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DETERMINATION OF SOME SOIL PHYSICO-CHEMICAL PROPERTIES OF AN ULTISOL AS INFLUENCED BY NPK FERTILIZER AND CROPPING RATIOS OF MAIZE (*Zea mays* L.) – EGUSI MELON (*Citrullus colocynthis* Hook L.) IN RAINFOREST AREA OF NIGERIA

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ABSTRACT
Field experiments were conducted (2009, 2010, 2011) at the Teaching and Research Farmland of the University of Benin to determine the effectof seven ratios (1:0, 0:1, 1:1, 2:1, 3:1, 1:2 and 1:3) of maize-egusi melon intercrop under four (0, 200, 400, 600 kg/ha) and six (0, 200, 400, 800, 1000 kg/ha) levels of NPK fertilizers on some soil properties of an utilsol in Benin City, Nigeria.
The results of the soils physico-chemical properties prior to planting and after harvesting of maize and egusi-melon showed significant differences ($p<0.05$, 0.001) in the various ratios of maize-egusi melon and NPK 20:10:10 fertilizers. Though not significant, soil pH was lower under the various cropping ratios of maize-egusi melon and NPK 20:10:10 fertilizers than the value prior to planting. In contrast, % C, N and P were significantly increased in all the experiments after harvesting of maize and egusi melon.
Significant increases in K, Ca and Mg contents were obtained due to cropping ratios and NPK fertilizer application generally in the experiments. Sole and intercropped plots of maize and egusi melon before planting and after harvest were characterized of dominance by sand but with significantly enhanced amounts of silt and clay by various cropping ratios and NPK fertilizers indicating stable soil texture.

INTRODUCTION

Continuous cultivation of farmlands occasioned by increase in human population resulting in shortage of land has become a characteristic feature of Nigeria farmers. This practice often result in soil degradation if not maintained. Though the use of mineral fertilizers (inorganic) proved to be more effective and convenient in soil fertility and productivity than the organic fertilizers, but the resulting effect of the former fertilizer on soil degradation and increased soil acidity and nutrient imbalance has necessitated the need to re-adopt the use of organic manures (Ehigiator, 1998). The manure has less negative effects on environmental and soil degradation. While the use of inorganic fertilizer is limited by high cost and scarcity, the organic manure

are limited by their low nutrient contents which makes crops demand for them to be high. An area which perhaps has not received adequate research attention is the use of combination of crops in various mixtures and ratios as means of nutrient recovery or restoration in degraded soils; especially as farmers in the tropics practice this system of crop cultivation regularly.

Integrated use of organic and inorganic fertilizers has been advocated lately (Agboola and Obatoru, 1989) and most recently by (Iren *et al.,* 2012, 2014).

There is limited information on the use of combined crops in various ratios as means of nutrient recovery or restoration in a degraded soil. This study is therefore aimed at combining various ratios of maize-egusi melon and NPK fertilizer to determine their effects on some soil properties of an ultisol.

MATERIALS AND METHODS

Experimental site/Design/Treatments

Field experiments were conducted for three years (2009, 2010, 2011) at the Teaching and Research Farm of the University of Benin (5^0 04' and 6^0 43'E, 6^0 14'S and 7^0 34'N) Benin City, Nigeria between March and August under rain fed conditions each year. The vegetation of the study area is tropical lowland rainforest with mean annual rainfall of 2300 mm and mean temperature of 32 ^{0}C. Soil of the study area and its environs are of the order ultisols generally described as leached, ferralitic type dominated by deep, reddish soils with clayey sub-soil and black organic matter (Egharevba and Osunde, 2000). Random soil sampling was done before planting to determine inherent soil nutrient status and after harvesting of maize and egusi-melon for nutrient uptake and left over. Soil auger was used to obtain random and composite soil samples at 0 - 30 cm depth in plots of maize (MA) and egusi-melon (EM) at seven cropping ratios of 1:0, 0:1, 1:1, 2:1, 3:1, 1:2 and 1:3 under four levels (0, 200, 400, 600 kg/ha) of NPK 20:10:10 fertilizers in 2009 and 2010 (as experiments 1 and 2 respectively) and six levels (0, 200, 400, 600, 800, 1000 kg/ha) of the fertilizers in 2011 as experiment 3. The fertilizer rates were increased to six in experiment 3 to validate results of experiments 1 and 2. Plant population of maize (MA) and egusi-melon (EM) in each experiment was MA 64: 0 EM, MA 0: 64 EM, MA 32:32 EM, MA 48:24 EM, MA 48:16 EM, MA24:48 EM and MA 16:48 EM representing ratios 1:0, 0:1, 1:1, 2:1, 3:1, 1:2 and 1:3 respectively of maize and egusi-melon. Four levels of the NPK 20:10:10 fertilizers were applied to the seven cropping ratios of MA and EM amounting to 28 plots replicated three times in experiments 1 and 2, and six rates in experiment 3 resulting in 42 plots replicated equally three times. The experiments were factorial in a Randomized Complete Block Design.

Laboratory Analysis

Soil properties were analyzed using standard procedures as described by IITA (1984) to determine pH (1:1 H_20), % C, N, P, K, Ca, Mg, S and Na, and particle size (% sand, silt and clay).

Data Analysis

Data collected were analyzed using procedures as outlined by Gomez and Gomez (1984) for Randomized Complete Design. Means that were statistically significant were separated using least significant diference (LSD) at 5 % level of probability.

RESULTS

Soil pH and carbon (%)

Cropping ratios of maize with egusi melon had no significant effect on soil pH after harvest in all the experiments (Table 1). The soil pH values obtained after harvesting the various crop mixtures were higher than the values present before planting the crops although treatment differences were not significant in all the experiments.

In contrast, the % C in the soil after harvesting the various maize-egusi melon mixtures was significantly ($P<0.05$) enhanced in all the experiments compared with the values in the soil before planting the crop mixture (Table 1). In Experiments 1 and 2, soil % C contents after harvest were generally higher in plots grown to crop mixtures than those sown either as sole maize or sole egusi melon.

Soil N (g/kg) and P (c.mol/kg)

Both soil N and soil P values were significantly increased in all the experiments after harvesting the crop mixtures as occurred for % C contents and the soil values at planting were lower (Table 1). In Experiments 1 and 2, soil N contents after harvest were generally higher in plots grown to crop mixtures than those grown either as sole maize or sole egusi-melon.

Sodium (Na) c.mol/kg

In both experiments 1 and 3, soil Na was similar before planting and after harvest in plots of the various maize-egusi melon mixtures (Table 1). However, in Experiment 2, growing the various mixtures on the plots significantly ($P<0.05$) increased soil Na after harvest compared with the values before planting.

Soil K and Ca (c.mol/kg)

The various crop mixtures generally increased significantly ($P<0.05$) soil K after harvest in Experiments 1 and 2 respectively, while they decreased it significantly ($P<0.0t$) in Experiment 3, compared with the respective values in the soil before growing the crops (Table 1). In Experiments 1 and 2, soil K contents after harvest were generally higher in plots grown to the crop mixtures than values obtained in either sole maize or sole egusi-melon. For soil Ca contents, this latter trend occurred only in Experiment 2, and while soil Ca content before planting in Experiment 1 was significantly ($P<0.05$) higher than the values obtained after harvesting the various crop mixtures and sole crops, the opposite trend generally occurred in Experiments 2 and 3 (Table 1).

Soil Mg and S (c.mol/kg)

The trend after harvest for soil Mg in plots of the sole crops and various mixtures was as in soil Ca whereby, in Experiment 1, significantly higher value occurred before planting in the soil (Table 1). This trend was reversed in Experiments 2 and 3 whereby higher soil Mg occurred after harvest in sole crops and various maize-egusi melon mixtures, values for the former being significant ($P<0.05$).

Significant differences occurred for soil S only in Experiments 1 and 2 ($P<0.05$ or 0.001). in the former, the sole crop values after harvest compared with the content before planting (Table 1). In Experiment 2, the sole crops and the various crop mixtures depleted soil S after harvest compared with the values in the soil before planting. The soil content after harvest were similar in plots of the sole crops and various crop mixtures respectively for either Mg or S.

Sand, Silt and Clay Contents (%)

The sand component of the soil was not sig-

nificantly affected by the various treatments of sole crops and cropping ratios both before planting and at harvest (Table 1). A similar trend occurred for the silt component in Experiment 1 only, while in Experiments 2 and 3 respectively the crop treatments significantly ($P<0.05$) increased the values after harvest compared with those before planting. The clay component of the soil was significantly ($P<0.05$ or 0.001) decreased in Experiments 1 and 2 on harvesting the various crop mixtures and sole crops grown compared with the values before planting while a reverse trend occurred in Experiment 2 (Table 1).

Effects of 20:10:10 NPK fertilizer rates on some soil Proprties

Soil pH and Carbon (%)

Both the soil pH and soil percent carbon (% C) after harvest were not affected by the various rates of 20:10:10 NPK fertilizer application as values similar to those obtained before planting occurred for these respective soil properties in all the experiments (Tables 2 and 3).

Soil N (g/kg) and P (c.mol/kg)

Soil N contents before planting and after harvest were similar in all the fertilizer treatments in the three experiments, excepting Experiment 2 where fertilizer rates of 400 and 600 kg/ha significantly ($P<0.05$) enhanced the value of N after harvest (Table 2). All the fertilizer rates (including 0 kg/ha where no fertilizer application occurred) significantly ($P<0.05$ or 0.001) enhanced the P status or content in the soil after harvest, compared with the content before planting, in Experiments 1 and 2 (Table 2).

Sodium (c.mol/kg)

In Experiment 1, the Sodium (Na) content in the soil decreased significantly after harvest, indicating that the uptake by the crop treatments surpassed any addition of this nutrient to the soil by the various fertilizer treatments (Table 2). However, in Experiment 3, fertilizer rates of 400, 600 and 800 kg/ha respectively improved the Na content of soil significantly ($P<0.001$) at crop harvest compared with the soil value before planting and also, at fertilizer rates of 0, 200 and 1000 kg/ha respectively (Table).

Soil K and Ca (c.mol/kg)

The respective soil contents of K and Ca before planting and after crop harvest were similar in Experiment 1 and application of various fertilizer rates to the plots had no influence on values obtained at removal of the crops (Table 2). A similar trend also occurred for soil Ca in Experiments 2 and 3 (Tables 2). In contrast, the various rates of fertilizer application significantly either enhanced (Experiment 2) or decreased (Experiment 3) soil K at harvest compared with the value before planting.

Soil Mg and S (c.mol/kg)

Application of fertilizer rates of 0 - 600 kg/ha of 20:10:10 NPK significantly ($P<0.05$) either decreased (Experiment 1) or increased (Experiment 2) the soil Mg after harvest compared with the values before planting (Table 2). The S content at planting was similar to values obtained at harvest under the various fertilizer treatments.

Sand, Silt and Clay Contents (%)

In Experiments 1 and 2, where fertilizer rates of 0 - 600 kg/ha were applied to the crop treatments, the silt and clay (Experiment 2 only) components of the soil were significantly ($P<0.05$) increased at harvest relative to values obtained before planting (Table 2). In Experiment 3, the sand, silt and clay components of the soil were similar before planting and at crop harvest.

DISCUSSION

The result of the soil physico-chemical properties before and after harvest of maize and egusi melon under the various cropping ratios (Table 1) and 20:10:10 NPK fertilizer rates (Tables 2) showed significant (P<0.05 or 0.001) differences in some of the properties assessed. Though the soil pH values lowered under the various cropping ratios and 20:10:10 NPK fertilizer rates as also observed by (Iren *et al.*, 2014) after harvest than before planting in Experiments 1 and 3, then increased more in value after harvest than before planting in Experiment 2 but were not significant. This agrees with earlier findings by Fondufe *et al.* (2001) and Ayoola and Adeniyan (2006) in which intercropping did not affect soil pH.

However, % C, N and K were significantly (P<0.001) enhanced due to cropping ratios in Experiments 1, 2 and 3. Perhaps the organic materials which resulted from the left over residues in this trial enhanced the organic matter and nutrient contents of the soil as earlier reported by Ehigiator and Ikhidero (1999), and Egharevba and Mayah (2001). This is feasible as the plots used for Experiment 1 were successively used for Experiments 2 and 3. Similar influence on % C, N, P and K due to intercropping was reported by Kurtz (2004), Ait (2007) and Osundare (2008) but for maize in mixture with cassava and Iren *et al* (2014) on flutted pumpkin. Although the % C and N contents were not significantly enhanced as a result of applied 20:10:10 NPK fertilizer rates in Experiments 1 and 3, but in Experiment 2, the 400 and 600 kg/ha rates of the fertilizer significantly (P<0.001) enhanced the N over the no fertilizer which could be due to residual effects of the previously applied fertilizer (Suomare *et al.,* 2002) or less competition for the nutrients by the tested crops resulting in less demand (Agoume and Birang, 2009; Anikwe, 2004). The significant increases in the amounts of Ca and Mg due to cropping ratios particularly in Experiments 1 and 2 and of pH in Experiment 2, though not significant, confirms the reports of Brady and Weily (1999) and Egharevba and Mayah (2001) that increase in the level of Ca and Mg contents of the soil will lead to increase in pH and thus, low soil acidity. Similarly, applied poultry manure at 7.5 tha increased 0.M, N, P, K, Ca and Mg (Adekiya *et al.,* 2014).

The physical properties (sand, silt and clay) of the soil were observed to have been significantly (P<0.001) enhanced by the various cropping ratios and partially by the 20:10:10 NPK fertilizer rates excepting sand.

This seems to agree with the findings by Ali *et al.* (2014) in which sand, silt and clay fractions were not significantly affected by manorial treatments though there was reduction in the sand contents in all the treated plots of maize.

Sole and intercrop plots of maize and egusi melon after harvest and even before planting were characterized of dominance by sand with values ranging from 74.61 to 79.10 % with significantly enhanced amounts of silt and clay by the various cropping ratios as land use systems significantly enhanced sand, silt and clay too in a similar trial (Agoume and Birang, 2009). It has been reported previously that soils of the South-south of Nigeria are acid sands with low nutrient retentive capacity due to low clay content of the soil (Ojanuga *et al.,* 1981). The sand nature of the soils indicate possible effect of low water retention ability (Soumare *et al.,* 2002) and may require regular supply of water and nutrients (Agbede, 2010). The fact that the different crop combinations had no negative effects on the soil texture particularly silt and clay in Experiments 1, 2 and 3 indicate a stable or enhanced soil tex-

ture. Past findings have clearly indicated the benefits of stable soil texture (Muller-Samann and Kotschi, 1997) and of intercropping (Kang, *et al.,* 1990., CTA, 1995, Jayne *et al.*, 2003) on soil properties to include yield stability, insurance against crop failure and thus sustainable agriculture.

CONCLUSION

The cropping ratios of maize and egusi melon NPK fertilizer rates had positive effect on soil pH. Significant increases in % C, N, and K were due to cropping ratios of maize-egusi melon and not as a result applied NPK fertilizers. Increase in the amount of Ca and Mg equally resulted in increase in soil pH. Sole and intercrop plots of maize and egusi melon prior to planting and after harvest were characterized by dominance of sand.

Table 1: Effects of Cropping ratios of maize and egusi melon on some soil properties in maize-melon plots.

Soil Parameters	Before planting	Cropping Ratios 1:0	01:	1:1 After	1:2 Harvest	1:3	2:1	3:1	S.E
Experiment 1									
P^H (H_2O)	5.75	5.68	5.65	5.64	5.63	5.71	5.68	5.66	0.12
% C	1.08	1.30	1.23	1.42	1.36	1.40	1.32	1.38	1.05*
N (g-kg)	7.60	7.96	7.60	8.40	8.00	8.35	7.98	8.10	0.31*
P (c.mol. kg)	15.85	16.15	17.75	18.35	18.10	17.90	17.80	17.90	0.77*
Na (c.mol. kg)	7.90	7.80	7.90	7.80	8.00	7.90	7.75	7.70	0.31
K (c.mol. kg)	41.10	39.60	40.90	41.85	40.60	42.25	42.70	40.70	1.62***
Ca (c.mol. kg)	225.20	198.0	197.2	201.4	183.7	196.7	205.2	197.2	7.40***
Mg (c.mol. kg)	41.10	32.90	33.40	32.75	34.15	35.05	34.60	34.00	0.52***
S (c.mol. kg)	0.17	0.18	0.19	0.19	0.19	0.18	0.20	0.18	0.01***
Sand (%)	75.64	77.64	78.72	76.84	78.12	79.10	77.13	76.16	4.1
Silt (%)	12.34	11.35	12.24	12.06	12.14	11.56	12.09	12.60	1.28
Clay (%)	12.02	11.01	9.04	11.10	9.74	9.34	10.78	11.26	0.40***
Experiment 2									
P^H (H_2O)	5.80	5.85	5.81	5.85	5.91	5.92	5.93	5.95	0.11
% C	1.30	1.43	1.27	1.43	1.88	1.85	1.94	1.96	0.07*
N (g-kg)	8.15	8.25	7.96	8.20	8.45	8.38	8.55	8.60	0.32*
P (c.mol. kg)	15.06	16.75	18.02	18.22	18.42	18.65	19.01	19.03	3.9
Na (c.mol. kg)	7.60	7.90	8.15	8.10	8.00	7.95	7.85	7.70	0.30*
K (c.mol. kg)	39.20	40.66	40.23	42.02	42.93	43.40	43.70	44.10	0.62*
Ca (c.mol. kg)	189.40	205.3	214.6	216.6	218.1	221.4	222.1	225.5	8.26*
Mg (c.mol. kg)	33.90	35.60	34.6	36.6	37.5	37.8	38.0	41.0	0.57*
S (c.mol. kg)	0.20	0.15	0.19	0.19	0.16	0.15	0.15	0.14	0.01*
Sand (%)	77.46	75.64	77.11	76.35	77.43	78.46	76.74	78.00	2.23
Silt (%)	11.35	12.34	11.35	11.74	11.57	7.66	11.11	12.60	0.49*
Clay (%)	10.19	12.02	11.54	11.91	11.00	13.88	12.15	9.40	0.52*
Experiment 3									
P^H (H_2O)	5.95	5.83	5.87	5.84	5.84	5.90	5.86	5.88	0.09
% C	1.40	1.45	1.86	1.74	1.68	1.95	1.83	1.79	0.07*
N (g-kg)	7.86	8.62	8.78	8.50	8.53	9.10	8.20	8.35	0.79*
P (c.mol. kg)	21.14	22.92	23.85	21.73	22.84	22.99	22.70	23.10	2.10
Na (c.mol. kg)	6.50	5.70	6.75	6.70	6.85	6.80	6.70	675	0.30
Mg (c.mol. kg)	40.38	41.98	43.86	41.25	42.52	42.75	41.05	40.50	0.57
K (c.mol. kg)	44.25	42.34	45.15	43.75	44.80	43.60	42.41	41.85	0.71*
Ca (c.mol. kg)	231.60	229.16	234.46	231.13	235.10	236.20	229.88	227.37	8.51*
S (c.mol. kg)	0.17	0.16	0.18	0.18	0.19	0.18	0.12	0.18	0.07
Sand (%)	74.61	75.22	73.67	75.03	74.77	73.81	75.51	76.51	0.03
Silt (%)	13.33	14.34	15.21	15.01	15.06	14.33	13.46	13.73	0.52*
Clay (%)	12.06	11.44	10.12	9.96	10.17	11.86	11.03	9.85	0.51*

*(P<0.05)

***(P<0.001)

Table 2: Effect of 20:10:10 NPK Fertilizer rates (kg-ha) on some soil properties in maize-egusi melon in experiments 1, 2 and 3

Soil Parameters	Before planting	Fertilizer Rates 0	200 After	400 Harvest	600	800	1000	S.E
Experiment 1								
P^H (H_2O)	5.75	5.73	5.72	5.76	5.88	-	-	0.07
% C	1.08	1.39	1.42	1.40	1.56	-	-	0.21
N (g-kg)	7.6	7.5	7.9	7.78	7.9	-	-	0.26
P (c.mol. kg)	15.8	15.9	17.2	16.8	17.4	-	-	0.17
Na (c.mol. kg)	7.9	7.6	7.5	7.5	6.9	-	-	0.17***
K (c.mol. kg)	41.1	42.1	41.8	42.4	43.5	-	-	0.88
Ca (c.mol. kg)	225.2	192.9	193.7	194.6	196.7	-	-	16.72
Mg (c.mol. kg)	41.0	32.7	33.5	34.4	35.0	-	-	0.36*
S (c.mol. kg)	0.17	0.18	0.18	0.20	0.22	-	-	0.02
Sand (%)	75.6	77.0	77.0	76.7	74.7	-	-	1.67
Silt (%)	12.3	11.3	11.6	12.6	13.0	-	-	0.30*
Clay (%)	12.0	11.6	11.4	12.1	12.2	-	-	0.78
Experiment 2						-	-	
P^H (H_2O)	5.8	5.9	5.9	5.9	5.9	-	-	0.06
% C	1.3	1.7	1.6	1.9	2.0	-	-	0.53
N (g-kg)	8.15	7.60	7.96	8.40	8.2	-	-	0.20*
P (c.mol. kg)	15.0	16.1	17.3	18.0	18.2	-	-	0.52*
Na (c.mol. kg)	7.6	7.8	7.9	7.8	8.1	-	-	0.33
K (c.mol. kg)	39.2	41.1	40.2	39.8	43.4	-	-	0.41*
Ca (c.mol. kg)	189.4	225.2	225.2	221.4	220.1	-	-	18.41
Mg (c.mol. kg)	33.90	41.0	39.7	38.0	36.6	-	-	0.39*
S (c.mol. kg)	0.20	0.17	0.19	0.18	0.19	-	-	0.02
Sand (%)	77.46	75.64	74.66	76.42	78.24	-	-	1.61
Silt (%)	11.35	12.34	12.12	12.36	10.60	-	-	0.30*
Clay (%)	10.19	12.02	13.22	11.22	11.16	-	-	0.29*
Experiment 3								
P^H (H_2O)	5.95	5.83	5.85	5.84	5.81	5.84	5.86	0.07
% C	1.40	1.42	1.44	1.51	1.48	1.63	1.68	0.08
N (g-kg)	7.8	8.2	8.9	9.3	9.5	9.5	9.7	0.09
P (c.mol. kg)	21.1	24.2	25.4	22.6	19.5	24.8	21.3	0.71***
Na (c.mol. kg)	6.5	6.2	6.3	6.8	6.9	6.5	6.4	0.43***
K (c.mol. kg)	231.6	198.8	223.6	222.1	216.3	221.5	227.7	0.53***
Ca (c.mol. kg)	44.2	39.6	41.4	40.2	38.7	42.2	43.0	1.34
Mg (c.mol. kg)	40.38	20.3	20.9	21.3	21.8	22.5	24.82	1.06
S (c.mol. kg)	0.17	0.19	0.20	0.21	0.23	0.22	0.20	0.03
Sand (%)	74.61	76.61	75.21	74.83	75.41	73.31	73.16	2.01
Silt (%)	13.3	12.7	12.77	13.5	12.8	14.7	14.7	1.84
Clay (%)	12.06	10.65	12.02	11.66	11.75	11.95	12.14	1.54

*($p<0.05$)
**($P<0.01$)
***($P<0.001$)

REFERENCES

Adekiya, A.O.I., Ojeniyi, S.O., Agbede, T.M. and Ewulo, B.S. (2014). Properties and Co-coyam performance as influenced by Tillage on an Alfisol in South West Nigeria. *Nigerian Journal of Soil and Tillage Research,* 1:87 – 92.

Agbede, T. (2010). Tillage and Fertilizer Effects on some soil properties, leaf nutrient concentrations growth and sweet potato yield on an Alfisol in South-Western Nigeria. *Soil Till-*

age Research, 110:25 – 32.

Agboola, A.A. and Obatoru, C.R. (1989). Problems and prospects of maintaining continuous arable crop production in the Humid tropics through soil organic matter. *Proceedings International Symposium UNESCO, UNDP, ICSU, Yamoussoukno* 641 – 653.

Agoume, V. and Birang, A.M. (2009). Impact of Land-use systems on some physical and chemical soil properties of on oxisol in the Humid Forest zone of southern Cameroon. *Tropicultura,* 27(1): 15 – 20.

Ait, S.O. (2007). Effects of varying density in cassava/maize intercrop and NPK fertilization on the performance of cassava. *Field Crops Research* 3: 201 – 205.

Ali, A. Achor, I.O. and A.O. Adaikwu (2014). Effect of *Leucaena leucocephala* biomass on Soil Physical and Chemical Properties in the sub-Humid Southern Guinea Savanna zone of Nigeria. *Nigeria Journal of Soil and Tillage Research* 1:103 – 110.

Anikwe, M.A.N. (2004). Quantifying the effects of crop and soil management practices on Soil productivity using N as a soil quality indicator. *Tropicultura* 22 (1) 40 – 46.

Ayoola, O.T. and Adeniyan, O.N. (2006). Influence of Poultry manure and NPK fertilizer on yield and yield components of crops under different cropping systems in South west Nigeria. *African Journal of Biotechnology* 5(15) 1386 – 1392.

Brady, N.C. and Weily, R.R. (1999). *Role of N, P and K in plant Nutrition in the Nature and Properties of Soils.* Prentice Hall Publishers News Jersey U.S.A. 862p.

CTA (1995). Farming Systems Research.

SPORE Bi-monthly Bull. 56: 1 – 5. CTA Wageningen Netherlands.

Egharevba, F. and Mayah, D.A. (2000). The Effect of Cassava peel extracts on the chemical properties of soils from some arable lands in Edo State of Nigeria. *Nigerian Journal of Applied Science* 19:98 – 104.

Egharevba, R.K. and Osunde D.O. (2000). The Effect of Crude Oil on seedling growth of two forest fruit trees: *Chrysophyleum albidun* (Gambaja albida) and *Dacryodes edulis* G. Don. *Journal of Sustainable Agriculture* 18(213) 25 – 35.

Ehigiator, J.O. (1998). Farmyard Manure: Need for its adoption as an alternative to chemical fertilizer. *Nigerian Journal of Horticultural Science,* 3: 1 – 9.

Ehigiator, J.O. and Ikhidero, B.O. (1999). Intercropping Effect of Cowpea (*Vigna unguiculata*) and pepper (*Capsicum frutescens*) on soil properties in an ultisol in mid western Nigeria. *Geo Research,* 3: 28 – 33.

Ewulo, B.S. (2014). Influence of Tillage and Poultry Manure on Soil Properties and Cornmel yield of Cocoyam. *Nigerian Journal of Soil and Tillage Research* 1:93 – 102.

Fondufe, E.Y., Eneji, A.E., Agboola, A.A. Yamamoto, S. and Honna, T. (2001). An Assessment of some Fertilizer Recommendations under Different cropping systems in a Humid Tropical Environment. *Tropicultura* 19(1): 21 – 27.

Gomez, K.A. and Gomez, A.A. (1984). *Statistical Procedure for Agricultural Research*. 2nd Edition, John Wiley and sons, New York U.S.A. pp.680.

IITA (1984). *Selected Methods of Soil and Plant Analysis*. International Institute of Tropical Agriculture (IITA) Nigeria and University of Guelph Publishers 63P.

Iren, O.B., John, N.M. and Imuke, E.A. (2012). Effects of Sole and Combined applications of organic manures and inorganic (urea) fertilizer on growth crude protein and nutrient uptake of flutted pumpkin (*Telfaria occidentalis,* Hook F.). *Journal of Agriculture, Forestry and Environment.* 2(1): 78 – 84.

Iren, O.B. John, N.M. and Imuke, E.A. (2014). Effects of Sole and Combined Applications of Organic Manures and Urea on Soil Properties and yield of fluted pumpkin (*Telfaria occidentalis,* Hook F.). *Nigerian Journal of Soil Science.* 24(1): 125 – 133.

Jayne, T.S. Kelly, V. and Crawford, E. (2003). Fertilizer consumption Trends in Sub-saharan Africa. *Policy synthesis* no 691: 1 – 4 US AID office Washington D.C. U.S.A.

Kang, B.T., Raynolds, L. and Attah-Krah, A.N. (1990). Alley farming advances. *Agronomy Journal* 43:315 – 359.

Kurtz, O.T. (2004). Influence of Cassava-based Intercropping System on Soil Organic carbon dynamics in the Tropical Agriculture.

Tropical Farming Systems 3:304 – 309.

Muller-Samann, K.M. and Kotschi, J. (1997). Soil in sustaining growth: soil fertility management in Tropical Small Holdings. *MargratsVerlag publication.WeikerSheim Germany* 480p.

Ojanuga, A.G., Lekwa, G. and Akamigbo, F.O.R. (1981). Survey, classification and genesis of Acid Sands. In: *Acid Sands of Southern Nig*eria: E.J. Udo and R.A. Sobulo (eds.) *Soil Science Society of Nigeria (SSSN) Special monograph* I 164p.

Osundare, B. (2008). Effects of Increasing maize population density in a cassava/maize mixture on major soil nutrients and performance of cassava in South western Nigeria. *Nigerian Journal of Soil Science* 18:60 – 67.

Soumare, M.A. Demeyer, F.M.O. Tack, G. and Vertoo M.G. (2002). Nutrient availability in the surface horizon of four tropical soils in Mali. *Tropicultura* 20(2): 58 – 63.