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SOIL CHEMICAL PROPERTIES, YIELD AND NUTRIENT UPTAKE OF MAIZE AS INFLUENCED BY PLANT AND ANIMAL BASED ORGANIC AMENDMENTS

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ABSTRACT

The influence of plant and animal-based organic amendments on soil chemical properties, yield and nutrient uptake by maize was studied for two years at the Research Farm of the Federal University of Agriculture, Abeokuta, Ogun State, South Western, Nigeria. The treatments used were: Poultry manure (PM); Compost (CP) derived from Poultry manure and *Tithonia diversifolia*; fresh *Tithonia diversifolia* applied as green manure (GM); Sunshine organo-mineral fertilizer (OMF); Neem organo compound fertilizer (NF) at 10 t/ha; N-P-K-20-10-10 (CF) at 120 kg N/ha; and control. They were arranged in a Randomized Complete Block Design with four replicates under maize (variety-SUWAN 1) cropping. Results showed that maize yield was significantly ($P<0.05$) increased by OMF and NF application when compared to the control in both years. N uptake was increased to 1.49 and 0.72 t/ha by OMF and NF applications respectively. P uptake was significantly ($P<0.05$) improved over the control by NF and OMF application while CF, OMF and PM applications promoted K uptake. P content of post-planting soil was increased by PM and NF while highest K content was given by CP application.

Key Words: Compost-uptake, post-planting, organo-mineral Fertilizer, Neem organo compound Fertilizer

INTRODUCTION

Tropical soils have been described to be generally low in organic matter, poorly buffered and low in CEC (Mokwunye and Batiano, 2001). It has also been observed that fertile agricultural soils have become severely degraded as a result of slash-and-burn agriculture with shortened fallow period (Onyekwere, 2009). Therefore, for a sustainable production of crops especially maize which requires relatively high soil fertility particularly with regard to nitrogen, phosphorus and potassium, external source of nutrients is mandatory. These nutrients could be supplied either from organic or inorganic sources or their combination. Busari *et al.* (2004), stressed the need for improved management practices through the use of external inputs from organic and inorganic

sources on tropical soils. Organic sources of nutrients could be either from plant and or animals. Application of organic source of nutrients which may be from plant or animal origin has been described by Francis *et al.* (1990) to be the current environmental and agricultural practice for maintaining soil and supplying plant nutrient. Examples of plant and animal materials which could be used as soil amendments are *Tithonia diversifolia* and poultry manure respectively. High nutrient concentrations have been reported in the former (Jama *et al.* 2000). Its green biomass has also been reported to be an effective source of nutrient for lowland rice (Ngarujah and Nizar, 1982). Poultry manure has equally been described as an excellent source of nutrients and has been recommended for incorporation into fertilizer programmes (Zublena *et al.*, 1997). Although, these organic materials have been used separately for crop production, it is necessary to use them together for comparism purposes. This experiment was designed to compare the effectiveness of different sources of organic and inorganic fertilizers on the growth and yield of maize as well as post planting soil chemical properties.

MATERIALS AND METHODS

Field experiment

The experiment was carried out at the Teaching and Research Farm of the Federal University of Agriculture (7° 15´ N, 3° 25´ E), Ogun State, Nigeria in 2009 and 2010 cropping seasons. Wet season in the area extends from March to October while the dry season is from November to February. Rainfall averaged 1130 mm is bimodal in nature. The first peak is in July and the second one in September. The mean monthly temperature is 29.63°C. The soils of the area are formed on basement complex, with Alfisols extensively distributed in the uplands while Entisols and Inceptisols are on the lowlands (Salako *et al.*, 2006).

The experimental site measuring 1,320 m^2 was manually cleared. Ten pre-planting core soil samples (0-15 cm) were collected with the aid of a soil auger, these were mixed to form a composite and used for the determination of physical and chemical properties. Plots measuring 5 m x 4 m were marked out and the following treatments were applied in a Randomized Complete Block Design (RCBD) with four replicates: Poultry manure (PM), fresh *Tithonia diversifolia* (GM), organo-mineral fertilizer (OMF), *Tithonia diversifolia* + poultry manure compost (CP), neem organo compound fertilizer (NF) at the rate of 10 t/ha, chemical fertilizer (CF) (N-P-K 20-10-10) at 120 kg N/ha and control. Organic based fertilizers were incorporated into the soil and left for two weeks before planting. At two weeks after treatment application, maize (variety-SUWAN 1) was planted at the rate of four seeds per hole which was thinned to two a week after planting, spacing used was 75 cm by 50 cm. Chemical fertilizer was applied by row method at two weeks after planting, weeding was done manually at four weeks interval.

Ten plants were randomly selected at the middle of each plot for data collection at six weeks after planting and the following parameters were measured: plant height which was done by measuring maize plant from soil level to the uppermost leaf, number of leaves by physical counting and leaf area by multiplying the leaf length by the breadth multiplied by 0.75 (Ellings, 2000). Whole plants were sampled at tasselling stage, oven-dried to constant weight at 65°C, the dry weights were taken after which they were milled for nitrogen, phosphorus and potassium determination. At maturity, maize cobs were harvested fresh and dried to 14 % moisture content and the grains were weighed. At the end of the experiment, soil samples (0-15 cm layer) were taken from each plot for chemical analysis.

Plant Analysis

Oven-dried plants were ground using mortar and pestle, nitrogen was determined using Micro-Kjeldahl method, phosphorus by Vanado molybdate method while potassium was determined using flame photometer (Juo, 1981).

Soil analysis
Soil samples collected before and after the experiment were air-dried, large clods were crushed with mortar and pestle after which they were sieved with 2 and 0.5 mm sieves. Nitrogen was determined by Micro-Kjeldahl (Bremner, 1965), phosphorus by Bray-1 extraction method followed by molybdenum blue colorimetry (Bray and Kurtz, 1945) and potassium by flame photometry after extraction with neutral ammonium acetate solution. Organic carbon was determined by wet oxidation method (Nelson and Sommers 1996), particle size was by hydrometer method while pH was determined in water by glass electrode method.

Statistical analysis
Results obtained were subjected to the analysis of variance (ANOVA) using SAS 2003 package and means separated by Duncan's Multiple Range Test (DMRT) at 5% level of probability.

RESULTS

The chemical properties of pre-planting soil is shown in Table 1, the pH was slightly acidic. The organic matter, total nitrogen, available phosphorus and potassium were low, while the texture was loamy sand. Nitrogen contents of *Tithonia diversifolia*, Sunshine organo-mineral and neem organo compound fertilizers were higher than other organic based fertilizers, *Tithonia diversifolia* and poultry manure had highest values of K while sunshine organo-mineral fertilizer had the highest value of organic carbon (Table 2). In 2009 planting season, fertilizer application whether chemical or organic showed no significant effect on maize height and leaf area, the number of leaves in the same year ranged from 11.75 to 13.63. Neem organo compound fertilizer application significantly ($P<0.05$) increased the number of maize leaves to 13.63 when compared with control, this value is however, not significantly different from those of other fertilizer types whether chemical or organic based. The lowest value (11.75) was obtained from control plants (Table 3). In 2010, plants treated with OMF, NF and CF had significantly ($P<0.05$) higher heights and number of leaves than control. Maize height ranged from 83.14 cm to 167.28 cm, the highest value (167.28 cm) was observed on plants treated with NF, closely followed by this is the value obtained by plants with the application of OMF (158.99 cm) while the shortest plants are ones without fertilization. A similar trend was observed for the number of maize leaves, the highest value (11.67) was given by NF treated plants, this was closely followed by plants with OMF application (11.25) while control plants had the lowest number of leaves (7.07). Observation on leaf area was similar to the above where the application of OMF and NF significantly ($P<0.05$) increased leaf area of maize to 673.86 and 711.10 cm respectively above the control (Table 3).

Table 1: Pre-planting Soil Chemical Properties and Texture

Chemical Property	Value
pH (H_2O)	6.80
Organic Matter (%)	1.30
Total Nitrogen (%)	0.14
Available P (mg/kg)	7.67
K (cmol/kg)	0.12
Ca (cmol/kg)	3.34
Mg (cmol/kg)	2.40
Sand (%)	86.4
Silt (%)	3.6
Clay (%)	10
Texture	Loamy sand

Table 2: Chemical Properties of the organic based Fertilizers used for the experiment

Fertilizer	N(%)	P(%)	K(%)	O.C. (%)
Poultry manure (PM)	2.0	0.65	5.7	8.84
Sunshine organo-mineral (OMF)	3.5	1.0	1.2	8.98
Compost (CP)	2.6	0.36	3.5	8.81
Neem organo-compound (NF)	3.8	1.33	6.4	8.95
Tithonia diversifolia (GM)	3.5	0.35	5.9	8.17

Table 3: Maize height, number of leaves and leaf area as affected by fertilizer application at 6WAP in 2009-2010. (n=4)

Fertilizer rate /ha	Maize height (cm)	Number of leaves	Leaf area (cm^2)
Year 2009			
OMF 10t	223.03	12.40ab	758.01
NF 10t	209.42	13.63a	857.45
GM 10t	214.22	12.75ab	827.76
PM 10t	214.22	12.13ab	739.84
CP 10t	251.14	13.10ab	785.78
CF 120 kg N	255.53	12.33ab	784.41
Control	249.70	11.75b	698.65
	NS		NS
Year 2010			
OMF 10t	158.99a	11.25a	673.86a
NF 10t	167.28a	11.67a	711.10a
GM 10t	102.40bc	8.35bc	408.15
PM 10t	105.70bc	7.77bc	408.09bc
CP 10t	84.79c	7.50c	296.37c
CF 120 kg N	114.11b	8.97b	475.36b
Control	83.14c	7.07c	306.41c

Means with the same letter(s) in columns are not significantly different from each other at $P<0.05$
OMF- Sunshine Organo-mineral Fertilizer
NF- Neem Organo-compound Fertilizer
PM- Poultry Manure
CP- Compost derived from poultry manure and *Tithonia diversifolia*
GM – Fresh *Tithonia diversifolia*
CF- Chemical Fertilizer
WAP-Weeks after planting

Fertilizer application with the exception of chemical fertilizer significantly (P<0.05) increased maize grain yield above the control in 2009, highest value of 2.78 t/ha was observed on plants treated with neem organo compound fertilizer, closely followed by this is the yield (2.74 t/ha) obtained from plants with the application of OMF. Yield increase followed this order of fertilizer application: NF>OMF>PM>GM>CP>CF>C. In 2010, significant yield increase was observed on plants treated with NF and OMF which had yield values of 2.50 t/ha and 1.85 t/ha respectively, lowest value (1.11 t/ha) was given by control plants (Fig. 1).

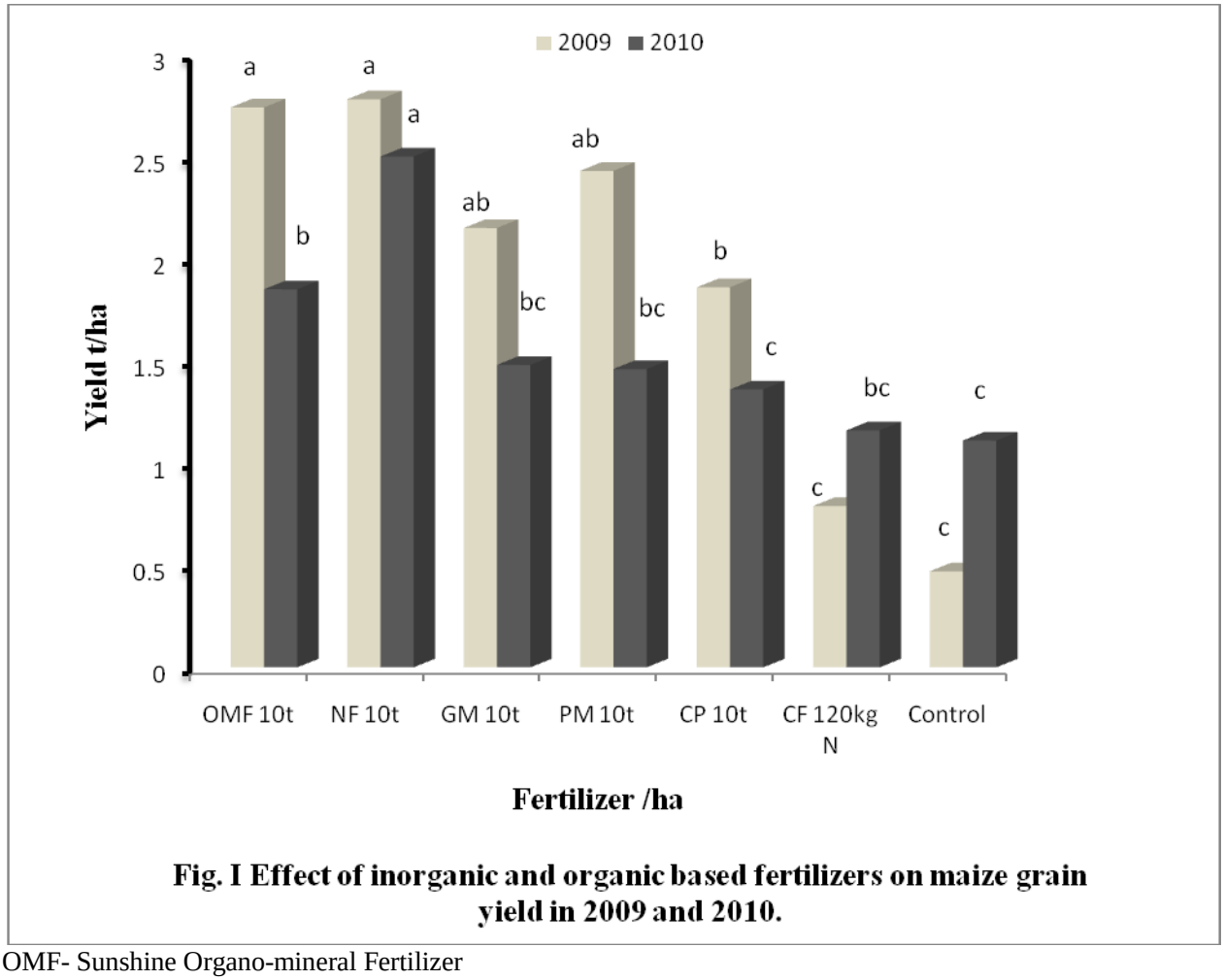

Fig. I Effect of inorganic and organic based fertilizers on maize grain yield in 2009 and 2010.

OMF- Sunshine Organo-mineral Fertilizer
NF- Neem Organocompound Fertilizer
PM- Poultry Manure
CP-Compost derived from poultry manure and *Tithonia diversifolia*
GM – Fresh *Tithonia diversifolia*
CF- Chemical Fertilizer

The effect of inorganic and organic based fertilizers on the uptake of N, P and K by maize is shown in Table 4. Plants treated with OMF and CF were significantly (P<0.05) higher in nitrogen and potassium uptake in 2009. Highest N and K uptake (1.49 and 2.41 t/ha respectively) were observed on plants with the application of OMF while the lowest uptake values (0.37 and 0.75 t/ha respectively) were observed in PM treated plants. Fertilizer application had no significant effect on P uptake. In 2010, all fertilizer treatments with

the exception of GM, significantly P<0.05) increased N and P uptake above the control, N uptake ranged from 0.32 to 0.72 t/ha. Increase in N uptake followed the order of fertilizer application: NF>OMF>CF>PM>CP>GM>C while P uptake ranged from 11.86 to 31.91 kg/ha and increase followed this order of fertilizer application: NF>OMF>PM>CP>CF> GM>C. Fertilizer application with the exception of OMF resulted in significant (P<0.05) increase in K uptake

Table 4: Effect of inorganic and organic based fertilizers on the uptake of N, P and K by maize, 2009-2010 (n=4).

Fertilizer rate /ha	N (t/ha)	P (kg/ha)	K (t/ha)
Year 2009			
OMF 10t	1.49a	86.37	2.41a
NF 10t	0.43c	69.84	0.86b
GM 10t	0.69c	83.98	1.38b
PM 10t	0.37c	72.80	0.75b
CP 10t	0.64c	88.32	1.38b
CF 120 kg N	1.01b	91.01	2.03a
Control	0.68c	66.09	1.36b
		NS	
Year 2010			
OMF 10t	0.64a	29.18ab	0.97e
NF 10t	0.72a	31.91a	3.60bc
GM 10t	0.33b	16.34cd	3.36cd
PM 10t	0.58a	21.84bc	8.72a
CP 10t	0.43b	20.36c	4.84b
CF 120 kg N	0.63a	20.24c	2.28d
Control	0.32b	11.86d	0.63e

Means with the same letter(s) in columns are not significantly different from each other at P<0.05
OMF- Sunshine Organo-mineral Fertilizer
NF- Neem Organocompound Fertilizer
PM- Poultry Manure
CP- Compost derived from poultry manure and *Tithonia diversifolia*
GM – Fresh *Tithonia diversifolia*
CF- Chemical Fertilizer

when compared with the control. The highest value (8.72 t/ha) was obtained in PM treated plants while the least value (0.63 t/ha) was from control plants.

Post-planting soil N, K, O. C. and Mg contents were not significantly affected by fertilizer application in 2009 while P and Ca were increased significantly ($P<0.05$) compared to control. Fertilizer application with the exception of NF increased phosphorus content of post planting soil. Values ranged between 15.75 mg/kg and 18.42 mg/kg, the highest value (18.24 mg/kg) was observed on plots treated with poultry manure, closely followed by this was GM while the least value (15.75 mg/kg) was from control plot. Application of OMF increased calcium content to 3.05 cmol/kg, this value is significantly higher than the control and other fertilizer values with the exception of PM and CP plots. In 2010, Nitrogen and pH were not affected by fertilizer application, peak values of P and O. C. (20.75 mg/kg and 1.88 % respectively) were obtained on NF treated plots. The highest value for P was significantly higher than those of other fertilizer types with the exception of GM. Organic carbon values ranged from 0.80 – 1.88 %, the highest value was significantly higher than values for other fertilizer types with the exception of OMF (1.57 %). Significant higher values of calcium and magnesium (2.45 and 1.60 cmol/kg respectively) when compared with the control and other fertilizer types resulted from the application of NF and CP respectively. Lowest values for the above (1.75 and 0.61 cmol/kg respectively) were from CF and GM plots respectively (Table 5).

Table 5: Effect of inorganic and organic based fertilizers on N, P and K content of Post-planting soil, 2009-2010 (n=4).

Fertilizer rate /ha	N (%)	P (mg/kg)	K (cmol/kg)	pH	O.C. (%)	Ca (cmol/kg)	Mg (cmol/kg)
Year 2009							
OMF 10t	0.15	16.78bc	0.17	6.75	1.14	3.05a	2.16
NF 10t	0.14	16.25cd	0.22	6.70	1.22	2.65bc	2.10
GM 10t	0.13	18.17ab	0.16	6.55	1.01	2.8bc	2.02
PM 10t	0.14	18.24a	0.18	6.40	1.01	2.9ab	1.92
CP 10t	0.12	17.42ab	0.20	6.85	0.96	2.9ab	2.09
CF 120 kg N	0.10	17.41ab	0.19	6.40	0.81	2.65bc	2.05
Control	0.14	15.75d	0.15	6.30	0.82	2.8bc	1.93
	NS		NS	NS	NS		NS
Year 2010							
OMF 10t	0.11	10.05c	0.6ab	6.4	1.57ab	2.20ab	1.49ad
NF 10t	0.12	20.75a	0.5ab	6.5	1.88a	2.45a	0.66d
GM 10t	0.12	14.75b	0.4b	6.1	1.36bc	2.15ab	0.61d
PM 10t	0.31	9.00c	0.5ab	6.0	1.22bc	2.3ab	1.12bc
CP 10t	0.11	9.25c	0.8a	6.0	1.13cd	2.05ab	1.6a
CF 120 kg N	0.09	10.25c	0.4b	6.0	1.12cd	1.75b	1.32ab
Control	0.09	9.00c	0.4b	5.8	0.80d	1.90ab	1.02c
	NS			NS			

Means with the same letter(s) in columns are not significantly different from each other at $P<0.05$

OMF- Sunshine Organo-mineral Fertilizer

NF- Neem Organocompound Fertilizer

PM- Poultry Manure

CP- Compost derived from poultry manure and *Tithonia diversifolia*

GM – Fresh *Tithonia diversifolia*

CF- Chemical Fertilizer

DISCUSSION

Response to fertilizer application was expected due to the low native nutrient status of the soil used for the experiment. Maize height and leaf area were not significantly affected by fertilizer application in 2009. Increase in the number of maize leaves observed in 2009 as a result of neem organo compound fertilizer treatment may be as a result of high nitrogen and potassium contents of the fertilizer. In 2010, all agronomic parameters observed were increased by fertilizer application, this may be due to the complementary effect of fertilizer application in 2009 and 2010. Highest values of maize height, number of leaves and leaf area resulted from organo-mineral and neem-organo compound fertilizer applications, high nitrogen contents of the fertilizers might have been responsible for this. The above parameters were also observed to be higher with chemical fertilizer than compost. Nutrient release from the latter is slow and probably slower than other organic based fertilizers while that of chemical fertilizer is immediate.

Application of organic based fertilizers generally increased maize yield in 2009, this observation is similar to that of Asawalam and Onyegbule (2009), who reported that organic manure increased maize grain yields. It was also observed that organo-mineral and neem organo compound fertilizer treatments gave yields that were significantly higher than those of compost and chemical fertilizer. Ojeniyi *et al*. (2009), reported that organo-mineral fertilizer application resulted in highest maize yield. Maize yield from chemical fertilizer did not differ significantly from control, this could be due to immediate nutrient release from the fertilizer where most of the nutrients might have been leached away. Higher maize yields were observed on neem organo compound and sunshine organo-mineral fertilizers in 2010, neem seed cake from which the former was derived has been described as a nitrification inhibitor (Puri, 1999) which prolongs the availability of nitrogen to crops. Organo-mineral fertilizer is a combination of both chemical and organic fertilizers which has been reported to increase the growth and yield of maize (Dania *et al*. 2012; Ayoola and Makinde, 2007).

The observed highest nitrogen and potassium uptakes in 2009 from organo-mineral fertilizer treatment are similar to the findings of Lawal *et al.* (2010), who reported that application of the above resulted in highest nitrogen, phosphorus and potassium uptake by white yam. High phosphorus content observed in post planting soil treated with organic based fertilizers in 2010 may be due to slow release of nutrients by the fertilizers.

CONCLUSION

The results of this study showed that maize grown with sunshine organo-mineral fertilizer (OMF), neem organo compound fertilizer (NF) and poultry manure (PM) at 10 t/ha gave higher yields and better crop quality while all the organic based fertilizers used in this study: CP, PM, OMF, GM and NF improved soil quality.

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REFERENCES

Ayoola, O. T. and Makinde, E. A. (2007). Complementary organic and inorganic Fertilizer Application Influence on Growth and Yield of Cassava/Maize/Melon Intercrop with a relayed cowpea. *Australian Journal of Basic and Applied Sciences* 1(3): 187-192.

Asawalam, D. O. and Onyegbule, U. (2009). Effects of some local mining materials and organic manure on

some soil chemical properties and growth of maize. *Nigerian Journal of Soil Science* 19 (2), 71-76.

Bray, R. H. and Kurtz L. T. (1945). Determination of total, organic and available forms of P in soils. *Soil Science Society of America Journal* 59: 39 – 45.

Bremner, J. M. (1965). Total Nitrogen. In: C. A. Black (ed.). *Methods of soil Analysis.* Part 3, Agronomy 9. American Society of Agronomy. Madison Wisconsin. Pp. 901

Busari, M. A., Adekunle, I. O. and Azeez, J. O. (2004). Effect of poultry manure and phosphorus application on the productivity and fodder quality of two *Centrosema* species in an Alfisol. *Proceedings of the 24th Annual Conference of the Soil Science Society of Nigeria*. December 6-10. 2004. University of Agriculture, Abeokuta, Nigeria.

Dania, S. O., Fagbola, O. and Isitekhale, H. H. E. (2012). Effects of Sawdust and organo-mineral fertilizer and their residual effect on the yield of maize on degraded soil. *Pak. J. Agric. Sci*. vol. 49(1): 61-66

Ellings, A. (2000). Estimation of Leaf Area in Tropical Maize. *Agronomy Journal* 92: 436-444.

Francis, C. A., Comelia, B. F. and Lary, D. K. (1990). Sustainable Agriculture in Temperate zone. John Wiley and sons Inc. New York. 437 pp.

Jama, B. C. A., Palm, C. A., Buresh, R. J., Niamg, A., Gachenco, C. N., Nziguheba, G. and Amadalo, B. (2000). *Tithonia diversifolia* as green manure for soil fertility Improvement in Western Kenya. *A Rev. Agroforestry Syst*., 49: 201-221

Juo, A. S. R. (1981). *Selected methods for Soil and Plant Analysis*. IITA manual series. No. 1. International Institute of Tropical Agriculture. Pp. 3- 14

Lawal, I. O., Adeoye, G. O., Asiedu, R. and Ojeniyi, S. O. (2010). Effect of Organo-Mineral. Fertilizer on Yield and Nutrient Uptake of white Yam (*Dioscorea rotundata* Poir.) in Ibadan, South Western Nigeria. *Proceedings of the 34th Annual Conference of the Soil Science Society of Nigeria*: 173-182.

Mokwunye, U. and Bationo, A. (2001). Meeting the phosphorus needs of the soils and crops of West Africa: the role of indigenous phosphate rocks. Integrated plant nutrient management in sub-Saharan Africa: from concept to practice. Ed. CAB International. pp. 209-224

Ngarujah, S. and Nizar, B. M. (1982). Wild sunflower as a green manure for rice in the mid-country west zone. *Tropical Agriculturist*: 138:69-78.

Nelson, D. W. and Sommers, L. E. (1996). Total carbon, organic carbon and organic matter, p.961 - 1010, In: D. L. Sparke (ed) *Methods of Soil Analysis*. Part 3, *Chemical Methods* SSSA Book Series no. 5. ASA and SSSA., Madison,W.I.

Onyekwere, I. N. (2009). Research Note: Properties of some wetland soils of the Niger Delta, Nigeria. *Nigerian Journal of Soil Science* 19(1):143-145.

Ojeniyi, S. O., Owolabi, O., Akinola, O. M. and Odedina, S. A. (2009). Field study of effect of organomineral fertilizer on maize growth, yield, soil and Plant nutrient composition in Ilesa, SouthWest Nigeria. *Nigerian Journal of Soil Science* 19 (1): 11-16.

Puri, H. S. (1999). *Neem: The Divine tree. Azadiracta indica*. Harwood Academic Publishers. Amsterdam. ISBN 90-5702-348-7

Salako, F. K., Tian, G., Kirchhof, G. and Akinbola, G. E. (2006). Soil particles in agricultural landscapes of a derived savanna in Southwestern Nigeria and Implications for Selected Soil properties. *Geoderma*, 137:90-99

SAS Institute, (2003). *SAS for linear models: A guide to the ANOVA and GLM procedures*. SAS Inst., Cary, NC.

Zublena, J. P., Barker, J. C. and Carter, T. A. (1997). Poultry manure as a Fertilizer source. Soil Facts.