EFFECT OF NPK (15:15:15) FERTILIZER ON CHEMICAL PROPERTIES OF SANDY LOAM ULTISOL UNDER RUBBER (*Heavea brasiliensis*) AND MAIZE (*Zea mays*) INTERCROP IN BENIN CITY, NIGERIA

[1]Idoko, S.O., *[1]Ighedosa, S.A., [2]Orhue, E.R., [1]Oghomieje, L.A., [1]Ibikunle, O.O. and [1]Momoh. D.O.

[1] *Rubber Research Institute of Nigeria, Iyanomo, Benin City, Edo State, Nigeria*
[2] *University of Benin, Benin City, Edo State, Nigeria*

*Corresponding author's e-mail: sandra.ighedosa@gmail.com

ABSTRACT

A study was conducted during 2014 and 2015 cropping seasons at the Rubber Research Institute of Nigeria, Iyanomo, Benin City, Edo state, Nigeria to determine the effects of NPK 15-15-15 fertilizer on some physico-chemical properties of the soil under rubber and maize intercrop systems. The study was a split plot design consisting of three cropping systems (Sole rubber, sole maize and rubber + maize) and four NPK 15-15-15 fertilizer levels (0, 200, 400 and 600 kg/ha), arranged in a Randomized Complete Block Design. Each treatment was replicated three times. Soil samples were collected prior to and after treatment application (before and after cropping seasons). Physiological growth characteristics (plant height, girth, number of leaves and leave area) of the crops were collected monthly. The grain yield of maize and the dry matter yield of rubber were collected at the end of the cropping season. All samples collected were analyzed using standard laboratory soil analysis procedures. Data generated were subjected to analysis of variance (ANOVA). The result showed no significant ($P \leq 0.05$) effect of cropping systems and fertilizer rates on particle size distribution (sand, silt and clay) of the soil texture. The highest significant grain yields (3.15 tones/ha/year for sole and 2.54 tones/ha/year for intercropping) were in 400 kg/ha NPK fertilizer treatments, higher than the grain yield obtained from lower rates of NPK fertilizer. The grain yields for maize in the second year were lower compared with the first season, they followed the same trend observed in the first season. Generally, there was significant improvement in soil fertility status due the application of NPK 15-15-15 fertilizer. This was indicated by the reduction in soil acidity, increased total N, available P, organic matter, exchangeable bases. Among the levels of NPK 15-15-15 fertilizer tested, application of 600 and 400 kg/ha NPK 15-15-15 fertilizer gave a significantly higher crop growth characteristics, yield and improved soil fertility status compared with the other fertilizer levels tested. Consequently, 400 - 600 kg/ha of NPK 15-15-15 was hereby recommended for rubber + maize intercropping systems.

Keyword: Soil chemical properties, NPK 15-15-15, intercrop, rubber and maize, southern Nigeria.

J. Agric. Prod. & Tech.2020; 9:35-47

INTRODUCTION

Rubber smallholdings account for more than 70 percent of the world's natural rubber production globally. Intercropping of rubber with arable crops has been found to be beneficial to the growth of rubber and capable of improving the economy of the rubber enterprise thereby reducing the need for subsidies and credit to rubber farmers (Idoko, *et al.*, 2010; Esekhade*,* 2003 and Zainol *et al.,* 1993,). These farmers face a lot of challenges in contributing their quota to the expansion of rubber production in Nigeria as a result of the long gestation period (5 to 7 years). This is a period which the rubber plantation cannot be tapped for latex and hence no income accrued from the huge capital investment and maintenance of the plantation. This situation has remained a disincentive to rubber farmers and has made rubber enterprise unattractive, especially to small-scaled farmers in Nigeria. One possible approach that may assist rubber farmers to improve their income while maintaining rubber production is to intercrop rubber with alternative cash crops. Hence, a timely adoption of appropriate plantation management practices that is capable of utilizing the under-utilized land resources and increases the revenue base of the enterprises is important to the attainment of the drive to increase rubber production in Nigeria.

Thus, Rubber Research Institute of Nigeria (RRIN) developed and promotes rubber intercropping technology with rubber plantations and other crops. The crops are planted along the rubber avenues for the first seven years of planting. Some of the crops that are environmentally compatible with rubber without negative effects to either crop include cassava, pineapple, maize, vegetables, plantain, cocoyam, pawpaw, pepper, melon and yam among others (Mesike *et al*., 2009). The intercropping can be done with mature/immature rubber plantations depending on the type of crop to intercrop with the rubber plants. The technology is feasible and economical as the system allows the farmers to utilize land resources efficiently by planting arable crops on the fallow spaces in- between the rubber plants. The system serves as means of regular flow of income to farmer in additional to the income from rubber which translates to higher economic returns to the farmer.

Maize (*Zea mays*) known as Corn is a cereal crop that is grown widely throughout the world in a range of agro ecological environments. Maize thrives best in a warm climate and is now grown in most countries that have suitable climate conditions (FAO, 1988). More maize is produced annually than any other grain. They have been reported to thrive well as intercrop with many crops especially rubber (Esekhade*, et al.,* 2003, Idoko, *et al.*, 2010).

However, several workers (Esekhade *et al.,* 2010) have reported the *need* for soil amendments in rubber based cropping systems to ensure that rubber (the main crop) as well as the companion crop do not suffer nutrient deficiency that could lead to reduction in the growth rate of rubber and low yield of companion crop. Hence, the need for a deliberate study to determine the response of rubber and maize to Nitrogen, Phosphorous and Potassium fertilizer application on the appropriate levels of these nutrients necessary for increased growth, development and yield of these rubber and maize crops in intercropping systems. This study was therefore aimed at evaluating the effect of N.P.K. 15-15-15 fertilizer as sources of N, P, and K. on some soil chemical properties using and growth response of maize and rubber under intercropping systems in Iyanomo, Benin City of Southern Nigeria.

MATERIALS AND METHODS

This study was conducted during 2014 and 2015 cropping seasons at the Soil and Plant Nutrition Division experimental plot of Rubber Research Institute of Nigeria, Iyanomo near Benin City, Edo State. The study area falls between latitude $6^{0}05^{1}$ and $6^{0}25^{1}$ North and longitude $5^{0}35^{1}$ and $5^{0}55^{1}$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 short dry spell in August. Selected physicochemical properties of the soils before cropping shows that the pH of the area was 5.23, the organic carbon was 17.0 g kg^{-1}, Total N was 1.50 g kg^{-1}, and available P was 8.70 mg P kg^{-1}. The texture of the area was Loamy sand. The experimental area was first opened for cropping about 50 years ago. The land utilization system since then has been 2 – 3 years of cropping followed by 5 – 6 years of bush fallow. The last fallow before the start of the experiment lasted for five years after it had been cropped to maize, yam, cocoyam, plantain and bananas for three years.

The study was arranged in a split plot design consisting of three cropping systems as main plots (sole rubber, sole maize and rubber + maize) and four fertilizer levels as sub-plots (0 kg NPK/ha as Control), 200 kg NPK/ha, and C 400 kg NPK/ha, 600 kg NPK/ha). All the treatments were replicated three times. Each plot was 3 m x 2 m with 2 m row and 1 m furrow in between the plots. Budded rubber stumps were planted at a spacing of 4 m x 2 m while the maize was planted at a spacing of 75 cm x 25 cm. Four (4) rubber budded stumps were planted per plot and maize were planted three (3) seeds per hole and later thinned to one (1). Soil samples were air dried, crushed and passed through 2mm sieve to obtain fine earth materials, which were subjected to standard laboratory analysis for the following parameters: Soil reaction (pH) was determined at soil: water ratio of 1:2.5 using glass electrode pH meter. Particle Size Distribution (PSA) of the soil was determined by the modified Bouyoucous Hydrometer method described by Day (1965). Textural classes were obtained by the soil textural triangle procedure. Organic Carbon was determined by the Chromic acid oxidation method described by Black (1965). Total Nitrogen of the soil were extracted using the Micro-Kjedhal procedure, while percentage Nitrogen in the extract were determined titrimetrically (AOAC, 1995). Available Phosphorous was extracted using Bray 1 solution and the Phosphorous determined using the Molybdenum blue colorations method (Bray and Kurtz, 1945). Exchangeable Bases were extracted with neutral normal ammonium acetate solution. Ca and Mg were determined by EDTA titration while Na and K were determined using digital flame photometry. Exchangeable Acidity (Al^{3+} and H^+): was obtained from KCl extraction through titration. Exchangeable Cation Exchange Capacity (ECEC) and Base Saturation (BS) were computed according to the prescriptions in Black (1965). ECEC was determined by summing base and acid cations (including H^+ determined by titration) and EA was determined by a second titration of the same $BaCl_2$ extracts. Percentage Base saturation (BS) was calculated as the sum of K, Mg, Ca and Na (the bases) in meq/100g soil divided by the CEC; and then multiplied by 100%.. Second cropping was carried out in order to investigate the residual effect of NPK fertilizer.

Data on the number of leaves leaf area and girth of rubber seedlings were taken on a monthly interval. The morphological characteristics of maize (Number of plant height and number of leaves) were collected two weeks intervals. All data generated were analyzed using analysis of variance (ANOVA) statistics (GENSTAT, 2008). Significant means were separated using Duncan Multiple Range Test (DMRT) at 5% probability level.

RESULTS

Effect of NPK fertilizer on the Post – Harvest Soil Properties in 2014: Table 1 shows the effect of the various soil amendments on some soil physical and chemical properties during the 2014 cropping season. Under sole maize, there were significant differences ($P<0.05$) among the treatments in pH, Available P and Calcium content of the soil, with the soil treated with 600 kg//ha NPK achieving higher value of 5.70 g/kg pH, 25.14 mg/kg Available P and 1.70 Cmol/kg Calcium compared to other treatments including control. There were significant differences (P<0.05) among the treatments treated with 400 kg/ha NPK achieving higher value of 2.07 Cmol/kg organic C, 3.55 g/kg organic matter, and 1.50 g/kg Exchangeable Acidity compared to other treatments including control. However, there were no significant differences (P>0.05) among the treatments in soil Nitrogen content. There were significant differences (P<0.05) among the treatments in Potassium, Magnesium , Sodium, ECEC and % Base saturation content of the soil with the soil treated with 200 kg/ha achieving value of 0.32 cmol/kg Potassium, 1.55 Cmol/kg Magnesium, 0.83 C mol/kg Sodium, 4.60 ECEC cmol/kg and 75.43 % Base saturation compared to other treatments including control.

In sole rubber, there were significant differences (P<0.05) among the treatments in pH, Potassium, Magnesium, Sodium, ECEC and % base saturation content of the soil with the soil treated with 200 kg//ha NPK achieving higher value of 5.54 g/kg pH, 0.32 C mol/kg Potassium, 1.54 Cmol/kg Magnesium, 0.83 Cmol/kg Sodium, 4.63 Cmol/kg ECEC and 75.60 % Base saturation compared to other treatments including control. There were significant differences (P<0.05) among the treatments treated with 400 kg/ha NPK fertilizer achieving higher value of 2.22 g/kg organic Carbon, 3.81 g/kg organic matter and 1.53 Cmol/kg Exchangeable Acidity compared to other treatments including control. However, there were no significant differences (P<0.05) among the treatments in soil Nitrogen content. There were significant differences (P<0.05) among the treatments in Available P, Calcium and Exchangeable Acidity content of the soil with the soil treated with 600 kg/ha NPK achieving higher value of 24.72 mg/kg Available P and 1.72 C mol/kg Calcium compared to other treatments including control.

In rubber and maize intercrop, there were significant differences (P<0.05) among the treatments in pH, organic Carbon, Available P, Calcium, Sodium and Exchangeable Acidity content of the soil with the soil treated with 600 kg//ha NPK achieving higher value of 5.60 g/kg pH, 1.99 g/kg organic carbon, 25.14 mg/kg Available P, 1.82 Cmol/kg Calcium and 1.36 Cmol/kg Sodium compared to other treatments including control. There were significant differences (P<0.05) among the treatments treated with 400 kg/ha NPK fertilizer achieving higher value of 3.75 g/kg organic matter and 1.48 Cmol/kg Exchangeable Acidity compared to other treatments including control. However, there were no significant differences (P<0.05) among the treatments in soil Nitrogen content. There were significant differences (P<0.05) among the treatments in Potassium, Magnesium, ECEC and % Base saturation content of the soil with the soil treated with 200 kg/ha achieving higher value of 0.55 C mol/kg Potassium, 1.75 C mol/kg Magnesium, 5.78 C mol/kg ECEC and 80.97 % Base saturation compared to other treatments including control.

Effect of NPK fertilizer on the Post – Harvest Soil Properties in 2015: Table 2 shows the effect of the various soil amendments on some soil chemical properties during the 2015 cropping season. Under sole maize, there were significant differences (P<0.05) among the treatments in pH content of the soil with the soil treated with 200 kg//ha NPK achieving higher value of 4.30 g/kg pH compared to other treatments including control

Table 1: Pre- cropping and Post – Harvest Physical and Chemical Soil Properties after NPK 15:15:15 Application in the 2014 cropping Season.

		Post-Harvest Soil Properties														
		Sole Maize					Sole Rubber					Rubber + Maize				
		Treatment (kg/ha)					Treatment (kg/ha)					Treatment (kg/ha)				
Soil Properties	**Pre – cropping**	**0**	**200**	**400**	**600**	**LSD (0.05)**	**0**	**200**	**400**	**600**	**LSD (0.05)**	**0**	**200**	**400**	**600**	**LSD (0.05)**
pH (1:2 H2O)	5.23	5.42^{c}	4.45^{d}	5.08^{b}	5.70^{a}	0.05	5.31^{b}	5.54^{a}	4.31^{d}	5.01^{c}	0.04	5.33^{b}	4.75^{c}	5.20^{b}	5.60^{a}	0.05
Org C (g/kg)	1.70	1.81^{b}	1.55^{d}	2.07^{a}	1.77^{c}	0.03	1.92^{b}	1.61^{c}	2.22^{a}	1.93^{b}	0.03	1.74^{b}	1.49^{c}	1.76^{b}	1.99^{a}	0.03
Org M (g/kg)	3.00	3.12^{b}	2.66^{d}	3.55^{a}	3.04^{c}	0.03	3.31^{b}	2.82^{d}	3.81^{a}	3.21^{c}	0.03	3.12^{b}	2.85^{c}	3.75^{a}	3.24^{b}	0.03
Total N (g/kg)	0.15	0.14	0.13	0.15	0.14	NS	0.11	0.11	0.11	0.11	NS	0.13	0.14	0.15	0.14	NS
Avail. P (mg/kg)	8.70	5.14^{d}	7.48^{b}	7.16^{c}	25.14^{a}	0.28	5.02^{d}	7.33^{b}	7.01^{c}	24.72^{a}	0.25	5.15^{c}	7.46^{b}	7.66^{b}	23.14a	0.28
K (mg/kg)	0.45	0.25^{b}	0.32^{a}	0.24^{b}	0.18^{c}	0.03	0.21^{b}	0.32^{a}	0.21^{b}	0.21^{b}	0.03	0.32^{b}	0.55^{a}	0.45^{a}	0.45^{a}	0.03
Mg (mg/kg)	1.10	0.69^{b}	1.55^{a}	0.37^{c}	0.32^{d}	0.05	0.73^{b}	1.54^{a}	0.40^{c}	0.31^{d}	0.05	0.65^{b}	1.75^{a}	0.65^{c}	0.35^{d}	0.05
Ca (Cmol/kg)	1.90	0.99^{b}	0.77^{b}	0.86^{b}	1.70^{a}	0.25	1.01^{b}	0.81^{d}	0.90^{c}	1.72^{a}	0.25	1.00^{b}	1.21^{b}	1.11^{b}	1.82^{a}	0.25
Na (Cmol/kg)	1.10	0.65^{b}	0.83^{a}	0.38^{c}	0.29^{d}	0.04	0.65^{b}	0.83^{a}	0.42^{c}	0.29^{d}	0.04	0.75^{c}	1.17^{b}	1.18^{b}	1.36^{a}	0.04
EA (Cmol/kg)	1.10	1.36^{c}	1.13^{d}	1.50^{a}	1.47^{b}	0.20	1.42^{b}	1.13^{c}	1.53^{a}	1.53^{a}	0.11	1.42^{b}	1.10^{c}	1.48^{a}	1.48^{a}	0.20
ECEC (Cmol/kg)	5.15	3.94^{b}	4.60^{a}	3.35^{c}	3.96^{b}	0.08	4.02^{b}	4.63^{a}	3.46^{c}	4.06^{b}	0.08	4.14^{d}	5.78^{a}	4.87^{c}	5.46^{b}	0.08
%BS	77.70	65.48^{b}	75.43^{a}	55.22^{d}	62.88^{c}	0.28	64.68^{b}	75.60^{a}	56.65^{d}	62.32^{c}	0.28	65.70^{d}	80.97^{a}	69.61^{c}	72.89^{b}	0.28
Sand (g/kg)	932.00	905	908	928	910	NS	875	908	906	900	NS	915	906	927	917	NS
Silt (g/kg)	11.50	19	18	16	18	NS	29	18	16	18	NS	19	20	16	15	NS
Clay(g/kg)	56.50	76	74	56	72	NS	96	74	78	82	NS	76	74	57	68	NS
Texture	LS	LS	LS	LS	LS		LS	LS	LS	LS		LS	LS	LS	LS	

[a-d]Mean values for a particular cropping system with different superscript(s) across the same row are significantly ($p<0.05$) different. LSD = Least significant difference. NS = Not significant; LS = Loamy sand; EA = Exchangeable Acidity; ECEC = Exchangeable Cation Exchange Capacity; BS = Base Saturation.

There were significant differences (P<0.05) among the treatments treated with 400 kg/ha NPK achieving higher value of 3.24 Cmol/kg organic C, 5.59 g/kg organic matter, 8.73 mg/kg Available P, 2.67 Cmol/kg Magnesium, 6.69 C mol/kg Calcium, 10.49 C mol/kg ECEC and 92.66 % Base saturation compared to other treatments including control. However, there were no significant differences (P<0.05) among the treatments in soil Nitrogen, Potassium and Sodium. There were significant differences (P<0.05) among the treatments in Exchangeable acidity content of the soil with the soil treated with 600 kg/ha NPK achieving value of 1.68 C mol/kg Exchangeable acidity compared to other treatments including control.

In sole rubber, there were significant differences (P<0.05) among the treatments in pH and Available P content of the soil with the soil treated with 600 kg//ha NPK achieving higher value of 4.15 g/kg pH and 4.82 mg/kg Available P compared to other treatments including control. There were significant differences (P<0.05) among the treatments treated with 200 kg/ha NPK fertilizer achieving higher value of 2.90 g/kg organic carbon, 4.55 g/kg organic matter and 4.43 C mol/kg Calcium compared to other treatments including control. However, there were no significant differences (P<0.05) among the treatments in soil Nitrogen, Potassium and Sodium. There were significant differences (P<0.05) among the treatments in Magnesium and Exchangeable Acidity content of the soil with the soil treated with 600 kg/ha NPK achieving higher value of 1.94 Cmol/kg Magnesium and 1.92 cmol/kg Exchangeable Acidity compared to other treatments including control.

In rubber and maize intercrop, there were significant differences (P<0.05) among the treatments in pH, organic Carbon, organic matter, Potassium, Sodium and % Base saturation content of the soil with the soil treated with 300 kg//ha NPK achieving higher value of 5.41 g/kg pH, 0.31 Cmol/kg Potassium, 1.49 C mol/kg Magnesium, 0.81 Cmol/kg Sodium and 90.03 % Base saturation compared to other treatments including control. There were significant differences (P<0.05) among the treatments treated with 400 kg/ha NPK fertilizer achieving higher value of 1.76 g/kg organic Carbon, 3.02 g/kg organic matter and 1.45 Cmol/kg Exchangeable Acidity compared to other treatments including control. However, there were no significant differences (P<0.05) among the treatments in soil Nitrogen content. There were significant differences (P<0.05) among the treatments in available P, Calcium and ECEC content of the soil with the soil treated with 600 kg/ha achieving higher value of 23.12 mg/kg Available P, 1.61 C mol/kg Calcium and 3.78 C mol/kg ECEC compared to other treatments including control.

Effect of NPK Fertilizer on Grain yield of Maize: The effect of intercropping and NPK fertilizer application on maize yield characteristics in 2014/2015 cropping season is shown in Table 3 below. The result showed that NPK fertilizer had a significant effect on the yield compared to other treatments in 2014 cropping season. The highest grain yield (3.15 tones/ha/year) was obtained from plots treated with 400 kg/ha NPK fertilizer and was significantly (P<0.05) higher than the grain yield obtained from lower rates of NPK fertilizer. The control treatment had the least grain yield (1.57 tones/ha/year) in 2014 cropping season. While in the intercropping the highest grain yield (2.54 tones/ha/year) was obtained from plots treated with 400 kg/ha NPK fertilizer and was significantly (P<0.05) higher than grain yield obtained from lower rates of NPK fertilizer. The control treatment had the least grain yield (1.26 tones/ha/year).

Table 2: Pre- cropping and Post - Harvest Physical and Chemical Soil Properties after NPK 15 :15 :15 Application in the 2015 cropping Season

Pre-Cropping Soil Properties		Post-Harvest Soil Properties														
		Sole Maize Treatment (kg/ha)					Sole Rubber Treatment (kg/ha)					Rubber + Maize Treatment (kg/ha)				
Soil properties		**0**	**200**	**400**	**600**	**LSD**	**0**	**200**	**400**	**600**	**(LSD)**	**0**	**200**	**400**	**600**	**LSD**
pH (1:2 H2O)	5.23	4.17^{b}	4.30^{a}	4.20^{b}	4.09^{c}	0.06	4.35^{a}	4.06^{c}	4.15^{b}	4.00d	0.20	5.21^{b}	5.41^{a}	4.27^{d}	4.89^{c}	0.06
Org C (g/kg)	1.70	2.18^{d}	2.70^{c}	3.24^{a}	2.86^{b}	0.04	3.01^{a}	2.90^{a}	2.81^{ab}	2.52^{c}	0.35	1.54^{b}	1.31^{c}	1.76^{a}	1.52^{b}	0.04
Org M (g/kg)	3.00	3.72^{d}	4.67^{c}	5.59^{a}	4.93^{b}	0.05	4.75^{a}	4.55^{ab}	4.55^{ab}	4.10^{c}	0.50	2.67^{b}	2.27^{d}	3.02^{a}	2.59^{c}	0.03
Total N (g/kg)	0.15	0.16	0.18	0.21	0.20	NS	0.20	0.20	0.20	0.20	NS	0.13	0.12	0.17	0.13	NS
Avail. P(mg/kg)	8.70	5.82^{d}	7.23^{c}	8.76^{a}	7.73^{b}	0.07	5.42^{a}	4.72^{b}	4.82^{b}	4.10^{c}	0.05	4.73^{d}	6.88^{b}	6.59^{c}	23.12^{a}	0.21
K (mg/kg)	0.45	0.26	0.23	0.26	0.22	NS	0.30	0.3	0.20	0.20	NS	0.23^{b}	0.31^{a}	0.22^{b}	0.17^{b}	0.04
Mg (mg/kg)	1.10	0.93^{c}	0.56^{d}	2.67^{a}	2.27^{b}	0.08	1.34^{b}	1.94^{a}	1.34^{b}	1.94^{a}	0.05	0.67^{b}	1.49a	0.37^{c}	0.31^{d}	0.05
Ca (cmol/kg)	1.90	1.88^{d}	2.28^{c}	6.69^{a}	4.13^{b}	0.07	5.93^{a}	4.43^{b}	3.13^{c}	1.63^{d}	0.05	0.94^{b}	0.73^{b}	0.81^{b}	1.61^{a}	0.29
Na (cmol/kg)	1.10	0.09	0.10	0.10	0.10	NS	0.10	0.10	0.10	0.10	NS	0.63^{b}	0.81^{a}	0.38^{c}	0.28^{d}	0.05
EA (cmol/kg)	1.10	1.53^{c}	1.48b	0.77^{d}	1.68^{a}	0.20	1.02^{d}	1.81^{b}	1.70^{c}	1.92^{a}	0.06	1.29^{c}	0.37^{d}	1.45^{a}	1.41^{b}	0.20
ECEC(cmol/kg)	5.15	4.69^{c}	4.65d	10.49^{a}	8.40^{b}	0.10	8.69^{a}	8.58^{b}	6.47^{c}	5.79^{d}		3.76^{b}	3.71^{c}	3.23^{d}	3.78^{a}	0.38
%BS	77.70	68.70^{c}	68.17^{d}	92.66^{a}	80.00^{b}	0.01	88.26^{a}	78.90^{b}	73.72^{c}	66.84^{d}	0.10	65.69^{b}	90.03^{a}	55.11^{d}	62.70^{c}	3.75
Sand (g/kg)	932.00	937	917	943	907		885	900	906	908		895	898	916	910	
Silt (g/kg)	11.50	8	19	10	19		19	18	16	18		19	20	16	18	
Clay (g/kg)	56.50	55	64	47	71		96	82	78	74		86	82	68	72	
Texture	LS	LS	LS	LS	LS		LS	LS	LS	LS		LS	LS	LS	LS	

[a-d]Mean values for a particular cropping system with different superscript(s) across the same row are significantly different ($p<0.05$). LSD = Least significant difference.
NS = Not significant, LS = Loamy sand; LS = Loamy sand; EA = Exchangeable Acidity; ECEC = Exchangeable Cation Exchange Capacity; BS = Base Saturation.

In 2015 cropping season, the result indicated that maize yield differed significantly (P <0.05) between the sole and the intercrop. The highest grain yield (2.61 tones/ha/year) was obtained from plots treated with 400 kg/ha NPK fertilizer and was significantly (P<0.05) higher than grain yield obtained from lower rates of NPK fertilizer in the sole cropping. The control treatment had the least grain yield (1.30 tones/ha/year). While in the intercropping the highest grain yield (2.10 tones/ha/year) was obtained from plots treated with 400 kg/ha NPK fertilizer and was significantly (P<0.05) higher than grain yield obtained from lower rates of NPK fertilizer. The control treatment had the least grain yield (1.04 tones/ha/year).

Rubber yield (Shoot): The result of the rubber yield under sole and intercrop is shown in Table 4 below. The treatments as well as their interactions had a significant effect (p <0. 05) on the yield (shoot) of rubber. Rubber under sole cropping gave the highest yield (shoot) 0.93 tones/ha/year was obtained from plots treated with 600 kg/ha NPK fertilizer and was significantly (P<0.05) higher than yield (shoot) obtained from lower rates of NPK fertilizer while those intercropped with maize had the highest a yield (shoot) of 0.80 tones/ha/year was obtained from plots treated with 600 kg/ha NPK fertilizer and was significantly (P<0.05) higher than yield (shoot) obtained from lower rates of NPK fertilizer.

Land Equivalent Ratio (L.E.R) For Rubber – Maize Intercrop: The Land Equivalent Ratio (LER) for Rubber/Maize cropping system at Iyanomo is as shown in Table 5 below. Result of LER as shown in Table 5 indicate that maize recorded a high level of yield reduction under intercropping with rubber. However, the yield (shoot) of rubber was not significantly affected by maize intercropping. Maize intercropped with rubber and treated with 0 kg/ha NPK fertilizer, 200 kg/ha, 400 and 600 kg/ha NPK fertilizer recorded a yield reduction of 35 %, 32 %, 31 % and 14 % respectively compared with the sole crop. While rubber intercropped with maize given 400 kg/ha and 900 kg/ha NPK treatment recorded a yield increase of 69 %, and 86 % respectively over the sole crop. However, those treated with 200 kg/ha NPK had a yield production of 32 %. The LER obtained from 0 kg/ha, 200 kg/ha, 400 kg/ha and 600 kg/ha NPK were 1.45, 1.48, 1.49 and 1.66 respectively. The result also indicated that intercropping Rubber with Maize resulted in a higher land use efficiency of 45%, 48%, 49% and 66% in intercrop treatments respectively.

Table 3: Maize yield as affected by different rates of NPK 15-15-15 fertilizer in sole maize and maize + rubber intercrop

Year Treatments	Fertilizer (kg/ha)	2014 Maize Yield (tons/ha)	2015 Maize yield (tons/ha)
Sole Rubber	0	1.57	1.30
	200	2.13	1.77
	400	3.15	2.61
	600	2.81	2.33
	LSD (0.05)	6.72	5.57
Rubber+Maize	0	1.26	1.05
	200	1.72	1.42
	400	2.54	2.10
	600	2.26	1.88
	LSD (0.05)	5.41	4.48

LSD = Least significant difference.

Table 4: Rubber yield (shoot) in Rubber/ Maize cropping system trials in Iyanomo, (tones/ha/year)

Treatment	Fertilizer (kg /ha)	Biomass (Tones/ha)
Sole Rubber	0	0.13
	200	0.27
	400	0.53
	600	0.80
	LSD (0.05)	0.39
Rubber+Maize	0	0.20
	200	0.40
	400	0.77
	600	0.93
	LSD (0.05)	0.47

LSD = Least significant difference.

Table 5 : Land equivalent ratio for Rubber/Maize cropping system at Iyanomo

Year		**2014**			**2015**		
Treatments Cropping System	Fertilizer (kg/ha)	MAIZE	RUBBER	**LER**	MAIZE	RUBBER	**LER**
Sole Rubber	0	0	1.00	1.00	0	1.00	1.00
	200	0	1.00	1.00	0	1.00	1.00
	400	0	1.00	1.00	0	1.00	1.00
	600	0	1.00	1.00	0	1.00	1.00
Sole Maize	0	1.00	0	1.00	1.00	0	1.00
	200	1.00	0	1.00	1.00	0	1.00
	400	1.00	0	1.00	1.00	0	1.00
	600	1.00	0	1.00	1.00	0	1.00
Rubber+Maize	0	0.80	0.65	1.45	0.80	0.65	1.45
	200	0.80	0.68	1.48	0.80	0.68	1.48
	400	0.80	0.69	1.49	0.80	0.69	1.49
	600	0.80	0.86	1.66	0.80	0.86	1.66

LER = Land Equivalent Ratio. LER greater than one shows greater advantage of intercropping compared with sole cropping.

DISCUSSION

Maize plants in sole cropping showed better significant grain yield compared with those planted in the intercrop. Harder *et al.,* (1991) reported a depression of maize yield when sown in mixture with cowpea; they attributed the reduction in maize yields to competition for growth factors between the associated crops. Ekwere *et al.,* (2013) who stated that delayed maturity of maize could be attributed to the effect of Nitrogen; it seems high doses of Nitrogen promoted vegetative growth of the component crops at the expense of reproductive factors.

The rubber yield (shoot) was higher in the sole crop treatments compared with those of the intercropped treatments. This is attributed to competition for resources between maize and rubber in the system. This result is in agreement with the submission of

Esekhade, *et al*., (2003) and Idoko, *et al*., (2010).

The result Land Equivalent Ratio (LER) of the cropping systems showed that the intercropping system (Rubber + Maize) recorded LER values above one, indicating greater advantage of intercropping over sole cropping. This result is in agreement with the submission of other workers in the intercropping trials (Idoko *et al.,* 2006*,* Yunusa, (1989), Willey (1979) and Abolaji *et al*.,(1998)who recorded LER values greater than one, in rubber based intercropping systems.

The result of the soil chemical properties after cropping showed improvement in the general soil chemical qualities compared with the values recorded before the application of treatments. The texture of the soils in the study area is loamy sand. The soils also were characterized by low pH, low nutrient status, low ECEC as observed by (Juo, 1981), and (Kang and Juo, 1986). This implies low fertility status of the soil which means that soils of the study area were largely deficient in major essential nutrients and are below the critical recommendation

The result presented showed that the soil texture of the soil under different level of NPK fertilizer (0, 200, 400 and 600kg/ha) both in sole cropping and intercrop plots falls within loamy sand textural class. This clearly demonstrated that, the soil textural class did not change, indicating that fertilizer and intercropping system showed no significant effect on the physical characteristics (sand, silt and clay) of the soil. It has been widely reported that, soil texture does not change so easily. Changes only occur over longer period of pedological process such as erosion, deposition of illuviation and weathering (Brady and Weil, 1999). The duration of the study was (2 years) was not long enough to expect any significant changes in the textural class of the soil. This agrees with the findings of Brady and Weil (1999) that the textures of soil can hardly change but can be improved by using organic manure or inorganic fertilizer.

Addition of NPK fertilizer and intercropping brought about improvement in the general fertility status of the soil as indicated by improved soil pH, total N, available P, organic matter, exchangeable bases. This agrees with the findings of other workers Orimoloye *et al.,* (2010) and Waizah *et al.,* (2011) that NPK fertilizer and intercropping has the tendency to increase the soil pH, reduced leaching, erosion, increase efficiency and utilization of inorganic fertilizer; hence the acidic nature of the experimental site which might have caused nutrient unavailability to the crop was checked by the limiting potential of NPK fertilizer (Udoh *et al.,* 2005; Ullah *et al.,* 2008).

The NPK fertilizer application in total Nitrogen did not show any significant difference in sole cropping and intercrop in both seasons. However, comparing the values of Nitrogen applied at rates 200kg/ha, 400kg/ha and 600kg/ha with the control, there was a slight increase which showed no particular trend. The result showed higher rate of fertilizer. The increase in total N may be due to the application of the NPK fertilizer in the soil. This agrees with the finding of Ayoola and Adeniyan (2006) that while testing the effect of inorganic and organic fertilizer on soil chemical and yield performance of maize he noticed that total N decreases but increases with increases level of NPK fertilizer applied. This was due to the fact that plant makes use of this total N in soil.

The reduction in Phosphorus showed that NPK fertilizer influence availability of plant nutrient through immobilization and mineralization process and reduced the P sorption ability of the soil thereby making the nutrient available for plant use Cheryl *et al.,* (1997). However, Phosphorus at rate 600 kg/ha of NPK application showed increase in the cropping systems in 2014 cropping season and only in the intercrop in 2015 cropping season. The increase in available Phosphorus may have been attributed to the fact that under extremely low pH or below, substantial amount of available Phosphorus is fixed by Fe and Al oxides contents of these soils Osemwota *et al.,* (2010). The reduction in Potassium in the cropping systems

Inorganic fertilizer apart from releasing nutrient elements to the soil, it has been shown that NPK fertilizer improves soil chemical and physical properties of the soil thereby enhancing crop growth and cob development (Ogbonna, 2008; Uko *et, al*; 2009).

CONCLUSIONS

- Application of NPK fertilizer led to the improvement in some chemical properties of the soil especially, soil acidity, basic cations and ECEC of the soil.
- Application of NPK fertilizer to the soil will play a direct role in the improvement of soil fertility and yield performance of crops grown in mixtures.
- Yield of maize and rubber were better in sole cropping compared with those grown under intercropping production system.
- The Land Equivalent Ratio obtained which is greater than 1 indicated a greater advantage of intercropping the two crops together compared with when grown individually as sole crops.

RECOMMENDATIONS

- Maize farmers should adopt application of NPK fertilizer to maize crop production at the rate of 400 kg/ha for optimum growth and yield.
- Rubber farmers planting young rubber on land cleared from long fallow may not need apply NPK in the first year to reduce cost and waste of resources.
- Farmers adopt Rubber and maize intercropping production systems instead of sole cropping for optimum yield and enhanced economic income.
- Further research should be carried out using a higher NPK fertilizer rate.

REFERENCES

Abolaji, J.O, Olsen, F.J. 1998. Effect of planting densities and plant arrangement pattern on growth and yield of maize and soya bean in mixtures. *Nig. J. Agron.*, 3: 104-107.

AOAC 1995. Official Methods of Analysis, 15th Edition, Washington, DC Bokanga, M. 1994.

Ayoola, O.T. and Adeniyan, O.N. 2006. Influence of poultry on yield and yield components of crops under different cropping systems in South west Nigeria. *African Journal of Biotechnology,* 5: 1386-1392.

Brady N.C. and Weil, R.R. 1999. The nature and properties of soils 12th ed. 1999, 1996 by Prentice Hall Inc. Simon and Schuster. Aviacom company upper saddle river. New Jersey. pp: 326 – 327.

Black, C.A. 1965. Methods of Soil Analysis. *ASA Monogram 11*. Madison Wisconsin

Bray, R.H. and Kurtz, L.T. 1945. Determination of total, organic, and available forms of phosphorus in soils. *Soil Science*, 59: 39-45.

Cheryl, A., Palm, Robert, Myers, J.K., Stephen, M. and Nandwa, M. 1997. Combined use of organic and inorganic nutrient sources for soil fertility maintenance and replenishment. In: Special Replenish Soil Fertility in Africa. SSSA. Special Publication, No. 51 American Society of Agronomy and Soil Science. Wl. Usa.

Day, P.R. 1965. Particle Fractionation and Particle Size Analysis in C.A. Black (ed)

Methods of Soil Analysis Part Agro. 9: 545 – 567.

Ekwere, O.J, Muoneke, C.O., Eka, M.J. and Osodeke, V.E. 2013. Growth and yield parameters of maize and *egusi* melon in intercrop as influenced by the cropping system and different rates of NPK fertilizer. *Journal of Agricultural and Crop Research Vol. 1(5),* pp. 69-75

Esekhade, T.U, Ugwa, I. K. and Idoko, S. O. 2010. The effects and economic viability of Intercropping in rubber on Acid sandy soil of southern Nigeria. *Indian Journal of Natural Rubber Research,* 9(1):36-39.

Esekhade, T.U. 2003. Effect of phosphorus and selected rubber based cropping systems on the early development of rubber *(Hevea brasiliensis (Wild.ex A.ed Juss) Mueller Agroviensis* in acid soil. PhD Thesis: Department of Agronomy, University of Ibadan.

FAO, 1988. Production yearbook 1987, vol. 41. Maize FAO, Rome, pp125 = 126.

Harder, R.W, Horst, J. Schmidt, G. and Frey, E. 1991. Yields and Land use Efficiency of maize-cowpea crop rotation in comparison to mixed and monocropping on an alfisol in Northern Ghana, *Journal of Agron. Crop Sci*. 166:326-337.

Genstat. 2008. Genstat for windows. Released 11.1.01575. 11th Edition, VSN International Ltd,. Oxford.

Idoko, S.O, Orimoloye, J.R.., Uzu, F.O. and Ugwa, I.K. 2006. Effects of rock phosphate and indigenous mycorrhizal fungi on cocoyam intercropped with matured rubber plantation. Proceedings of the International Rubber Conference, Vietnam. 30: 236 – 245.

Idoko, S.O, Ehigiator, J. O. Esekhade, T. U. and Orimoloye, J.R. 2012. Rubber, Maize and Cassava Intercropping Systems on Rehabilitated Rubber Plantation Soil in South Eastern Nigeria. *Journal of Agriculture and Biodiversity Research* 1(6) 97-101.

Juo, A.S.R. (1981). Mineralogy of Acid Sands of Southern SSSN Special publication *Mornograph* 1:19-26.

Kang, B.T. and Juo, A.S.R. 1986. Effect of forest clearing on soil chemical properties and crop Performance. In: R. Lal, P.S. Sanchez and R.W. Cumming Jr. (Eds) Land Clearing Development in the tropics. Rotterdam, Boston.2:1, 56-60 during the immature period. Development in plantation Crop Research 1998. Rubber Research Institute of India Kottayam India pp, 230-232.

Mesike, C. S., Sagay, G.A., Owie, O.E.D., Ehika, S.N., Ebenuwa, C. and Ubani, S.E. 2009. Economic Replacement Model for Rubber Plantation in Nigeria. *Presented at the RRIN Semiar Series on the 24th June at Iyanomo*, Benin City, Nigeria.

Ogbonna, P.E. 2008. Effect of combined application of organic and inorganic fertilizers on fruit yield of egg plant (*Solanum melongena*). Pro. 42nd Annual Conf. agricultural Society of Nigeria (ASN) October 19 -23 p.236 – 250.

Orimoloye, J.R., Ugwa, I.K. and Idoko, S.O. 2010. Soil management strategies for rubber cultivation in an undulating topography of Northern Cross River State

Osemwota, I.O. 2010. Effect of abattoir effluent on the physical and chemical properties of soils, *Environmental Monitoring and Assessment*, 167:399-404.

Udoh, D.J., Ndon, B.A. Asuquo, P.E. and Ndaeyo, N.U. 2005. Crop production techniques for the tropics concept publication Lagos. Nigeria, PP. 48 -49, 211 – 216.

Uko, A. E., Udo, I. A. and Shiyam, J. O. 2009. Optimizing poultry manure rates for two okra (*Abelmoschus esculentus*) varieties in a warm wet Climate. *Journal of Agriculture Biotechnology and Ecology*, 2(3):273 – 285.

Ullah, M.S., Islam, M.S., Islam, M.A. and Haque, T. 2008. Effect of organic manure and chemical fertilizers on the yield of brinjal and soil properties. *Journal of Bangladesh Agricultural University.* 6(2): 271 - 276.

Waizah, Y., Uzu, F.O., Orimoloye, J.R and Idoko, S.O. 2011. Effect of Rubber Effluent, Urea and Rock Phosphate on Soil properties and Rubber Seedlings in an acid sandy soil. *African Journal of Agricultural Research,.* 6(16):3733-3739.

Willey, R.W. 1979. Intercropping: Its importance and research. Part 1. Competition and yield advantage. *Field Crop Abstract.* 32:1-10.

Yunusa, I.A.M. 1989. Effect of planting densities and plant arrangement pattern on growth and yield of maize and soya bean in mixtures. *J. Agric. Sci.* Camp., 112: 1-8.

Zainol, E.A., A.W. Mahmud and Sudin, M.N. 1993. Effects of intercropping systems on the surface processes in an acid ultisols. Changes in soil chemical properties and influence on crop performances. *Natural Rubber Research.* **8920**: 124 – 136.