Global Research in Environment and Sustainability
January 2024, Vol. 2, No. 1, pp. 47-56.

Studies on the Effect of Rubber Effluent and NPK Applications Following Cropping with Rubber (*Hevea brasilliensis* Wild ex A. de Juss. Muell.Arg.) and Snake Tomato *Trichosanthes cucumerina* L. Haines) on Some Post Harvest Soil Chemical Properties in a Newly Established Rubber Plantations in Iyanomo

Uwumarongie, A.M.D., Emuedo, O.A., Uzunuigbe E.O., Omorogbe J.A., Idehen C.N., Ugiagbe-Ekue, U., Chukwuka, A. N., Aghedo, S.O., Musa, S.O., Momoh, R.L., & Idahosa, O.E.

1. Rubber Research Institute of Nigeria, Iyanomo. P.M.B 1049,Edo State, Nigeria

Abstract:
The soil is the most important natural resource, because on it, the entire vegetation is dependent and by extension man, hence a field study was conducted in 2018 and 2019 cropping season to determine the effects of rubber effluent and NPK applications following cropping with rubber and snake on some post-harvest soil chemical properties in a newly established rubber plantation in Iyanomo. The treatments involved a combination of sole and intercropped combination with NPK and rubber effluent application rates laid out in a randomized complete block design in three replications. Pre- and Post-harvest soil analysis was carried out and data were collected on Particle size, Soil pH, Available Phosphorus, Exchangeable bases, total nitrogen and exchangeable acidity. Results of pre cropping soil analysis showed that soils of the experimental site were strongly acidic with values lower than critical level for some essential nutrients (table 1) while the post-harvest soil analysis showed that the soils benefited from the amendment with fertilizers (NPK and rubber effluent) (table 3a and b). The increase in soil pH, N, Ca, Mg, K, and Na and decrease in exchangeable acidity in plots fertilized with NPK and rubber effluent is attributed to the amending effects of the fertilizer. This finding implies that rubber effluent and NPK reduced soil acidity as the reaction changed from strongly acidic to moderately acidic.

Keywords: soils, fertilizer, rubber effluent, NPK, soil chemical properties and post-harvest

INTRODUCTION

Rubber (*Hevea brasiliensis* Wild ex A. de Juss. Muell.Arg.) is the world's number one source for natural rubber (Abolagba and Giroh, 2006). It belongs to the family Euphorbiaceae and is commercially grown in plantations for the white exudates (latex) which are commonly referred to as white gold (Asokan *et al.* 2000). There are about twenty species that are known to produce latex; of these about twelve belong to the Hevea genus and only *Hevea brasiliensis* is economically exploited (Asokan *et al.* 2000).

Trichosanthes cucmerina is among the traditional underutilized food crop of increasing importance in several parts of Africa including Ghana and Nigeria, mainly for the red fruit pulp used as a substitute for the regular tomato sauce (FAO, 1998). The scarcity and untold price hike that occur annually as a result of the off season of the tomato plant and recent invasion by *Tuta* *absoluta* that ravaged the entire tomato farm directed research efforts to looking for an alternative to the regular tomato. Intercropping snake tomato with natural rubber will help give the necessary awareness that the crop needs to bring it to lamp light.

The soil is the most important natural resource, because on it, the entire vegetation is dependent and by extension man. Man, directly depends on vegetation for food, hence it's necessary to preserve the top soil and help to improve its organic matter content in order to increase its nutrient providing ability (Defoer, 2002). The soils of the southern parts of Nigeria with few exceptions are characterized to have sub – optional nutrient status. Available phosphorus (P), Nitrogen (N) content, organic matter content and the available potassium (K) content are invariably low except for some soils of Northern Calabar (Onuwaje and Uzu, 1980).

Fertilizers, according to the IFA (2008), are materials that contain 5% or more of the three essential plant nutrients. They are soil amendments that guarantee the minimum percentages of Nitrogen, Phosphate and Potassium (Adrian *et. al*. 2014). Generally, Fertilizer among other advantages, improves soil nutrient, results in faster growth of crops, increases crop yield and improves the quality of fruits/crops, by making available the essential plant nutrients in readily available forms (EPA, 2013). Inorganic fertilizer application has been a major source of amendment and augmenting the soil, but the cost, availability and adulteration issues resulting from its use, growing concern on health hazards caused by the consumption of food crops produced by frequent application of chemical fertilizers as a result of the residual effect on the crop and the soil, among others are problems associated with chemical/inorganic fertilizer use (Carroll and Salt, 2004). Consequently, there is now a concerted effort to review the use of chemical fertilizers and to place more emphasis on the use of organic fertilizers such as green manure, compost manure, farm yard manure, effluents etc (Dhevagi, 2002; Hossain *et al.*, 2008).. Rubber factory effluent is considered a by-product (waste) from rubber processing factories and contains various plant growth substances including a number of elements such as N, K, P, Ca, Mg (Wilfred, 2002). Udoh *et al*., 2005; FAO, 2000 reported that rubber effluent contains substantial amount of plant nutrients particularly N and K. its use as soil nutrient amendment will help ameliorate the problem of disposal which has been a source of concern to rubber factory owners and environmentalist and also go a long way in the reduction of the cost of rubber production, improving soil fertility for the benefit of the crop and also take care of issues of water pollution and a substitute to inorganic fertilizer use. Hence this research work is directed towards evaluating the effect of rubber processing effluent and NPK15:15:15 as soil nutrient amendment in a rubber and Snake tomato intercrop and their effect on some postharvest soil chemical properties in a newly established rubber plantation.

MATERIALS AND METHODS

Experimental Site

The study was conducted in 2018 and 2019 cropping seasons at the Research farm of Rubber Research Institute of Nigeria (RRIN), Iyanomo near Benin City, Edo State, which lies within the Rain Forest zone of Nigeria. The study area falls between latitude $6^{o}00$ and $7^{o}00'$N and longitude $5^{o}00'$ and $6^{o}00'$E. 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. The soils of this humid forest belt are mainly ultisols and the site is classified locally as kulfo series with pH range between 4.0 and 5.5 (RRIN, 1998)

Experimental Design and Field Layout

The treatments involved a combination of sole rubber and snake tomato and their intercropped combination with NPK (applied at 60kgNha^{-1}) and rubber effluent application rates (0, 50, 60 and 70kgNha^{-1}) laid out in a randomized complete block design in three replications. For rubber component in the intercrop, the treatments were:

- RE1RS-Rubber Effluent at application rate of 50 Kg N ha^{-1} cropped with rubber and snake tomato (Intercrop)
- RE1SR- Rubber Effluent at application rate of 50 Kg N ha^{-1} cropped with sole rubber
- RE2RS- Rubber Effluent at application rate of 60 Kg N ha^{-1} cropped with rubber and Snake tomato (Intercrop)
- RE2SR- Rubber Effluent at application rate of 60 Kg N ha^{-1} cropped with sole rubber
- RE3RS- Rubber Effluent at application rate of 70 Kg N ha^{-1} cropped with rubber and snake tomato (Intercrop)
- RE3SR- Rubber Effluent at application rate of 70 Kg N ha^{-1} cropped with sole rubber
- RSC- Rubber and snake tomato intercrop control
- RSNPK- 60 Kg NPK applied to rubber and snake tomato intercrop
- SRC- Sole Rubber Control
- SRNPK- 60 Kg NPK applied to sole rubber

Cultural Practices, Data Collection and Analysis

The snake tomato seeds were raised into seedlings in a polybag nursery filled with a mixture of top soil and poultry manure in ratio 3:1 for two weeks.

An experimental field measuring 26 by 60 m was cleared of the existing vegetation manually with the aid of cutlasses and hoes, the debris were packed out of the site, thereafter the field was marked out into plots measuring 3 by 7m with a metre pathway. The rubber effluent was applied immediately to the designated plots as per treatment two weeks prior to transplanting of rubber saplings, The pulled budded stump (young rubber) was placed in the hole in such a way that the budded patch is just above the ground level at a spacing of 3 by 7 m. The snake tomato seedlings were transplanted to designated plots at a spacing of 0.5 by 0.5 m, a week after the planting out of the rubber saplings. The NPK fertilizer was applied to the designated plots as per treatment two weeks after transplanting of snake tomato seedlings.

Standardization of Rubber Effluent

Rubber Effluent sourced from three Rubber Factories in Edo State (Odia, Okomu, and Osse Rubber Estate) and analyzed to check for possible variation in nutrient composition from the different sources, which can also give an idea of possible variation due to the type of clone. This was done using the standard laboratory standard (results of effluent analysis is shown in table 2). The Effluent was applied two weeks prior to transplanting of rubber sapling in order to decompose and equilibrate in the soil while NPK was applied two weeks after transplanting (WAT).

Soil Analysis

Prior to cropping with rubber and snake tomato, soil samples were randomly collected from the experimental site at a depth of 0 - 30 cm depth using auger and bulked together to form a composite sample. The composite soil sample was air-dried and sieved through a 2 mm mesh and analyzed for its physical and chemical properties using standard laboratory procedures. After harvest, soil samples were randomly collected from each plot separately and analyzed for its post-harvest chemical properties.

Particle size analysis was determined by hygrometer method (IITA, 1979), The soil pH was determined in 1:2 soils to water ratio using glass electrode digital pH meter, Available Phosphorus was extracted using Bray-1 solution and the phosphate in the extract was assayed calorimetrically by the molybdenum blue colour method and was determined by a spectrometer as described by IITA (1979). Exchangeable bases were extracted using 1N neutral ammonium acetate solution. Calcium and magnesium content of the solution were determined volumetrically by EDTA titration procedure by Houba *et al.* (1988). The level of calcium, potassium, and sodium was determined by flame photometer, the total nitrogen of the soil was determined by Micro kjeldahl procedure described by IITA (1979). The exchangeable acidity was determined by the KCL extraction and titration method of Houba *et al.* (1988).

Data Analysis

Data collected were analyzed with GENSTAT programme, using analysis of variance and significant differences among treatments means were separated using the LSD procedure at 0.05 level of probability.

RESULTS

The soils were strongly acidic and low in organic C, total N, available P and exchangeable Ca (Table 1). The Ca/Mg ratios were moderate. The soils were texturally sandy loam. The chemical analysis of the rubber effluent used for the study showed that it was moderately acidic with total dissolved solids, chemical oxygen demand and biochemical oxygen demand (Table 3). It contained total N, available P, organic C, K, Mg, Na and Ca in appreciable amount. However, the composition of the effluent varies with sources

Table 1: Pre-cropping characterization of some selected soils properties from the experimental site

Parameter	Site		Critical level	Fertility class
	New plantation	Existing plantation		
pH (H_2O) 1:1	5.4	5.4		SA
Organic carbon (g kg^{-1})	17.2	17.2	30.00 g kg^{-1} (Enwezor*et al*., 1989)	Low
Total nitrogen (g kg^{-1})	0.84	0.81	1.50 g kg^{-1} (Solulo and Osiname, 1981)	Low
C: N	20.48	21.23		
Available phosphorus (mg kg^{-1})	10.5	13	16.00 mg kg^{-1} (Adepetu*et al*., 1979)	Low
Exchangeable cation (cmol kg^{-1})				
Calcium	0.8	0.82	2.60 cmol kg^{-1} (Agboola and Corey, 1973)	Low
Magnesium	0.2	0.25		
Ca/Mg	4	3.4	3.00 (FDALAR, 1975)	Adequate
Potassium	0.16	0.17	0.16 - 0.20 (Hunter, 1975)	
Sodium	0.06	0.06		
Exchangeable acidity (cmol kg^{-1})				
Hydrogen	0.2	0.16		

Aluminium	0.1	0.11		
Particle size (gk g^{-1})				
Sand	886	886		NA
Silt	61	64		NA
Clay	39	36		NA
Textural class	Sandy loam	Sandy loam		NA
SA - Strongly acidic NA - Not applicable				

Table 2: Chemical composition of rubber effluent

Parameter	Odia	Okomu	Michellin
pH (H_2O)	6.2	6.2	6.4
Organic carbon (%)	29.6	25.8	15.96
Total nitrogen (%)	1.1	0.4	0.8
Phosphorus (%)	2.03	3.25	5
Potassium (%)	0.22	0.24	0.43
Magnesium (%)	0.38	0.38	0.4
Calcium (%)	0.49	0.5	0.57
Sodium (%)	0.04	0.05	0.06
zinc (%)	0.05	0.05	0.07
Copper (%)	0.02	0.02	0.03
Manganse (%)	0.08	0.08	0.09
Iron (%)	0.1	0.11	0.14
Chemical oxygen demand (mg l^{-1})	410	230	550
Biochemical oxygen demand (mg l^{-1})	250	270	870
Total dissolved solids (mg l^{-1})	760	160	330

Post-Harvest Soil Chemical Properties

The results of analysis of treated (NPK and rubber effluent) soil after cropping with snake tomato in sole and intercrop with rubber grown on newly established rubber plantation are presented in Tables 3 a and 3b. In both experiments and in the combined analysis, the highest pH was recorded in STNPK and RE3ST plots which were similar with all other treatments except RSC, RE2ST and RE2RS plots which had the lowest pH.

Plots cropped with RE1ST had the highest organic carbon in the first-year experiment which was identical with plots grown with RE1RS, RE1ST, RE3ST, RSC, RSNPK and STNPK but significantly different from plots cropped with RE2RS, RE2ST, RE3RS and STC. In the second-year experiment, organic carbon content varied between 8.84 and 19.24 g kg^{-1} for plots cropped with STC and RSNPK, respectively. However, organic carbon observed in the plot cropped with STC was identical with RSC, RE3RS, RE2ST and RE2RS plots. Plots grown with RSNPK had organic carbon comparable with the plots cropped with RE3ST and STNPK. In the combined analysis, RSNPK plots had the highest organic carbon content which was identical with RE3ST and RE1ST cropped plots while RE2ST cropped plot had the lowest organic carbon which was comparable with plots grown with RE2RS and STC. Total N in the first-year experiment ranged from 0.26 and 0.86 g kg^{-1} for plots grown with STNPK and RSC respectively. However, total N in RSC plot was similar with the plots grown with RSNPK, RE3ST, RE1ST and RE1RS. In the second-year experiment, the total N ranged from 0.65 and 1.17 g kg^{-1} for STC and RSNPK plots respectively. Total N recorded in RSNPK plot was not significantly higher than the total N content of RE3ST and RE3RS plots. When both experiments were combined, the plot cropped with RSNPK recorded the highest total N while plots grown with STC and STNPK had the lowest total N. Total N was higher in the second-year experiment than in the first-year experiment.

Available P was lowest in the plot grown with RSC in both experiments and in the combined analysis however, available P observed in RSC plot in combined analysis was comparable with the plot cropped with STC. The highest available P was recorded in STNPK plot and was identical with other treatments except plots with RSC and STC in both experiments and in the combined analysis. Available P was higher in the first-year experiment than in the second-year experiment.

The exchangeable Ca content in RE1RS plot was significantly different from other treatments except in the plot cropped with STNPK in the first experiment. The lowest exchangeable Ca was recorded in RE1ST plot. In the second experiment, the highest exchangeable Ca was recorded in RE3RS and STNPK plots while the lowest was recorded in RSC but identical with RE1ST and RE1RS plots. Plots cropped with STNPK and RE3RS had the highest exchangeable Ca while the lowest exchangeable Ca was observed in RE1ST plot but identical with the plot grown with RSC in the combined analysis. Exchangeable Ca was higher in the first-year experiment than in the second-year experiment.

Exchangeable Mg was not significantly different among treatments in the first-year experiment. The highest exchangeable Mg was observed in plots cropped with RE3RS and RE3ST in the second-year experiment. However, RE3RS and RE3ST plots were not significantly higher than RE2RS and RE2ST. RE3RS plot had the highest exchangeable Mg content which was only significantly different from RSC, RSNPK and STC plots in the combined analysis.

Exchangeable K was similar among treatments in the first-year experiment. In the second-year experiment, exchangeable K was highest in the plot grown with STNPK but comparable with RSNPK, RE3ST, RE2RS and RE3RS plots. The lowest exchangeable K content was recorded in STC and RSC plots but not significantly lower than RE2ST, RE1RS and RE1ST plots. Exchangeable K content was highest in plot cropped with STNPK which was significantly higher than STC, RSC and RE1ST plots when both experiments were pooled together.

All treatments in the first-year experiment had identical exchangeable Na content values. In the second-year experiment, exchangeable Na was highest in RE3RS plot but identical with RE3ST and RE2RS plots. Plot cropped with RSC had the lowest exchangeable Na which was comparable with RSNPK, STC, STNPK, RE1RS and RE1ST plots. In the combined analysis, RE3RS plot had the highest value which was identical with RE3ST plot. RE1RS, RSC and RSNPK cropped plots had the lowest values which were similar with RE1ST, RE2ST, STC and STNPK plots.

The exchangeable H^+ values were identical among treatments in the first-year experiment. In the second-year experiment, the exchangeable H^+ values were similar among the treatments except in STC and STNPK plots. The lowest exchangeable H^+ was observed in STC plot and identical with the values recorded in plots grown with RSC and STNPK. In the combined analysis, exchangeable H^+ ranged from 0.10 and 0.41 cmol kg^{-1} for plots cropped with RSNPK and RSC, respectively. However, RSC plot was comparable with STC, RE3ST, RE3RS, RE2RS, RE1ST and RE1RS plots.
The exchangeable Al^{3+} varied between 0.00 and 0.10cmol kg^{-1} for plots grown with STNPK and RE2ST, respectively. However, RE2ST plot had similar value with RE1ST and RSC plots. In the second-year experiment, STNPK and STC plots had the lowest exchangeable Al^{3+}values but identical with other treatments except RE2ST and RE2RS plot which had the highest exchangeable Al^{3+} values. In the combined analysis, exchangeable Al^{3+} ranged from 0.01 and 0.09cmol kg^{-1} for STNPPK and RE2ST plots, respectively.

Table 3a: post-harvest soil chemical properties following cropping of snake tomato treated with NPK and rubber effluent in newly established rubber plantation

Treatment	pH (H_2O)			Organic carbon			Total nitrogen			Available phosphorus		
				(g kg^{-1})			(g kg^{-1})			(mg kg^{-1})		
	1st	2nd year	Combined	1st	2nd year	Combined	1st	2nd year	Combined	1st	2nd year	Combined
RE1RS	6.20	6.20	6.20	9.78	9.40	9.59	0.80	0.76	0.78	10.20	9.43	9.82
RE1ST	6.00	6.00	6.00	10.87	9.46	10.17	0.79	0.73	0.76	10.50	9.41	9.96
RE2RS	5.80	5.80	5.80	8.59	8.87	8.73	0.70	0.82	0.76	9.25	9.36	9.30
RE2ST	5.60	5.60	5.60	8.39	8.89	8.64	0.68	0.81	0.75	9.36	9.39	9.38
RE3RS	6.20	6.20	6.20	8.38	9.84	9.11	0.67	1.03	0.85	9.10	9.49	9.30
RE3ST	6.30	6.30	6.30	10.14	19.17	10.15	0.81	1.11	0.96	9.36	9.62	9.49
RSC	5.70	5.70	5.70	10.20	9.21	9.71	0.86	0.75	0.80	8.75	8.40	8.57
RSNPK	6.00	6.00	6.00	10.14	19.24	10.19	0.81	1.17	0.99	9.36	10.04	9.70
STC	6.20	6.20	6.20	8.78	8.84	8.81	0.70	0.65	0.67	9.00	8.53	8.77
STNPK	6.30	6.30	6.30	9.58	10.15	9.87	0.26	0.96	0.61	10.60	10.84	10.62
Mean	6.03	6.03	6.03	9.49	9.51	9.50	0.71	0.88	0.79	0.79	9.43	9.49
LSD $_{(0.05)\ TRT}$	0.354	0.354	0.235	0.141	0.458	0.272	0.088	0.134	0.077	0.077	0.039	0.207
LSD $_{(0.05)}$ year	0.105			ns			0.034			0.092		

RE1RS - Rubber effluent at application rate of 50 kg N ha-1 cropped with rubber and snake tomato (Intercrop)
RE1ST - Rubber effluent at application rate of 50 kg N ha-1 snake tomato (Sole)
RE2RS - Rubber effluent at application rate of 60 kg N ha-1 cropped with rubber and snake tomato (Intercrop)
RE2ST - Rubber effluent at application rate of 60 kg N ha-1 snake tomato (Sole)
RE3RS - Rubber effluent at application rate of 70 kg N ha-1 cropped with rubber and snake tomato (Intercrop)
RE3ST - Rubber effluent at application rate of 70 kg N ha-1 snake tomato (Sole)
RSC - Rubber-snake tomato intercrop without NPK/rubber effluent treatment (control)
STC - Sole snake tomato (control)
STNPK - Sole snake tomato treated with 60 kg N ha-1 of NPK 15:15:15
RSNPK - Rubber-snake tomato treated with 60 kg N ha-1 of NPK 15:15:15

Table 3b: post-harvest soil chemical properties following cropping of snake tomato treated with NPK and rubber effluent in newly established rubber plantation.

Treatment	Exchangeable cation (cmol kg^{-1})												Exchangeable acidity (cmol kg^{-1})					
	Calcium				Magnesium		Potassium			Sodium			Hydrogen			Aluminum		
	1st	2nd year	Combined	1st	2nd year	Combined	1st	2nd year	Combined	1st	2nd year	Combined	1st	2nd year	Combined	1st	2nd year	Combined
RE1RS	1.3	0.78	1.04	0.23	0.18	0.21	0.25	0.19	0.22	0.13	0.11	0.12	0.2	0.11	0.16	0.03	0.04	0.03
RE1ST	0.85	0.77	0.81	0.2	0.15	0.18	0.22	0.17	0.2	0.14	0.12	0.13	0.15	0.12	0.13	0.08	0.05	0.07
RE2RS	0.84	0.85	0.85	0.18	0.2	0.19	0.2	0.27	0.24	0.13	0.15	0.14	0.12	0.12	0.12	0.06	0.07	0.07
RE2ST	0.73	0.8	0.76	0.18	0.2	0.18	0.2	0.22	0.21	0.12	0.14	0.13	0.35	0.12	0.24	0.1	0.08	0.09
RE3RS	1.23	1.24	1.24	0.2	0.23	0.22	0.23	0.28	0.25	0.15	0.17	0.16	0.1	0.11	0.11	0.03	0.04	0.04
RE3ST	0.9	1.12	1.01	0.19	0.23	0.21	0.2	0.29	0.25	0.13	0.16	0.15	0.1	0.12	0.11	0.05	0.05	0.05
RSC	0.84	0.73	0.79	0.12	0.1	0.11	0.24	0.16	0.2	0.13	0.1	0.12	0.75	0.07	0.41	0.07	0.04	0.05
RSNPK	0.9	1.12	1.01	0.19	0.15	0.17	0.2	0.29	0.24	0.13	0.11	0.12	0.1	0.1	0.1	0.05	0.04	0.04
STC	1.15	0.84	0.99	0.2	0.12	0.16	0.23	0.16	0.2	0.15	0.12	0.14	0.39	0.06	0.23	0.03	0.03	0.03
STNPK	1.25	1.24	1.25	0.23	0.18	0.2	0.24	0.3	0.27	0.14	0.12	0.13	0.05	0.08	0.07	0	0.03	0.01
Mean	1	0.95	0.97	0.19	0.17	0.18	0.22	0.23	0.23	0.14	0.13	0.13	0.23	0.1	0.17	0.05	0.05	0.05
LSD $_{(0.05)}$	0.078	0.058	0.047	ns	0.049	0.046	ns	0.077	0.064	ns	0.02	0.014	ns	0.039	0.14	0.02	0.021	0.014
LSD $_{(0.05)}$ year	0.021			ns			0.029						ns			ns		

Foot note
RE1RS - Rubber effluent at application rate of 50 kg N ha-1 cropped with rubber and snake tomato (Intercrop)
RE1ST - Rubber effluent at application rate of 50 kg N ha-1 snake tomato (Sole)
RE2RS - Rubber effluent at application rate of 60 kg N ha-1 cropped with rubber and snake tomato (Intercrop)

RE2ST - Rubber effluent at application rate of 60 kg N ha-1 snake tomato (Sole)
RE3RS - Rubber effluent at application rate of 70 kg N ha-1 cropped with rubber and snake tomato (Intercrop)
RE3ST - Rubber effluent at application rate of 70 kg N ha-1 snake tomato (Sole)
RSC - Rubber-snake tomato intercrop without NPK/rubber effluent treatment (control)
STC - Sole snake tomato (control)
STNPK - Sole snake tomato treated with 60 kg N ha-1 of NPK 15:15:15
RSNPK - Rubber-snake tomato treated with 60 kg N ha-1 of NPK 15:15:15

DISCUSSION

The soils of the experimental site were strongly acidic with values lower than critical level for some essential nutrients. This implied that the soil has low fertility status. Law-Ogbomo and Osaigbovo (2008) reported that most Nigerian soils are of low in native fertility owing to the highly weathered soils coupled with leaching and continuous cropping. Soil fertility is a very important factor in soil productivity in relation to nutrient and yield (Erhabor, 1995). Plants need supply of appropriate proportionate essential nutrients from the soil for optimum growth, development and yield. Low soil fertility status without adequate soil nutrient amendment will result in growth and yield depression due to nutrient deficiencies (Law-Ogbomo *et al*., 2020).

The analysis of the rubber effluent table2 showed variability depending on location. They were moderately acidic and contain N, P, K and Ca in appreciable quantity. The effluent has high concentration of organic carbon, COD and BOD at safe level. This finding is in agreement with Orhue *et al*. (2007) who reported highly significant amount of total suspended and dissolved solids, phosphate and total N in rubber effluent. Orhue and Osaigbovo, (2013) reported that rubber effluent had great potential as organic fertilizer and could be beneficial to arable crops without additional cost as effluent are waste product of rubber processing factories and its disposal has been a major concern to factory owners. This is an indication that rubber effluent which ought to be waste and pollutant to the environment can be made to be an avenue for wealth creation through its conversion to organic fertilizer.

The post-harvest fertility status of the soil was improved in line with reports by Law-Ogbomo *et al*. (2014) that reported increase in fertility status after fertilizer application which is a reflection of the availability of essential plant nutrients in NPK and rubber effluent. The increase in soil pH, N, Ca, Mg, K, and Na and decrease in exchangeable acidity in plots fertilized with NPK and rubber effluent is attributed to the amending effects of the fertilizer. This finding implies that rubber effluent and NPK reduced soil acidity as the reaction changed from strongly acidic to moderately acidic.

The decrease in exchangeable acidity might have led to higher soil pH. The increase in soil pH could have led to higher availability of exchangeable cations. The decrease in organic carbon in both the fertilized and unfertilized plots is not in conformity with the observation of Odedina *et al*. (2003), who reported that organic fertilizer increased soil organic matter.

The increase in N content in soil of rubber intercropped with snake tomato treated with NPK (RSNPK) compared to the sole snake tomato soils treated with NPK (STNPK) is a demonstration of N cycling as reported by Mbow *et al*. (2014). The decrease in available P compared to the initial concentrations could have resulted from decrease in soil organic carbon. The mineralization of available P due to microbial actions resulted in the production of organic acid, which make soil P available (Law-Ogbomo *et al*., 2016). The higher exchangeable Ca observed in RE3RS and RE2ST plots implies higher rate of mineralization of Mg as the fertilized plots contained more nutrient reserve than the unfertilized plots. The increase in exchangeable cation implies increase in the soil effective cation exchange capacity (ECEC) brought about through fertilizer application.

CONCLUSION AND RECOMMENDATION

The study shows that the soil analysis after the harvest of snake tomato showed that the soils benefited from the amendment with fertilizers (NPK and rubber effluent). Based on the findings from this study, snake tomato intercropping with rubber should be supplemented with fertilizer application to improve the fertility of the soil to sustain soil and higher growth of rubber and yield of snake tomato.

REFERENCES

Abolagba, E. O., Aigbekaen, E. O., and Omokhafe, K.O. (2003). Farm gate marketing of natural rubber in the south east rubber growing zone of Nigeria. *Nigeria Journal of Agriculture and Rural Development, 6,* 40-48.

Abolagba, E.O. and Giroh, D.Y. (2006). Constraints to sustainable Development of Rubber Industry in Nigeria. Moor Journal of Agricultural Research. 7(1): 42 –48

Aigbekaen, E.O., Imarhiagbe, E.O., & Omokhafe, K.O. (2000). Adoption of some recommended Agronomic practices of natural rubber in Nigeria. *Journal of Agriculture for Fish, 1*, 51–60

Asokan, M.P.; Sushamakumari, S.; Anthony, P.; Lowe, K.C.; Power, J.B. and Davey, M.R. (2000). Plant requirement from embryogenic cell suspension derived protoplasts of rubber. Plant Cell, Tissue and Organ Culture, 61: 81-85

Dhevagi P., Oblasami G. (2002); Effect of paper mill efflu- ent on germination on agricultural crops, *J. Ecobio*, 4, 243-249

Enwezor, W.O., Udo. E.J., Usoroh. N.J., Ayotade, K.A and Adepeju, J.P. (ED) fertilizer use and management practices for crops in Nigeria, Lagos, federal ministry of Agriculture and Rural development 1989. P20-45(series 2)

Erhabor, P.O. (2005). Economic appraisal for proven technologies of OST, OFAR and SPAT results from 1986-1995 in Nigeria. Vols. 1 and 2. Project Coordinating Unit, Abuja, Nigeria.

FDALR (1995). The reconnaissance soil map of Nigeria (1: 650,000) Soil Report Volume 3 Federal Department of Agricultural Land Resources, Lagos, Nigeria

Hossain M.M., Hasan S.M.R., Mzumder M.E.H., Rana M.S., Faruque A., Akter R. (2008) Brine shrimp lethality bioassay and radical scavenging activity of Artocarpus lacucha Buch. -Ham.*Bangladesh. J. Life Sci*. 20 (2): 27-34.

Houba, V.J.G., Vander lee, J.J., Nowzamski, I. and Walinga,I. (1988). Soil and plant analysis, part 5: soil analysis procedure. *Dept of soil science and plant nutrition, Agriculture University*. Wageningen, Netherlands.

Howstuffworks, (2013). Properties and uses of rubber. Retrieved from http://science.howstuff works.com/life/botany/rubberinfo1.htm? &lang=en_us. Accessed June 1, 2013.

International Institute for Tropical Agriculture (IITA) (1979). Selected methods for soil and plants analysis.IITA manual series No.1 Ibadan, Nigeria.

Jacob, J. (2000). Rubber Tree, Man and Environment. In: Natural Rubber: Agromangement and Crop Processing (Eds P.J.George & C. Kuruvilla Jacob). Rubber Research Institute of India. Kottayam, pp. 509-610.

Law-Ogbomo, Kolawole & Osaigbovo, Agbonsalo. (2018). Productivity of cucumber (Cucumis sativus L) and postharvest soil chemical properties in response to organic fertilizer types and rates in an ultisols. *Tropical and Subtropical Agroecosystems*, 21(2018):513 – 520

Law-Ogbomo, K. E., Ahmadu, R., & Ogedegbe, S. A. (2020). Comparative effects of some soil amendments on the agronomic performance of maize varieties in a low fertile soil. *Notulae Scientia Biologicae*, 12(1), 189-195

Law-Ogbomo, K.E.; Osaigbovo, A.U. and Ogedegbe, S. (2014) Soil nutrient status and okra pod yield as influenced by plant density and cattle dung manure application RAHMANN G & AKSOY U (Eds.) (2014) Proceedings of *the 4th ISOFAR Scientific Conference*.'Building Organic Bridges', at the Organic World Congress 2014, 13-15 Oct., Istanbul, Turkey (eprint ID 22646)

Law-Ogbomo, KE; Osaigbovo, AU (2016). Growth and yield of ewedu (Corchorus olitorius) as influenced by food waste compost and inorganic fertilizer in a humid ultisol of southwestern Nigeria. *Nig. J. Agric. Food Environ*. 12(1): 80-84

Law-Ogbomo, K.E and Remison, S.U (2007) The Response of Dioscorea rotundata to NPK Fertilizer Application in Edo State, *Nigeria Research Journal of Agriculture and Biological Sciences,* 3(6): 917-923

Mbow C, Smith P, Skole D, Duguma L, Bustamante M (2014) Achieving mitigation andadaptation to climate change through sustainable agroforestry practices in Africa. *Current Opinion in Environmental Sustainability* 6:8ñ14.

Michael U (2006). Keynote address on the Presidential Initiative on Rubber Production and utilization. Rubber Research Institute of Nigeria, 17th January 2006.

Nigerian Rubber Association of Nigeria (2013): The Need for the revitalization of the rubber industry in Nigeria. *NRAN Press Statement* June 2013.

NRCSG (2002). Nigerian Rubber Consultative Study Group. Field Survey.

Odedina, S.A., J.N. Odedina, S.O. Ayeni, S.A. Arowojolu, S.D. Adeyeye and S.O. Ojeniyi, 2003. Effect of types of ash on soil fertility nutrient availability and yield of tomato and pepper. *Nig. J. Soil Sci*., 13: 61-67

Ogbebor, O. O., (2013). "The Sustainability of Agriculture in Nigeria Using Rubber as a Case Study" Electronic Theses and Dissertations. Paper 2312.http://dc.etsu.edu/etd/2312

Orhue, E. R. and Osaigbovo, A. U. **(**2013) The effect of rubber effluent on some chemical properties of Soil and early growth of maize (*Zea mays* l) *Bayero Journal of Pure and Applied Sciences,* 6(1): 164 – 168

Orhue E.R., Uzu, F., and Osaigbovo, A. (2007). Effect of Combining Rubber Effluent with Single Super Phosphate (ssp) on Some Soil Chemical Properties and Early Growth of Maize (*Zea may*s L). *Journal of Agronomy.* 2.10.3923/ja.2007.250.261.

RMRDC (2005): Raw Materials Research and Development Council Field Survey Result. 2005. http://www.rmrdc.gov.hg/survey report 2005/Rubber.pdf.