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Effect of integrated nutrient management on selected soil physical properties and grain yield of maize in abakaliki, south eastern Nigeria

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ABSTRACT

An experiment was carried out at the Teaching and Research Farm of the Faculty of Agriculture and Natural Resources Management, Ebonyi State University Abakaliki to study effect of integrated nutrient management on some soil selected physical properties and grain yield of maize. The field was laid out in a Randomized Complete Block Design. There were five treatments namely poultry droppings mixed with burnt rice husk dust (PBRHD), cow dung mixed with unburnt rice husk dust (CURHD), goat dung mixed with saw dust (GSD) and NPK 20:10:10 fertilizer and control replicated four times. The data obtained from the study were subjected to Statistical Analysis System for Agriculture. The result showed that poultry droppings mixed with burnt rice husk dust (PBRHD), cow dung mixed with unburnt rice husk dust (CURHD), goat dung mixed with sawdust (GSD) and NPK 20:10:10 fertilizer had significantly ($P<0.05$) higher effect on total porosity, hydraulic conductivity, gravimetric moisture content (GMC) relative to control. The amendment of PBRHD showed significant ($P<0.05$) effect on hydraulic conductivity, gravimetric moisture content (GMC) and water retention (WR) when compared with control and NPK 20:10:10 fertilizer treatment. Significantly ($P<0.05$) lower dispersion ratio was obtained under PBRHD amended plots relative to control and NPK 20:10:10 fertilizer treatment. Furthermore, CURHD and GSD significantly ($P<0.05$) increased water retention relative to control and NPK 20:10:10 fertilizer application. Total porosity, hydraulic conductivity, gravimetric moisture content and dispersion ratio were higher by 6, 13, 87 and 64% in PBRHD amended plots when compared with NPK 20:10:10 fertilizer amended plots. The texture remained sandy clay loam after cropping. There was significantly ($P<0.05$) higher effect of PBRHD amendment on grain yield of maize compared to control and NPK 20:10:10 fertilizer treated plots. This was 22 and 20% increments of grain yield of maize in plots amended with PBRHD relative to control and NPK 20:10:10 fertilizer treatment. Generally, the integrated nutrient management improved soil physical properties and grain yield of maize more than control and NPK 20:10:10 fertilizer treatment. The order of improvement is PBRHD>CURHD>GSD>NPK 20:10:10 fertilizer>C. Integrated nutrient management could be recommended for soil management and sustainable productivity in Abakaliki agro-ecosystem of Nigeria.

Introduction

In Nigeria as well as other tropical countries, high cost and scarcity of mineral fertilizer have caused a paradigm shift in research interest to utilization of organic wastes as nutrient sources in crop production (Uyovbisere and Elemo, 2000). Huge quantity of organic wastes in relation to inorganic fertilizer required for soil amendment makes it imperative for combination of nutrient sources. According to Uyovbisere and Elemo (2000) integration of organic wastes reduces the quantity required and enhances nutrient releases. Furthermore, use of organic wastes to improve soil productivity as an alternative to mineral fertilizer will help in disposal of the wastes which generation has reached alarming proportion especially in developing countries such as Nigeria.

Organic wastes are of immense importance as potential materials in soil productivity restoration (USDA, 2002). Previous studies by Uyovbisere and Elemo (2000) showed superior effect of integrated nutrient supply over sole use of inorganic source. For instance, there was balanced nutrient supply, improved soil fertility and crop yield under integrated nutrient management (Olayinka and Adebayo, 2003; Adeniyan and Ojeniyi, 2006) with intensive use of land. Singh and Babasubramanian (1980) and Chand *et al.* (2006) corroborated Sustainable soil productivity due to integrated nutrient management. Sutanto *et al.* (2003) noted high crop yield under integrated nutrient management on acid soils. Integrated nutrient management is effective in the tropics where soil productivity depletion is rapid as a result of accelerated soil erosion, leaching and non-replaceable crop harvest system. This situation needs to be reversed such that soil nutrients level would not continue to decline unabated (Donova *et al.*, 1998). The fast means to halt rapid soil loss of productivity would be by integrated nutrient management. This is especially so since the process would ensure balanced and effective nutrient releases or even spread to

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sustain crop growth for the growing season. Even though, there had been studies on organic sources of nutrients in the area, information on integrated nutrient management is still not comprehensive. Consequently, studies are needed into integrated application of organic wastes. This study therefore was to study effect of integrated nutrient management on some selected soil physical properties and gain yield of maize in Abakaliki, Southeastern Nigeria.

Materials And Methods

Experimental site

The experiment was conducted at the Teaching and Research Farm of the Faculty of Agriculture and Natural resources Management, Ebonyi State University, Abakaliki. The area is located by Latitude $06^{o}4^{1}$N and Longitude $08^{o}65^{1}$ E in the derived savanna of the southeast agroecological zone of Nigeria. The rainfall pattern is bimodal and spread from April-July and September-November with a short spell in August normally referred as "August break". The minimum and maximum annual rainfalls of the area are 1700 and 2000 mm with annual average of 1800 mm. The mean annual temperatures are 27^{o}C and 31^{o}C for minimum and maximum usually experienced in periods of rainy and dry seasons. The relative humidity is 80% during rainy season but declines to 60% in dry season between December and April (ODNRI, 1989). The soil is derived from sedimentary rocks from successive marine deposits of the cretaceous an tertiary periods. The soils is shallow with unconsolidated parent materials of shale residuum within 1m of the soil surface. The soil according to Federal Department of Agricultural Land Resources (FDALR, 1985) consists of Olive brown sandy shales, fine grained sandstones and mudstones and belongs to the order *ultisol* classified as Typic Haplustult.

Field methods

A land area of 0.03ha was used for the experiment. The land was cleared of existing vegetation and debris removed. The field was laid out in randomized complete block design (RCBD). The plots measured 3 x 3 m with 0.5 m space while the replicates were separated by 1 m alley. The treatments were poultry droppings mixed with burnt rice husk dust, (PBRHD), cow dung mixed with unburnt rice husk dust (CURHD), goat, dung mixed with sawdust (GSD), NPK 20:10:10 fertilizer and control. The treatments except NKP 20:10:10 fertilizer were applied at 10tha^{-1} of poultry droppings, cow dung, goat dung and 10tha^{-1} of burnt rice husk dust, unburnt rice husk dust and saw dust properly mixed and partially fermented. The NPK 20:10:10 fertilizer was applied at 400kgha^{-1}. The treatments were replicated four times to give a total of twenty experimental plots in the experiment. The treatments were spread on the plots and later incorporated into the soil with hoe during soil tillage while NPK 20:10:10 fertilizer was applied two weeks after maize seed germination.

The NPK 20:10:10 fertilizer was sourced from Ebonyi State Agricultural Development Programme (EBADEP), Onyebonyi Izzi, Abakaliki. The burnt and urburnt rice husk dust were collected at rice milling industry (RMI) and saw dust at timber shade market (TSM) Abakaliki, respectively. Maize variety (Oba super II) was used as a test crop. The maize seed was obtained at Ministry of Agriculture, Ebonyi State, Abakaliki. The maize seeds were planted at a seed rate of two per hole at a depth of 5 cm while planting distance of 25 x 75cm was used. Two weeks after germination (WAG), the seedlings were thinned down to one per hole, subsequently seed replacement was done for those which failed to germinate. There was a total of 53,333 plants population for a hectare. Weeds were removed at three weekly interval till harvest of maize cobs. Grain yield of maize was obtained by harvesting the cobs when the husks were fully dried. The cobs were dehsuked, shelled and grains dried to constant weight. Yield was determined at 14% moisture content.

Soil sampling

Composite soil sample was collected with auger at 0 -20 cm depth for pre-planting analysis. Soil samples were further collected with cores at three points on each plot for post-planting soil analysis. The mean values of three cores of soil collected from each plot was used in data computation.

Laboratory methods

Particle size distribution was determined using Gee and Or (2002) method. Bulk density determination was done as described by Stolt (1997). Total porosity was calculated from bulk density value as follows:

$$TP = \frac{(1-BD)}{Pd} \times \frac{100}{1} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

Where

TP = Total porosity

BD = Bulk density

Pd = Particle density (assumed at 2.65 g cm-^{3}).

Mean weight diameter (MWD) was determined with the formular

$$MWD = \sum_{i=1} x_i W_i \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2$$

where

MWD = mean weight diameter of water stable aggregate

X_i = mean diameter of each fraction (mm)

W_i = mean proportion of the total sample weight corresponding to size fraction

Aggregate stability determination was as described by kemper and Roseanau (1998). Dispersion ratio was determined using the expression:

$$\%DR = \frac{\text{Water dispersed aggregate}}{\text{Calgon dispersed aggregate}} \times \frac{100}{1} \quad \ldots\ldots 3$$

where

%DR = Percent dispersion ratio

Gravimetric moisture content was determined according to Obi (2000) method.

Available phosphorus was determined by the Bray-2 method as described by Page *et al*. (1982). Organic carbon determination was by the method described by Nelson and Sommers (1982). The total nitrogen determination was done using micro Kjeldhal distillation method of Bremner (1996). The exchangeable Calcium and Magnesium were determined by titration method of Mba (2004). Sodium and potassium were extracted with 1 N ammonium acetate (NH_4OAC) solution and determined using flame photometer. Cation Exchange Capacity (CEC) was determined by ammonium acetate (NH_4OAC) displacement (Jackson, 1958) method. Effective Cation Exchange Capacity (ECEC) was evaluated by summation method as follows: ECEC = TEB + TEA

where

ECEC = Effective cation exchange capacity (cmolkg^{-1})

TEB = Total exchangeable bases(cmolkg^{-1})

TEA = Total exchangeable acidity (cmolkg^{-1})

The soil pH was determined in the soil/water solution ratio of 1:2.5. The base saturation was calculated as follows:

$$\% BS = \frac{TEB}{CEC} \times \frac{100}{1}$$

where

% BS = Percentage base saturation

TEB = Total exchangeable bases
CEC = Cation exchange capacity

Data Analysis

Data obtained in the field and laboratory were subjected to analysis of variance (ANOVA) while means which were significant separated with Fisher's Least Significant Difference as recommended by Steel and Torrie (1980).

Results And Discussion

Pre-planting soil properties

Table 1 shows result of soil properties at initiation of study. The texture was sandy clay loam. The pH value in KCI was 5.7 and this was slightly acidic according to Landon (1991) rating. Percent organic carbon and organic matter were high (Enwezor *et al.,* 1989) while total nitrogen was low. Available phosphorus according to the rating of Landon (1991) was medium. Calcium and magnesium dominated the exchange complex of soil. Cation exchange capacity was low according to Landon (1991). Base saturation was 69% thereby confirming the acidic nature of soil.

Table 1. Pre-planting soil properties

Soil Parameters	Units	Values
Sand	gkg^{-1}	510
Silt	gkg^{-1}	330
Clay	gkg^{-1}	160
Texture class		Sandy clay loan
pH in KCL		5.7
Organic carbon	%	1.76
Organic matter	%	3.04
Total nitrogen	%	0.15
Available phosphorus	$mgkg^{-1}$	18.65
Calcium	$cmolkg^{-1}$	7.60
Magnesium	$cmolkg^{-1}$	3.8
Potassium	$cmolkg^{1}$	0.29
Sodium	$comlkg^{-1}$	0.22
Effective cation exchange capacity	$comlkg^{-1}$	17.20
Base saturation	%	69.24

Effect of Amendments on Particle Size Distribution of Soil

Table 2 shows effect of amendments on particle size distribution of soil. There were variations in particles size distribution among the treatments. Plots receiving combination of organic wastes treatment had lower sand fraction and higher silt and clay fractions in comparison to control and NPK 20:10:10 fertilizer amendment. The higher percentage of sand fraction in NPK 20:10:10 fertilizer treatment and control suggests that integrated nutrient management could facilitate formation of fine sized particles which is good for nutrient retention and supply, water retention and compatibility. High sand percentage encourages leaching and vulnerability to droughty conditions which reduce soil productivity. However, the texture of the soil remained sandy clay loam in all the treatments after cropping. Texture according to Obi (2000) is a permanent property of soil and cannot easily be modified by cultural practices. Foth and Turk (1972) noted that texture had good relationship with nutrient storage, water retention, porosity and specific surface area, soil compatibility and compressibility (Smith *et al.,* 1998) which affect inherent productivity of the soil.

Table 2. Effect of amendments on soil particle size distribution

Treatment	Sand gkg^{-1}	Silt gkg^{-1}	Clay gkg^{-1}	Texture
Control	460	270	270	SCL
NPK 20:10:10 fertilizer	470	260	270	SCL
PBRHD	440	280	280	SCL
CURHD	430	290	280	SCL
GSD	420	310	270	SCL

PBRHD –Poultry droppings mixed with burnt rice husk dust, CURHD – cow dung mixed with urburnt rice husk dust, GSD.- Goat dung mixed with saw dust, SCL-sandy clay loam.

Effect of Amendments on Soil Physical Properties

The effect of amendments on soil physical properties is shown in Table 3. The plots amended with poultry droppings mixed with burnt rice husk dust (PBRHD), cow dung mixed unburnt rice husk dust(CURHD) and goat dung mixed with saw dust (GSD) showed highly significantly ($P<0.05$) higher effect on total porosity when compared to the control. The total porosities of plots amended with mixed organic wastes were slightly higher compared with those of NPK 20:10:10 fertilizer and goat dung mixed with saw dust (GSD) treatments. Significantly ($P<0.05$) higher effect on hydraulic conductivity was shown by mixed organic wastes amendments and NPK 20:10:10 fertilizer treatment relative to control. Furthermore, the PBRHD showed highly significant ($P<0.05$) effect on hydraulic conductivity in comparison to those of control and NPK 20:10:10 fertilizer amended plots. Similarly, gravimetric moisture content (GMC) of mixed organic wastes treatments and NPK 20:10:10 fertilizer treated plot was significantly ($p<0.05$) higher than control. Gravimetric moisture content of PBRHD and CURHD amended plots was significantly ($p<0.05$ higher relative to NPK 20:10:10 fertilizer and GSD amended ones. The plots amended with PBRHD and CURHD showed significantly ($P<0.05$) higher effect on aggregate stability compared to that of the control. The aggregate stability values varied among the mixed organic wastes treatment and NPK 20:10:10 fertilizer with the plot amended with PBRHD giving the highest value. Water retention varied among the treatments with the plots amended with PBRHD, CURHD and GSD having their respective water retention values significantly ($P<0.05$) higher than the control and NPK 20:10:10 fertilizer amendment. Furthermore, the plot amended with CURHD showed significantly ($P<0.05$) higher effect on water retention than those of PBRHD and GSD, respectively. The dispersion ratio of PBRHD and CURHD amended plots and that of NPK 20:10:10 fertilizer treated one was significantly ($P<0.05$) lower than the control. Again, the dispersion ratio of PBRHD and CURHD was significantly ($P<0.05$) lower than those of NPK 20:10:10 fertilizer and GSD amended ones. Bulk density varied among the treatments with those of mixed organic wastes and NPK 20:10:10 amended plots being lower than that of the control. Even though, mean weight diameter (MWD) of control and amended plots were not significant, those of mixed organic wastes treated plots except for GSD and NPK 20:10:10 fertilizer amended ones were higher than that of control. The mean weight diameter of PBRHD amended plot was 9% higher than that of GSD treated plot.

The significant treatment effect of mixed organic wastes treatment on total porosity is a positive indication that poultry droppings, cow dung and goat dug mixed with burnt rice husk dust, unburnt rice husk dust and saw dust could open up soil pores. This facilitated soil water storage and retention as evidenced in plots where those wastes were amended compared to control and NPK 20:10:10 fertilizer amendment. Adeleye *et al.* (2010) and Asadu *et al.* (2008) reported significant total porosity of organic wastes amended soil. Furthermore, Obi and Asiegbu (1980) noted increased water retention due to higher storage pores created by organic wastes amendment. The increased total porosity enhanced hydraulic conductivity of the soil. For instance, the amendment of PBRHD and GSD increased the hydraulic conductivity by 45% and 44% when compared to control, respectively. This finding is in agreement with the observation of Nwite (2013) on hydraulic conductivity of organic wastes treated soil. Bulk density was reduced due to organic wastes amendment and this accounted for 13% reduction in plots amended with CURHD. Bulk density as obtained in organic wastes amended plots were within non limiting values (Grossman and Berdanier, 1982).

Mean weight diameter is an index of soil stability (Obi, 2000) and therefore, the organic wastes amendment stabilized the soil and reduced soil dispersion. There were 115 and 83% reductions in soil dispersion in plots amended with PBRHD and CURHD relative to control. Soil stabilization and low dispersion ratio are productive indicators as they would increase the productivity of the soil.

Table 3. Effect of amendments on physical properties of soil

Treatment	BD gCm^{-3}	TP%	$HCcmhr^{-!}$	GMC %	AS %	MWD %	WR%	DR%
Control	1.57	41	39.57	11.26	13.38	2.71	44.54	0.84
NPK20:10:10 fertilizer	1.43	47	63.58	13.30	29.54	2.75	44.61	0.64
PBRHD	1.41	48	71.76	14.31	32.73	2.81	67.86	0.39
CURHD	1.39	49	65.30	14.05	31.26	2.79	83.25	0.46
GSD	1.50	45	70.85	12.18	30.71	2.58	63.44	0.73
FLS (0.05)	NS	3.9	8.15	0.72	8.51	NS	7.86	0.16

PBRHD – poultry droppings mixed with burnt rice husk dust, CURHD-cow dung mixed with unrburnt rice husk dust, GSD – goat dung mixed with saw dust, BD – bulk density, TP – total porosity, GMC. -gravimetric moisture content, As – aggregate stability, MWD – mean weight diameter, WR – water retention, DR – dispersion ratio.

Effect of amendments on grain yield of maize

Effect of integrated nutrient management on grain yield of maize is shown in Table 4. The amendment of poultry droppings mixed with burnt rice husk dust and cow dung mixed with unburnt rice husk dust showed significantly ($P<0.05$) higher effect on grain yield of maize relative to control. On the other hand, significantly ($P<0.05$) higher effect was shown by poultry droppings mixed with burnt rice husk dust (PBRHD) on grain yield of maize compared to control and NPK 20:10:10 fertilizer, respectively. This translated to 66 and 6% increments in grain yield of maize in PBRHD amended plots when compared to control and NPK 20:10:10 fertilizer amendment.

Application of poultry droppings mixed with burnt rice husk dust ensured even and balanced release of nutrients which culminated in significant grain yield of maize in plots where integrated nutrient management were applied. This suggests improved and sustained nutrient supply in contrast to control and NPK 20:10:10 fertilizer treated plots. This finding was corroborated by Quansah *et al.* (1998) and Palm (1995) that higher crop yields under integrated nutrient management were obtained relative to control. Oppong (1995) also reported higher grain yield of maize under poultry droppings and farm yard manure management.

Table 4. Effect of amendments on grain yield of maize

Treatment	Grain yield of maize (tha^{-1})
Control	5.0
NPK 20:10:10 fertilizer	5.3
PBRHD	8.3
CURHD	7.8
GSD	6.0
FLSD (0.05)	2.5

PBRHD-Poultry droppings mixed with rice burnt husk dust, CURHD- cow dung mixed with unburnt rice husk dust, GSD-goat dung mixed with saw dust.

Conclusion

This work studied integrated nutrient management as an alternative to inorganic fertilizer amendment in Abakaliki agro-ecosystem. The result showed that integrated nutrient management produced superior effect on soil physical properties and grain yield of maize. Integrated nutrient management generally reduced bulk density and in turn increased total porosity, improved water regime and stabilized the soil. This enhanced grain yield of maize. Poultry droppings mixed with burnt rice husk dust more than any other treatment improved water storage and stability of the soil. The amendments could be rated in the following order of PBRHD > CURHD>GSD>NPK 20:10:10 fertilizer> C based on their positive impact on soil physical properties and grain yield of maize. Therefore, integrated nutrient management could be adopted as an alternative to inorganic fertilizer amendment for sustainable soil productivity in Abakaliki area.

References

Adeleye, E.O., Ayeni, L.S. and Ojeniyi S.O. (2010). Effect of poultry manure on soil physico-chemical properties, lead nutrient contents and yield of yam (*Dioscorea rotundata)* on Alfisol in south western Nigeria. *Journal of Africa Science* 2010, *6 (10):* 509 – 518.

Adeniyan, O. N. and Ojeniyi, S. O. Comparative effectiveness of different levels of poultry manure with NPK Fertilizer on soil fertility, Nutrient uptake .of maize. Moor Journal of Agriculture Research 2006, 4:194-197.

Asadu, C. L. A., Ucheonye Oliobi, C. and Agada, C. Assessment of Sewage Application in Southeastern Nigeria. Part 1: Impact on Selected Soil Morphological and Physical Properties. Outlook on Agriculture 2008, 37 (1): 57 – 62.

Bremner, J.M. Nitrogen-Total. *In:* Sparks, D.L. (ed). Methods of Soil Analysis. Chemical Methods. American Soc. Agron. 1996, 5 (3): 1085-1121.

Chand, S., Anwar, W. and Potra, D. Influence of Long-term application of organic and inorganic fertilizer to build up soil fertility and Nutrient uptake in mint mustard cropping sequence. Communications in Soil Science and Plant Analysis 2006, 37:63-76.

Donova, G. and Rassey, C. Soil fertility management in Sub-Sahara Africa. Agronomy1998, 3:928-135.

Enwezor, W. O., Usoro, N. J., Ayoade, K. A. A ., Adepetu, J. A., Chude, V. O. and Udegbe, C. J. Fertilizer use and Management Practices for crop in Nigeria, No. 2. Produced by the Fertilizer Procurement and Distribution Division of the Federal Ministry of Agriculture, Water Resources and Rural Development, Lagos. Nigeria 1989, 1-120pp.

Foth, H. D. and Turk, C. Fundamentals of Soil Science. New York, John Wiley and Sons Ltd 1972, 25p.

Gee, G.W. and Or, D. Particle Size Analysis. *In:* J. H. Dane and G.C. Topp (eds). Methods of Soil Analysis. Physical Methods. Soil Sci. Soc. America 2002. 5 (4): 255-293.

Grossman, R.B. and Berdanier, C.R. Erosion Tolerance for Cropland. Application of the Soil Survey Data Base. America Society of Agronomy Special Publication, Madison, Wisconsin, USA 1982, No 45.

Jackson, M. I. The Soil Chemical Analysis London, Constable 1958.

Kemper, W. D. and Rosenau, R.C. Aggregate Stability and Size Distribution. *In:* Klute, A. (ed), Methods of Soil Analysis. Am. Soc. Agron, 1986, 9 (1) :425-444.

Landon, J. R. Booker, Tropical Soil Manual. A handbook for Soil Survey and Agricultural Land Evaluation in Tropics and

Sub-Tropics. John Wiley and Sons. Inc. Third Avenue, New York, USA 1991, 474p.

Mba, C.C. Selected Methods for Soil Plant, Environment Analysis. Handbook, Department of Soil Science University of Nigeria Nsukka 2004, 47p.

Nelson, D.W. and Sommers, L.E. Total Carbon, Organic Carbon and Organic Matter. *In:* Page, A.L. (ed). Methods of Soil Analysis. Part 2. Chemical and Microbiological Properties 2nd edition. Agronomy series Madison, Wisconsin, USA 1982, No. 9.

Nwite, J. N. Evaluation of the Productivity of a Spent Crankcase Soil Contaminated Soil Amended with Organic Wastes in Abakaliki, Southeastern Nigeria. Ph.D Thesis, University of Nigeria, Nsukka 2013, 1 – 56 pp.

Obi, M. E. and Asiegbu, B.O. The physical properties of some eroded Soils of southeastern Nigeria. Soil Science 1980, 130:29 - 48.

Obi, M. E. Soil Physics. A Compendium of Lecturers. Atlanto Publishers, Nsukka Nigeria 2000, 28p.

Olayinka, A. and Adebayo, A. The effect of loading rates of saw dust on plant growth, plant nutrient up take and soil chemical properties. Bioresources 1983, 9:250-268.

Overseas Development of Natural Resources Institute (ODNRI). Nigeria Profile of Agricultural Potential, ODA United Kingdom 1989, 3p.

Page, A.L., Miller, R. H,. and Keeney, D. R. (eds). Methods of Soil Analysis. Part 2. American Soc. Agronomy. Madison, Wisconsin 1982, 579 p.

Palm, C. A. Contribution of Agroforestry trees to Nutrient Requirements of intercropped Plants. Agroforestry System 1995, 30: 1 05 -1 24

Quansah, C. Asare, E., Safo. F. Y., Ampontuah, O., Kyvei—Baffour, N. and Bakang, J. A. The effect of Poultry Manure and Mineral fertilizer on maize cassava intercropping in Peri-urban Kumasi, Ghana. *In:* Arechsel, P. and Gyiele, L. (eds). Farm Research on Sustainable Land Management in Sub-Sahara in Africa: Approaches, Experience and Lessons. IBSRARM Proceeding No. 19, Bangkok, Thailand 1998, 73- 90.

Singh, K. K. and Babasubramanian, V. Maintenance of soil fertility in the Hills with incorporation of legumes cropping sequence. India J. Agric Science 1980, 480: 4-40.

Smith, C. W., Johnson, M.A. and Lovenretz, S. 1. Assessing the compaction susceptibility of South African forestry soils. *In:* Soil Properties affecting Compatibility and Compressibility. Soil Tillage Research 1998, 43.33 – 356

Statistical Analysis System (SAS). User’s Guide, 1985 (ed). Statistical Analysis System Institute Inc. Cary, NC 1985.

Steel, R.G.D. and Torrie, J. H. Principles and Procedure of Statistics. A Biometric Approach. 2nd edition, McGraw Hill, Book Co. Inc. New York 1980, 1 – 2 pp.

Stolt, J. (ed). Manual of Soil Physical Measurements. *In:* Wageningen, D. L. O. 3rd ed. Starring Centre, Tech Doc. 1977, 37p.

Sutanto, R., Suproyo, A. and Mass, A. The management of upland acid soils for sustainable food crops production in Indonesia. Soil Management 2003, 5(3): 1576 -1580.

United State Development Agency (USDA). Organic Matter Management and Soil Conservation into Agriculture Service Information, Bulletin 2003, No. 229.

Uyovbisere, E. O. and Elemo, K. A. Effect of inorganic fertilizer and foliage *Azadiracta* and *Parkia speci*e on the productivity of early maize. Nigeria Journal of Soil Research 2000,1:17-22.