Journal of Soil Science and Environmental Management Vol. 2(7), pp. 198-205, July 2011
Available online at http://www.academicjournals.org/JSSEM
ISSN 2141-2391 ©2011 Academic Journals

Full Length Research Paper

Comparative effectiveness of long yam bean (*Sphenostylis stenocarpa)* and organic and inorganic fertilizers in improving soil nutrient status and yield of maize in southwest Nigeria

F. O. Adekayode

Department of Crop, Soil and Pest Management, Federal University of Technology, Akure, Nigeria.
E- mail: adekay98@yahoo.com

Accepted 13 June, 2011

The comparative effectiveness of long yam bean and organic and inorganic fertilizers for soil fertility improvement was carried out in an investigation conducted in Araromi Farms (latitude 7°16'N and longitude 5°17'E) in Akure North Local Government Area of Ondo State Nigeria in 2007, 2008 and 2009. The experimental design was a randomized complete block consisting of four treatments replicated three times. The four treatments were organic compost at 2 t/ha, inorganic NPK fertilizer at 250 kg/ha, plots planted with long yam bean and a control without any inputs. Maize seeds obtained from Ondo State Agricultural Development Project were planted at 60 × 30 cm to give a plant population of 55,500 plants per hectare. Pre treatment and post treatment soil samples were taken for laboratory analysis for a comparison of the assessment of the cumulative effects of organic compost, inorganic fertilizer and long yam bean in improving soil fertility over a period of three years. The organic matter and nitrogen contents in the long yam bean and other manured plots were not significantly different. The soil nutrient status produced as a result of manure treatments reflected in the yield of maize. In 2007 significantly higher maize grain yield of 1.58 t/ha was obtained in NPK plot compared to other treatments while in 2008 and 2009, significantly higher maize grain yield of 1.76 and 1.86 t/ha respectively were obtained in organic compost plot with a comparable maize yield values between long yam bean and the NPK fertilizer plots in 2008. The profitable analysis showed a higher net revenue and benefit/cost ratio in long yam bean than in other treatment plots. The effectiveness of intercropping maize with long yam bean to maintain soil fertility and improve the yield of maize was comparable with the use of inorganic NPK 15-15-15 fertilizers and organic compost.

Key words: Long yam bean, organic and inorganic fertilizers, soil nutrient improvement, maize yield.

INTRODUCTION

The use of organic and inorganic manure in improving soil fertility for improved crop performance and yield had been reported (Palm et al., 1997; Gitari and Friesen, 2001). Celik et al. (2004) while investigating the effects of compost, mycorrhiza, and fertilizer on soil properties observed that mycorrhizal inoculation with compost was more effective in improving soil physical properties than the inorganic fertilizer and concluded that organic fertilizer sources had major positive effects on soil physical properties. The use of organic manure in improving soil physical properties had been achieved through improvement of soil structure (Avnimelech and Cohen, 1988), improved infiltration rate and soil water content (Ebaid and El-Refaee, 2007) and reduction in bulk density (Hagan et al., 2010; Hathaway-Jenkins et al., 2010). The improvement in chemical properties had been achieved through improved nutrient contents (Omotayo and Chukwuka, 2009; Mahmoodabadi et al., 2010).

The use of inorganic fertilizer in improving soil nutrient status though had been found desirable had to be employed with some cautions as the cumulative effects over a long-term use had been reported to have such undesirable effects as increased soil acidity (Mae-Wan, 2010; Devaney, 2010), nutrient imbalance and consequently reduced crop yield (Ayoola, 2010). The use of organic manure on the other hand though resulting in improved soil physical and chemical properties, had the disadvantages of bulkiness and low nutrient concentration (Chong, 2007). Further more the unjudicious use of organic manure had been reported to result in salt and heavy metal accumulation which may adversely affect plant growth (Ramesh et al., 2009). The use of leguminous crops in improving soil fertility had been reported in previous research (Klu et al., 2001; Ibeawuchi et al., 2007; Nekesa et al., 2007; Saka et al., 2007; Sridevi and Mallaiah, 2007; Eusuf-Zai et al., 2008).

Maize had a high requirement for nutrients which justified its being a good indicator of the nutrient status of the soil as it responded readily to the application of fertilizer (Iken and Amusa, 2004). Kogbe and Adediran (2003) investigated the response of maize to nitrogen, phosphorus and potassium (NPK) in the savannah zone of Nigeria and observed that both the open pollinated variety and hybrid maize responded well to NPK. Previous research by Ayoola and Makinde (2007) had reported several observations on the response of maize to both organic and inorganic fertilizers. There was however a great need for further investigation on intercropping of maize with leguminous crop such as long yam bean for soil fertility improvement while it had been postulated that the undesirable consequences of long-term use of organic and inorganic fertilizers and the transportation cost of bulky organic manure could be avoided by intercropping leguminous crops with other crops to improve soil fertility. The objective of this research was to investigate how effectively long yam bean would compare with organic compost and inorganic NPK fertilizers for soil fertility improvement for an improved production of maize.

MATERIALS AND METHODS

Site description

The experiment was carried out at Araromi Farms in Akure North Local Government Area in Ondo State Nigeria in April of each year of 2007, 2008 and 2009. The project site was located on latitude7°16'N and longitude 5°17'E within the forest-savannah transition zone of southwest Nigeria with a semi-deciduous vegetation. Soil at the project site was an alfisol derived from medium grained granite and gneiss (Smyth and Montgomery, 1962; Periaswamy and Ashaye, 1982). The rainfall pattern had a definite cycle of rainy season of March to October and dry season of November to February. In 2007 and 2008 the annual rainfall in each year was 1685.9 and 1612.5 mm, respectively while the mid annual temperature was 27.2 and 26.2°C, respectively. The experimental site had been cropped continuously for arable maize production for three years without fertilizer application and had been left fallow for three years before commencement of the experiment. The predominant weeds were siam weed (*Chromolaena odorata*) and guinea grass (*Aspilia africana*).

Preparation of organic composts

The organic compost was prepared by composting organic materials using basket method of composting (Madeleine et al., 2002). The circular outline of a 60 cm diameter and 60 cm deep pit was lined with a basket. The bottom was filled to a thickness of 10 cm with crop residues such as maize stalks and shelled cobs. Cured poultry manure was added to a thickness of 15 cm while green young leaves and wood ash were added to a thickness of 15 and 0.5 cm, respectively. Repeatedly, cured poultry manure, green young leaves and wood ash were added in layers until the pit was full. The top of the pit was covered with banana leaves. After three weeks, the pile was turned to a second pit and after another three weeks turned into the third pit and left to mature at the tenth week before application to the crops in the field. A shed was made over the compost pits.

Chemical analysis of the organic compost

Two grams of the processed forms of the organic compost was analyzed. The nitrogen content was determined by Kjedahl method while the organic carbon was determined by wet oxidation method through chromic acid digestion while P, K, Ca, Mg, Fe, Zn, Cu and Mn were determined using the perchloric acid digestion (wet oxidation) method (AOAC, 1980).

Soil sampling and analysis before planting

Prior to the commencement of the experiment in 2007, fifteen core (4 cm diameter and 10 cm high) soil samples were collected randomly from 0 to 15 cm depth in the site using soil auger, mixed thoroughly and the bulk sample taken to the laboratory, air dried and sieved to pass through a 2 mm screen for soil physical and chemical analysis.

Field experiments and manure treatment

The experimental design was a randomized complete block consisting of four treatment plots replicated three times. The four treatment plots were organic compost at 2 t/ha, inorganic NPK fertilizers at 250 kg/ha, plot planted with long yam bean and a control without any treatment. Downy Mildew Resistant (DMR) open pollinated maize that matured in ten weeks obtained from Ondo State Agricultural Development Project were planted at 60 × 30 cm to give a plant population of 55,500 stands per hectare and 140 stands per 5 × 5 m plot. The compost and inorganic NPK 15-15-15 fertilizer were applied at 2 t/ha and 250 kg/ha, respectively to give 36 and 4.5 g of organic compost and inorganic NPK fertilizer per maize stand, respectively while the long yam bean was planted at 15 cm from the maize plant. The manures were applied at planting and hand weeding carried out at six weeks after planting. Pre treatment and post treatment soil samples were taken for laboratory analysis.

Post planting soil sampling and analysis

A core (4 cm diameter, 10 cm high) soil samples in a 1 × 1 m quadrat in each plot was taken at harvest for soil chemical analysis. The soil samples in each treatment plot were bulked air-dried and sieved through a 2 mm sieve and analysed following the laboratory procedures described by Carter (1993). The particle size distribution was determined using 50 g of soil in 0.1M NaOH as dispersing agent using Hydrometer (ASTM 1524) methods. The soil pH was determined in water using a glass electrode pH meter. Organic carbon was determined by oxidising soil sample with dichromate solution and later titrated with ferrous sulphate solution (Walkley and Black, 1934). The total nitrogen was determined using

Table 1. Physical and chemical properties of soils (0 to 15 cm depth) in Araromi farms in Ondo State Nigeria in 2007 before the commencement of the experiment.

Soil property	Values
Sand (%)	69
Silt (%)	11
Clay (%)	20
Soil texture	Sandy loam
pH (H_2O)	6.0
Organic matter (g/kg)	1.89
Total N (g/kg)	0.15
Available P (mg/kg)	7.3
Exchangeable K (cmol/kg)	0.16
Exchangeable Ca (cmol/kg)	2.64
Exchangeable Mg (cmol/kg)	0.92

micro-Kjeldahl method and the available phosphorus determined by the Bray P-1 method (Bray and Kurtz, 1945). The exchangeable cat ions were extracted by leaching 5 g of soil with 50 ml ammonium acetate at pH 7. The potassium and sodium in the leachate were determined with a flame spectrophotometer while the calcium and magnesium were determined with atomic absorption spectrophotometer.

Agronomic parameters and data collection

Five maize plants within the 1 × 1 m quadrat in each plot were harvested for the yield for statistical analysis.

Statistical analysis

Data were collected in 2007, 2008, 2009 and subjected to analysis of variance (ANOVA) multiway classification with the treatment means compared using the Least Significant Difference (LSD) at 5% probability. The profitable analysis based on expenditure and income on maize production in the different manure application was computed. The expenditure consisted of the operational cost of land preparation of ploughing and harrowing, procurement of manure, purchase of maize seeds, purchase of long yam bean seeds, cost of manual planting, application of manure, cost of weeding, cost of harvesting and cost of shelling and bagging. The gross income consisted of sales of maize and long yam bean while the net income was obtained by subtracting the total production cost from the gross income.

RESULTS

Table 1 shows the result of the pre-treatment analysis. The soils were sandy loam and slightly acidic. The organic matter, total nitrogen, available phosphorus and exchangeable potassium, calcium and magnesium were low. The compost in addition to having medium to high NPK content also contained sufficient quantities of calcium and magnesium with the micro nutrient elements of iron, copper and zinc while the C/N ratio of 6.46 indicated medium to high nitrogen content. Tables 3, 4 and 5 show the soil chemical properties at harvest for 2007, 2008 and 2009. The pH indicated a neutral range in plots treated with organic compost and long yam bean while slightly acidic range of 6.0 to 6.3 were observed in the plots treated with inorganic NPK and the control plot. The organic matter contents were significantly higher in organic compost and long yam bean plots compared to other plots with the highest values observed in organic plot followed in a decreasing order of magnitude by long yam bean, inorganic and the control plots, respectively. The nitrogen and phosphorus contents which were in the medium range were in the first year 2007 significantly higher both in NPK and organic compost plots compared to the long yam bean and the control plot but in 2008 and 2009 the differences in values were no longer significant except the control plot with significantly lower values.

The sodium values were in the low range though the highest values were obtained in the plot treated with organic compost. The calcium and magnesium were generally in the low range though higher values were obtained in the organic compost plot. The cat ion exchange capacity values were significantly high in organic compost and followed in a decreasing order of magnitude by NPK, long yam bean and control plots, respectively.

The soil nutrient status produced as a result of manure treatment reflected in the yield of maize. In 2007, significantly higher yield values were obtained in NPK plot compared to other treatments. The percentage increase in the yield in NPK over long yam bean, organic compost and the control plots were 8.9, 12.8 and 73.6%, respectively. However, in 2008 a significantly higher yield were obtained in organic compost plot and the percentage increase in the yield values over long yam bean, NPK and control plots were 6.7, 8.6 and 87%, respectively while also in 2009 the percentage increase in the organic compost plot over long yam bean, NPK and the control plots were 8.1, 14.8 and 197.7%, respectively.

Over a period of three years, the application of NPK fertilizer did not produce changes in the soil nutrient status that followed any particular trend. Maize yield in 2008 and 2009 had the same values of 1.62 t/ha which was 2.5% over the 1.58 t/ha obtained in 2007. The application of organic compost caused the organic matter content to increase over the years which reflected in the yield of maize. Maize yield of 1.86 t/ha in 2009 was 5.7 and 32.9% over the yield values of 2008 and 2007, respectively. The long yam bean also caused an increase in organic matter content and this reflected in the yield of maize with the yield of 1.72 t/ha in 2009 being 4.2 and 18.6% over that obtained in 2008 and 2007, respectively. Tables 7, 8 and 9 show the profitable response resulting from the application of inorganic and organic manure and the planting of long yam bean on maize production in 2007, 2008 and 2009. The highest revenue value was observed in long yam bean which were derived from both the sales of maize and long yam bean seeds and this resulted in higher Benefit/Cost Ratio compared to other

Table 2. The chemical analysis of the organic compost used for the experiment.

C	N	C/N ratio	P (mg/kg)	K	Na	Ca	Mg	Fe	Cu	Zn
(%)				(%)				(mg/kg)		
26.7	4.13	6.46	382	1.21	1.02	0.32	0.43	36.47	0.14	1.42

*Basket method of composting (Madeleine et al. 2002).

treatments. In 2007, the yield of maize and the revenue obtained were higher in NPK than in organic compost whereas in 2008 and 2009 maize yield and revenue were higher in organic compost than in NPK. The least yield and revenue values were in all cases observed in the control plot.

DISCUSSION

The soil nutrient status of the experimental site before the commencement of trial (Table 1) was evaluated following the categorization employed in Kparmwang and Malgwi (1997) for nutrient level of tropical soils while the slightly acidic soil status was based on the discussion of Brady and Weil (1999) in the categorization of soil acidity or alkalinity. The low soil nutrient status of the experimental site could be attributed to the previous continuous cropping without manure application thereby justifying the site for the research.

The result of the chemical analysis of the organic compost (Table 2) confirmed that the ten weeks duration for the composting was long enough for a mature compost production and further that the trace elements Cu and Zn of 0.14 and 1.42 mg/kg, respectively were far below the permissible limit of 400 and 700 mg/kg for Cu and Zn, respectively. The quality assessment of compost as stipulated in the Canadian Council of Ministers of the Environment (CCME) 2005 had been employed in evaluating the suitability of the compost for the trial while the safe use of compost in improving soil fertility had been evaluated on the four criteria of the content of foreign matter, pathogen, trace elements and the maturity of compost (CCME, 2005).

The lower pH values observed in plots treated with NPK fertilizers compared to the other treatments of organic compost and long yam bean corroborated earlier research (Ayoola and Makinde, 2007; Ibeawuchi et al., 2007). Nitrogen compounds contained in fertilizer had been reported to produce ammonium ion that acidify soil by the nitrification of NH_4 to NO_3^- by which hydrogen ions could be produced (Chien et al., 2008). Harmsen et al (1990) had in previous research discussed the acidifying effects of fertilizers from an ionic-balance equation which explained how nitrogen fertilizers containing NH_4^+ could induce soil acidification. The neutral pH range observed in organic compost plot could be adduced to the effect of organic manure to cause a decrease in soil exchangeable Al^{3+} (Khoi et al., 2010). The neutral pH range also observed in long yam bean plot corroborated the previous observation of Moyin-Jesu (2008) with leguminous pigeon pea crop.

The higher organic matter content observed in the organic compost corroborated the explanation of Branson et al. (2010) and Dodson and Stearman (2010) on carbon sequestration resulting from addition of compost to soil while Rivero et al. (2004) had in previous research reported the addition of compost to increase the quantity of humic acids. The long yam bean had been considered by Klu et al. (2001) as a rich source of leaf litter which when decomposed would increase the soil organic matter and this explained the comparable organic matter content with the organic compost plot.

The significantly higher nitrogen, phosphorus and potassium levels in the NPK plot could be adduced to the readily soluble chemical fertilizers that resulted in the immediate solubility and availability of the nutrients. The use of inorganic fertilizer in improving soil fertility had been discussed to have direct and fast effects as nutrients in fertilizers are soluble and immediately available to plants and only relatively small amounts would be required for the crop growth since they are quite high in nutrient content (Makinde et al., 2010). The high nitrogen content observed in the long yam bean plot could be as a result of the leguminous plant capabilities to fix nitrogen in the root nodules (Jo et al., 1980; Bargali and Bargali, 2009). The nutrient contents in all the manured plots in the second and third year 2008 and 2009 respectively were comparable because of the additional nutrients obtained from the decomposition of the crop residues from the previous year harvest which corroborated an earlier observation (Klu et al., 2001).

The nutrient level which reflected in the yield of maize caused the differences in maize yield in the first year 2007 and the subsequent two years 2008 and 2009. In 2007, the nutrients in the NPK fertilizers which were soluble and immediately available in the soil resulted in the significantly higher maize yield of 1.58 t/ha making 8.96, 12.86 and 73.63 % over long yam bean, organic compost and the control plots, respectively. However, in 2008 and 2009, the organic compost which had properties to release nutrients slowly and the capability to contribute to the residual pool of nutrients in the soil, had 1.76 t/ha maize making 6.67, 8.64 and 87.23 % over long yam bean, NPK and the control plots respectively in 2008, while in 2009 the yield in organic compost plot was

Table 3. Soil chemical properties at harvest in 2007.

Treatment	pH	Organic matter	N (%)	P (ppm)	K (cmol/kg)	Na (cmol/kg)	Ca (cmol/kg)	Mg (cmol/kg)	CEC (cmol/kg)
NPK 15-15-15 at 250 kg/ha	6.3	3.24	0.28	12.2	0.34	0.16	2.87	0.84	4.44
Organic Compost at 2 t/ha	6.6	3.66	0.26	11.1	0.25	0.18	3.18	0.91	4.65
Plot planted with long yam bean	6.5	3.54	0.25	10.0	0.23	0.15	2.68	0.77	3.94
Plot without manure (Control)	6.0	2.11	0.17	7.4	0.16	0.15	2.61	0.71	3.75
LSD (0.05)	0.2	0.24	0.02	0.4	0.03	0.02	0.10	0.05	0.04

Table 4. Soil chemical properties at harvest in 2008.

Treatment	pH	Organic matter	N (%)	P (ppm)	K (cmol/kg)	Na (cmol/kg)	Ca (cmol/kg)	Mg (cmol/kg)	CEC (cmol/kg)
NPK 15-15-15 at 250 kg/ha	6.0	3.25	0.29	12.9	0.36	0.17	2.65	0.85	4.15
Organic Compost at 2 t/ha	6.8	4.39	0.29	12.3	0.27	0.19	3.21	0.82	4.60
Plot planted with long yam bean	6.7	4.07	0.28	10.7	0.24	0.17	2.57	0.75	3.84
Plot without manure (control)	6.0	2.48	0.17	7.8	0.17	0.15	2.42	0.70	3.55
LSD (0.05)	0.2	0.18	0.02	0.7	0.04	0.02	0.18	0.06	0.06

Table 5. Soil chemical properties at harvest in 2009.

Treatment	pH	Organic matter	N (%)	P (ppm)	K (cmol/kg)	Na (cmol/kg)	Ca (cmol/kg)	Mg (cmol/kg)	CEC(cmol/kg)
NPK 15-15-15 at 250 kg/ha	6.2	3.26	0.30	13.0	0.38	0.17	2.76	0.89	4.31
Organic Compost at 2 t/ha	6.7	4.42	0.29	12.3	0.29	0.19	3.21	0.83	4.64
Plot planted with long yam bean	6.6	4.10	0.28	10.8	0.25	0.16	2.62	0.78	3.92
Plot without manure (Control)	6.3	2.47	0.16	8.4	0.18	0.16	2.61	0.73	3.80
LSD (0.05)	0.2	0.10	0.02	0.4	0.03	0.02	0.15	0.09	0.04

Table 6. Maize grain yield in 2007, 2008 and 2009.

Treatment	Maize grain yield (t/ha) in 2007	Maize gain yield (t/ha) in 2008	Maize grain yield (t/ha) in 2009
NPK 15-15-15 at 250 kg/ha	1.58	1.62	1.62
Organic Compost at 2 t/ha	1.40	1.76	1.86
Plot planted with long yam bean	1.45	1.65	1.72
Plot without manure (Control)	0.91	0.94	0.97
LSD (0.05)	0.04	0.06	0.04

Table 7. The effects of manure on yield of maize and the profitable analysis in 2007.

Treatment	Yield of maize (t/ha)	Yield of long yam bean (t/ha)	Total cost of production (US dollars)	Total revenue (US dollars)	Net revenue (US dollars)	Discounted factor at 15%	Benefit/cost ratio
NPK 15-15-15 at 250 kg/ha	1.58	Nil	566.70	1,264.00	697.30	0.87	2.23
Organic Compost at 2 t/ha	1.40	Nil	666.67	1,120.00	453.33	0.87	1.68
Plot planted with long yam bean	1.45	1.16	366.67	2,320.00	1953.33	0.87	6.33
Plot without manure(Control)	0,91	Nil	323.33	728.00	404.67	0.87	2.25

Table 8. The effects of manure on yield of maize and the profitable analysis in 2008.

Treatment	Yield of maize (t/ha)	Yield of long yam bean (t/ha)	Total cost of production(US Dollars)	Total revenue (US Dollars)	Net revenue (US Dollars)	Discounted factor at 15%	Benefit/cost Ratio
NPK 15-15-15 at 250 kg/ha	1.62	Nil	566.70	1,296.00	729.30	0.87	2.29
Organic compost at 2 t/ha	1.76	Nil	666.67	1.408.00	741.33	0.87	2.11
Plot planted with long yam bean	1.65	1.24	366.67	2,808.00	2441.33	0.87	7.66
Plot without manure(control)	0.94	Nil	323.33	752.00	428.67	0.87	2.32

Table 9. The effects of manure on yield of maize and the profitable analysis in 2009.

Treatment	Yield of maize (t/ha)	Yield of long yam bean (t/ha)	Total cost of production (US dollars)	Total revenue (US dollars)	Net revenue (US dollars)	Discounted factor at 15%	Benefit/cost Ratio
NPK 15-15-15 at 250 kg/ha	1.62	Nil	566.70	1,296.00	729.30	0.87	2.29
Organic compost at 2 t/ha	1.86	Nil	666.67	1,488.00	821.33	0.87	2.23
Plot planted with long yam bean	1.72	1.26	366.67	2,888.00	2521.33	0.87	7.87
Plot without manure(control)	0.97	Nil	323.33	776.00	452.67	0.87	2.40

1.86 t/ha maize making 8.14, 14.81and 91.75 % over long yam bean, NPK and the control plots respectively. The comparable yield values in the long yam bean and the other manured plots could be as a result of high nitrogen content induced due to the nitrogen fixation which resulted in high quantity of leaf litters and plant biomass which after decomposition increased some other macro and micro nutrients in the soil (Bargali and Bargali, 2009). The profitable analysis shown in Tables 7, 8 and 9 which indicated higher net revenues and benefit/cost ratio in the long yam bean plot than other plots was as a result of the lower production cost and the additional income from the sales of long yam bean seeds with that realized from maize sales. Furthermore, long yam bean had been an acceptable diet of the people and a source of plant protein to supplement the animal type especially among the low income group and the demand for it by consumers could be as high as that of maize.

Conclusion

The effectiveness of intercropping maize with long yam bean to maintain soil fertility and improve the yield of maize was comparable with the use of inorganic NPK 15-15-15 fertilizers and organic compost. The unfavorable effects of long term application of inorganic and organic fertilizers and the burden of the transportation of bulky and large amount of needed organic compost could be avoided with the intercropping of leguminous long yam bean with maize or other crops.

REFERENCES

Association of Official Analytical Chemists (AOAC) (1980). Official methods of Analysis 13th edition, Washington DC, pp. 376-384.

Avnimelech Y, Cohen A (1988). On the use of organic manures for amendment of compacted clay soils: Effects of aerobic and anaerobic conditions. Biological Wastes, 26 (4): 331-339

Ayoola OT, Makinde EA (2007). Complementary organic and inorganic fertilizer application: Influence on growth and yield of cassava/maize/melon intercrop with relayed cowpea. Australian J. Basic. Appl. Sci., 1(3):187-192.

Ayoola OT (2010). Yield performance of crops and soil chemical changes under fertilizer treatments in a mixed cropping system. Afr. J. Biotechnol., 9 (26): 4018 – 4021.

Bargali K, Bargali SS (2009). *Acacia nilotica*: a multipurpose leguminous plant. Nat. Sci., 7(4): 11-19.

Brady NC, Weil RR (1999). The Nature and Properties of Soils (12th Edition). Prentice Hall, New Jersey, p. 881.

Branson J, Stearman G, Dodson R (2010). Effect of compost rate on soil organic matter content. American Society of Agronomy (ASA), Crop Science Society of America (CSSA) and Soil Science Society of America (SSSA) 2010 International Annual Meetings. http://a-c-s.confex.com/crops/Paper59723.html cite was accessed on the 5th January 2011.

Bray RH, Kurtz LT (1945). Determination of total organic and available forms of phosphorus in soils. Soil Sci., 59: 39- 45.

Canadian Council of Ministers of the Environment (CCME) (2005). Guidelines for Compost Quality. http://www.ccme.ca/assets/pdf/compostgdlns_1340_e.pdf cite was accessed on the 5th January 2011.

Carter MR (1993). Soil Sampling and Methods of Soil Analysis. Canadian Society of Soil Science. Lewis Publishers, London, p. 823.

Celik I, Ortas I, Kilik S (2004). Effects of compost, mycorrhiza, manure and fertilizer on some physical properties of a Chromoxerent Soil. Soil Tillage Res., 78: 59-67.

Chien SH, Gearhar MM, Collamer DJ (2008). The effects of different ammonical nitrogen sources on soil acidification. Soil Sci., 173(8): 544-551.

Chong RS (2007). Using Organic Fertilizers. Food and Fertilizer Technology Centre. http://www.agnet.org/library/bc/53008 cite was accessed on the 5th January 2011

Devaney E (2010). Environmental Effects of Chemical Fertilizers. http://www.ehow.com/facts_envt-effects-fert.html. cite was accessed on the 5th January, 2011

Dodson R, Stearma G (2010). Compost and cover crop management in organic vegetable production. American Society of Agronomy (ASA), Crop Science Society of America (CSSA) and Soil Science Society of America (SSSA) 2010 International Annual Meetings. http://a-c-confex.com/crops/Paper58604.html. cite was accessed on the 5th January, 2011.

Ebaid RA, El-Refaee IS (2007). Utilization of rice husk as an organic fertilizer to improve productivity and water use efficiency in rice field. Africa Crop Science Conference Proceedings. 8: 1923-1928.

Eusuf ZAK, Horiuchi T, Matsui T (2008). Effects of compost and green manure of pea and their combinations with chicken manure and rapeseed oil residue on soil fertility and nutrient uptake in wheat-rice cropping system. Afr. J. Agri. Res., 3(9): 633-639.

Gitari JN, Friesen DK (2001). The use of organic and inorganic soil amendments for enhanced maize production in the Central Highlands of Kenya. Seventh Eastern and Southern Africa Regional Maize Conference 11th to 15th February 2001. pp. 367-371.

Hagan D, Escobedo F, Toor G, Mayer H, Klein J Dobbs C (2010). Soil bulk density and organic matter in urban Miami-Dade County, Florida. The Institute of Food and Agricultural Sciences (IFAS) Document SL 327. http://edis.ifas.ufl.edu/ss537 cite was accessed on the 5th January 2011.

Harmsen K, Loman H, Neeteson JJ (1990). A derivation of the Pierre-Sluijsmans equation used in the Netherlands to estimate the acidifying effect of fertilizers applied to agricultural soils. Fertilizer Res. 26: 319-325.

Hathaway-Jenkins LJ, Godwin RJ, Pearce B, Sakrabani R, Whitmore A (2010). A comparison between conventional and organic farming practices 2: Soil hydraulic properties. 19th World Congress of Soil Science, Soil Solutions for a Changing World held in Brisbane, Australia, pp. 1-8.

Ibeawuchi II, Ofoh MC, Nwufo MI, Obiefuna JC (2007). Effects of Landrace Legumes, Velvet Bean, Lima Bean and African Yam Bean on the performance of yam, cassava based crop mixtures. J. Plant. Sci., 2(4): 374-386.

Iken JE, Amusa NA (2004) Maize Research and Production in Nigeria. Afr. J. Biotechnol., 3: 302-307.

Jo J, Yoshida S, Kayama R (1980). Growth and nitrogen fixation of some leguminous forages grown under the acidic soil condition. J. Jpn. Grassland Sci., 25 (4): 326-334.

Khoi CM, Guong VT, Trung PNM, Nilsson SI (2010). Effects of compost and lime amendment on soil acidity and nitrogen availability in acid sulfate soil. 19th World Congress of Soil Science, Soil Solution for a Changing World held in Brisbane, Australia, pp. 52-55.

Klu GYP, Amoatey HM, Bansa D, Kumaga FK (2001). Cultivation and use of African Yam Bean (*Sphenostylis stenocarpa*) in the Volta Region of Ghana, Africa. J. Food Technol., 6(3):74-77.

Kogbe JOS, Adediran JA (2003). Influence of nitrogen, phosphorus and potassium application on the yield of maize in the savannah zone of Nigeria. Afr. J. Biotechnol., 2: 345 – 349.

Kparmwang T, Malgwi WB (1997). The Genesis, Classification and Productivity Limitations of Sandstone soils in Northwestern Nigeria. Proceedings of the 23rd Annual Conference of Soil Science Society of Nigeria (Singh BR. Ed.), pp. 43-50.

Madeleine I, de Smet P, Tersmette T, Veldkamp T (2002). Preparation and use of compost. The Technical Centre for Agriculture and Rural Cooperation (CTA), Agrodok. 8: 68.

Mae-Wan HO (2010). China's Soils Ruined by Overuse of Chemical Fertilizers. http://www.i-sis.org.uk/chinasSoilRuined.php. cite was accessed on the 5th January 2011.

Mahmoodabadi MR, Amini S, Khazaeipoul K (2010). Using animal manure for improving soil chemical properties under different leaching conditions. Res. J. Soil Water Manage., 1(2): 34-37.

Makinde EA, Fagbola O, Akinrinde EA, Makinde EA (2010). Effects of organic, organomineral and NPK fertilizer treatment on the quality of *Amaranthus cruentus* (L.) on two soil types in Lagos, Nigeria. Nat. Sci., 8 (3):56-62.

Moyin-Jesu (2008). Use of pigeon pea (*Cajanus cajan* L.) as soil amendment for the growth, leaf chemical composition and yield of white yam (*Dioscorea rotundata* L.). Continental J. Agri. Sci., 2: 6-17.

Nekesa AO, Okalebo JR Kimetto S (2007). Adoption of leguminous trees/shrubs compost and farmyard manure (FYM) as alternatives to improving soil fertility in Trans Nzonia District, Kenya. A.Bationo (eds.). Advances in integrated soil fertility management in Saharan Africa: Challenges and Opportunities, pp. 955-960.

Omotayo OE, Chukwuka KS (2009). Soil fertility restoration techniques in Sub-Saharan Africa using organic resources. Afr. J. Agri. Res., 4 (3): 144-150.

Palm CA, Myers RJK, Nandwa SM (1997). Combined use of organic and inorganic nutrient sources for soil fertility maintenance and replacement. In: Replenishing soil fertility in Africa. Buresh RJ, Sanchez, PA, Calhoun PG, (eds.) Soil Science Society of America Special Publication, 51: 193-217.

Periaswamy SP, Ashaye TI (1982). Updated classification of some Southwestern Nigeria soils. Ife J. Agri., 4(1,2): 25-41.

Ramesh P, Panwar NR, Singh AB, Ramana S, Rao AS (2009). Impact of organic manure combinations on the productivity and soil quality in different cropping systems in Ramesh Central India. J. Plant. Nut. Soil. Sci., 172 (4): 577-585.

Rivero C, Chirenje T, Ma LQ, Martinez G (2004). Influence of compost on soil organic matter quality under tropical conditions. Geoderma, 123: 355-361.

Saka JO, Adeniyan ON, Akande SR, Balogun MO (2007). An economic evaluation of intercropping Africa Yam Bean, Kenaf and Maize in the Rainforest Zone of Nigeria. Middle East. J. Sci. Res., 2 (1): 1-8.

Smyth AJ, Montgomery RF (1962). Soils and Land use in Central Western Nigeria. Government Printer, Ibadan, Western Nigeria, p. 265.

Sridevi M, Mallaiah KV (2007). Production of extracellular poly-saccharide by Rhizobium strains from root nodules of leguminous green manure crop *Sesbania sesbania* (L.) Merr. Int. J. Soil. Sci., 2 (4): 308-313.

Walkley A, Black CA (1934). An examination of the Degtjareff method for determining soil organic matter and proposed modification of the chronic acid titration method. Soil Sci., 37: 29 – 38.