments on *Hevea* seedlings plant girth (cm) at different months after treatments' application.

Treatments	Months After Treatment Applications (MAA)					
	2	**3**	**4**	**5**	**6**	**7**
Control	2.30	2.68^{b}	3.58	4.34^{b}	4.71^{b}	5.45^{b}
Urea + Rock P	2.23	2.92^{a}	3.94	5.11^{a}	5.86^{a}	6.85^{a}
Poultry manure	2.46	2.99^{a}	3.62	5.21^{a}	5.76^{a}	6.86^{a}
SE ±	0.089	0.158	0.151	0.155	0.164	0.271

^{ab} Means along the same column with different superscripts are significantly ($p < 0.05$) different.

Table 5: Effects of soil amendments on plant leaf area (cm) of *Hevea* seedlings at different months after treatments' application.

Treatments	Months After Treatment Applications (MAA)					
	2	3	4	5	6	7
Control	29.04	28.93[b]	27.18[b]	31.23[b]	30.75[b]	30.73[b]
Urea + Rock P	26.97	34.48[a]	34.76[a]	39.32[a]	36.33[a]	37.58[a]
Poultry manure	29.04	33.17[a]	32.96[a]	39.34[a]	37.02[a]	36.89[a]
SE ±	1.264	1.406	1.090	1.290	1.207	1.174

[ab]Means along the same column with different superscripts are significantly ($p < 0.05$) different.

Table 6: Effects of Soil amendments on leaf number of *Hevea* seedlings at different months after treatments' application.

Treatments	Months After Treatment Applications (MAA)					
	2	3	4	5	6	7
Control	11.13	12.87	16.40[b]	18.93[b]	20.40[b]	23.20[b]
Urea + Rock P	10.13	14.27	19.00[ab]	23.40[ab]	26.80[a]	29.90[a]
Poultry manure	11.33	14.67	20.53[a]	24.73[a]	26.73[a]	29.90[a]
SE ±	0.71	0.869	1.098	1.250	1.618	2.150

[ab]Means along the same column with different superscripts are significantly ($p < 0.05$) different.

DISCUSSION

The physico-chemical characteristics of the soils of the study area was loamy sand in texture, characterized by low pH, low nutrient status, low ECEC and low water holding capacity as observed by Kang and Juo (1986) and Juo (1981). The sandy surface soil with clayey subsoil typically characteristic of the area studied was described as desirable for rubber growth under high rainfall condition (Asawalam and Ugwa 1993). The sandy nature may be due to excessive rainfall experienced in the region or influence of the parent material. This also explains why the soils have low potassium reserve as typical sandy soils have ion exchange capacity which determines the quantity of ions that a soil can retain against leaching (Edem, 2007). During erosion and leaching, the highly mobile basic cations are generally washed away leaving sesquioxides which contribute to the acidity of the soil. Similar observations were made by earlier authors (Uni Uyo Consult, 2003; Donahue 1983) that soils become acidic even when derived from basic parent materials by the leaching away of those basic cations (Ca^{2+}, Mg^{2+}, K^{+} and Na^{+}) by rain water and the replacement of many of them by H^{+} from carbonic acid formed from water and dissolved CO_2. This is typical of Ultisols and Oxisols of Southern Nigeria (Anegbeh 1997).

The P content of the soil of the study area was generally low, the low P could be attributed to the presence of Aluminium (Al) and Iron (Fe) and their oxides and hydroxides which increases the P-fixation (Sample *et al*, 1980), The low value obtained for total nitrogen might be as a result of excess leaching and low organic carbon content of the soil prior to treatment.

Exchangeable bases in the soil were also very low with Ca having the highest value of 1.15cmol kg^{-1}, which is less than 4cmol kg^{-1} being the lower limit for fertile soils (FAO, 1976). Other cations such as potassium (K) and magnesium (Mg) were also low, a characteristics of soils derived from coastal plain sands. The results were in line with the rating of National Special programme for Food Security NSPFS (2005) that the exchangeable Potassium content of the soils of this region is low (0.2cmol kg^{-1}). The low K and other basic cations may be caused by low pH. Whalen *et al.,*(2000) reported that soil pH affect nutrients solubility and influence the sorption or precipitation of nutrients with aluminium and iron. Increasing the pH of acidic soils had been shown (Hue, 1992) to improve the macro nutrients but reduces the solubility of elements such as Aluminium and Manganese. The percentage base saturation was expectedly low since the basic cations were low, reflecting high precipitation leading to strong weathering and leaching condition of the area. This is further indicative of low fertility status of the soils of the study area.

The results revealed that at two months after application of the treatments, the plant height, leaf area, girth and leaf number were almost the same in all the treatments. This is probably attributed to the low inherent soil nutrient as the treatments applied were slow in releasing plant nutrients, especially the poultry manure. The increase in the mean plant height, leaf area, girth and leaf number in seedlings treated with poultry manure and urea + rock phosphate at latter growth stage could be attributed to increase in the amount of micro and macro nutrients available in urea + rock phosphate and poultry manure, though rubber seedlings grown on soils supplemented with inorganic fertilizer had higher leaf area of 37.58 cm^2 which was not significantly different from those raised on soils amended with poultry manure (35.44 $cm^{2)}$. The response and trend of seedlings raised on soil with poultry manure were similar to those raised on urea + rock phosphate though poultry manure amendment elicited the highest plant height and girth in the study which were significantly ($p < 0.05$)different from those on the control treatment.

Overall, application of organic manure resulted in enhanced plant growth as in urea fertilizer at the latter growth stage when the mineralization of the organic manure might have been intensified and more nutrients were released into the soil for plants use. Urea/rock phosphate treated plots as well as poultry manure plots were not different from each other at the end of the experiment. This could be due to the fact that with longer duration of growth, urea- N might have been lost through leaching and volatilization and possibly because poultry manure is slow in mineralization. The height and girth increased significantly in all the treatments except that of the control.

CONCLUSION AND RECOMMENDATIONS

● Rubber seedlings grown in soils amended with poultry manure showed better vegetative growth (leaf area, leaf number, plant height, girth) as compared with seedlings grown in soils amended with inorganic fertilizers and control.

● The use of poultry manure as an alternative to inorganic fertilizer is recommended to farmers and should be encouraged among rubber farmers in Southern Nigeria.

● Efforts should be made to carry out similar experiment in Northern Nigeria, with varied ecology, where rubber had been introduced by Rubber Research

Institute of Nigeria to validate this recommendation.

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