Effect of Poultry Manure on Soil Physico-Chemical Properties, Leaf Nutrient Contents and Yield of Yam (*Dioscorea rotundata*) on Alfisol in Southwestern Nigeria.

Adeleye, E.O[1]., Ayeni, L.S[1] And Ojeniyi, S.O[2]

1. *Department of Agricultural Science Education, Adeyemi College of Education, P.M.B. 520, Ondo, Ondo State, Nigeria.*
2. *Department of Crop, Soil and Pest Management, Federal University of Technology, P.M.B. 704, Akure, Ondo State, Nigeria.*

[1]leye-sam@yahoo.com

Abstract-The main effect of poultry manure on soil physico-chemical properties, leaf nutrients contents and yield of yam (*Dioscorea rotundata*) was investigated in a factorial experiment involving tillage at five levels- ploughing, ploughing plus harrowing, manual ridging, manual heaping and zero-tillage; poultry manure at 0 t/ha and 10 t/ha laid out in a split-plot design at two locations in Ondo, Nigeria. The data obtained indicated that poultry manure application improved soil physical properties; it reduced soil bulk density, temperature and also increased total porosity and soil moisture retention capacity. It also, improved soil organic matter, total N, available P, exchangeable Mg, Ca, K and lowered exchange acidity. It also increased nutrient uptake, growth and yield of yam significantly. The use of poultry manure in crop production is recommended as it will ensure stability of soil structure; improve soil organic matter status, nutrients availability and high crop yield. [Journal of American Science 2010;6(10):871-878]. (ISSN: 1545-1003).

Key words: Bulk density, moisture retention, organic matter, nutrient uptake, exchange acidity

1. Introduction:

Small holder farmers in southwestern Nigeria depend upon root and tuber crops especially cassava and yam as a dietary supplement and a major source of energy and nutritional requirements. There is an increasing gap between the levels of supply and demand for yam.

This arises from the subsistence system of its production, high production costs, and the need for appropriate land improvement for restoring, replenishing, conserving and maintaining the quality of agricultural land Land improvement techniques used for yam production in southwestern Nigeria include mulching, bush fallow and crop rotation. Population pressures have enforced the shortening of the fallow period and field rotation cycle resulting in the loss of soil productivity with a consequent reduction in yam yield.

Nutrient deficiencies and imbalances are the main constraints to crop production in southwestern Nigeria (Ojeniyi, 1990). Application of fertilizers constitutes a practice by farmers in an attempt to correct the deficiencies of nutrient elements. Increases in productivity associated with the use of mineral fertilizer are undisputable. However, fertilizer costs remain high. At the farm level, inefficient distribution systems often prevent fertilizer being available. Another major problem, is the indiscriminate use of mineral fertilizer without soil test, this is adversely affecting the soil chemical and physical properties causing nutrient imbalance (Nottidge et al, 2005). In addition, the use of mineral fertilizers on continuous basis in tropical soils has been associated with reduced crops yield, increased soil acidity and nutrient imbalance (Ojeniyi, 2002; Mbah and Mbagwu, 2006).

Problems that militate against the use of chemical fertilizers on yam include high cost, unavailability, misused of chemical fertilizers and the belief by the peasant farmers that chemical fertilizers promote weeds, vegetative growth rather than tuber formation and yield of poor qualities in terms of taste and storage life (Daramola, 1989). Bamire and Amujoyegbe (2005) revealed that apart from high cost and scarcity of inorganic fertilizers, it destroys the quality of 'pounded yam' a highly preferred food of the people in southwestern Nigeria. The high cost of mineral fertilizer and the difficulties involved in its used has awakened interest in the use of organic wastes as nutrient sources. Several studies carried out indicate positive effects of organic wastes on soil productivity. The use of organic manures is considered less likely to have detrimental effect on soil physico-chemical properties compared with mineral fertilizers.

The use of poultry manure as soil amendments to sustain adequate crop yields has been found effective for cereals and vegetable crops in southwestern Nigeria.

However, there appears to be scarcity of research information on the use of poultry manure in yam production in southwestern Nigeria Hence, this study aimed at evaluating the potential of poultry manure in enhancing soil fertility and yam production in southwestern Nigeria.

2. Materials and Methods:

Site Description

Field experiments were carried out at two sites namely; Adeyemi College and Gbajia in Ondo (07^0 05N, 04^0 55) in the rainforest zone of southwestern Nigeria for two farming seasons (2007 and 2008). The soil is sandy loam and belongs to Ondo series (Egbeda Fasc) and is classified as alfisol (Oxic tropul dalf) (Hapstead, 1974). The plots at the two sites were gently sloppy and have been previously cultivated to arable crops such as maize and cassava. The two sites have been under bush fallow for two years.

Field Experiments and Experimental Design:

The trials consisted of five soil preparation methods, namely ploughing (p), ploughing plus harrowing (PH), manual ridging (MR), manual heaping (MH) and zero tillage (ZT) each combined with and without poultry manure at the rate of 10 t/ha in a factorial experiment of 5 by 2 to produce 10 treatment combinations. The experimental design used was split-plot design. A total land area of 110m by 50m was marked out for the experiment. The site was divided into three blocks and the adjacent blocks were demarcated by 5-metre alley ways. Each block was further divided into 10 plots of 5m by 5m. The treatments were allorted to the plots and each treatment replicated three (3) times. The same treated plots were maintained for the two planting seasons. Yam setts having an average weight of 300g were planted two weeks after poultry manure had been applied. Individual emerged yam stands were separately staked, while manual weeding with hoe was subsequently used to control weeds in all the treated plots.

Determination of Soil Physical Properties

Soil bulk density was determined from oven-dried undistributed core samples collected to the depth of 10cm by core method (Stolte et al, 1992). Total porosity (Ps) was calculated from bulk density (Db), assuming a particle density (Dp) of 2.65 g cm^{-3}, using the relationship between particle density (Dp) and bulk density (Db) i.e. Ps = 100 (1- Db/ Dp). Soil temperature was measured at 15.00 hours using a soil thermometer inserted to 10cm depth. Soil moisture content was measured with the TDR-100 moisture meter. These soil physical properties were measured a month after the treatments were applied and at a 4-weekly intervals there after until the week 20 of field experimentation.

Growth and Yield Data:

Ten yam stands were selected per replicate (plot) for the measurement of growth and yield parameters at harvest. Vine girth was measured at 15cm above heap level using a pair of vernier calipers. The vine length was measured with a measuring tape. The number of branches from the main vine and the number of leaves per plant were recorded. Tuber weight was determined using a weighing balance and tuber length with a measuring tape. Leaf area was determined graphically.

Leaf Nutrient Contents Analysis:

At five months after planting, mature leaves were collected from the 10 tagged yam stands per plot. The leaf samples were oven-dried at 65^0C for 48 hours and ground for routine chemical analysis. Leaf N was determined using the micro-kjeldahl digestion method. P was determined colormetrically by vanadomolybdate method, K by flame photometer and Ca and Mg by the atomic absorption spectrophotometer.

Soil Sampling and Chemical Analysis:

Surface soil samples (0 - 15cm) were taken prior to the application of treatments. The pre-treatment samples comprised of a composite sample made up of 15 cores per experimental site. Another set of soil samples were taken at the end of each planting season. The sample comprised of a composite sample of 2 cores per plot.

The soil samples were air-dried, sieved to pass through a 2-mm mesh and chemically analysed. The soil pH was determined using glass electrode pH meter in a 1:2 soil – water ratio. Organic carbon content was determined by Walkley-Black dichromate oxidation method. Total N was determined by the micro-kjeldahl method. Available P was extracted by the Bray-1 method and determined colorimetrically. Exchangeable Ca, K, Mg, and Na were extracted with 1.0N NH_4OAc using a soil: solution volume ratio of 1:10. The K and Na in the extract were read using a flame photometer, while Ca and Mg were determined by Atomic Absorption Spectrophotometer (AAS). Exchange acidity was determined from 1.0N KCl extract and titrated with 1.0N HCl. Cation exchange capacity was determined by the summation of NH_4OAc-extractive cations and KCl-exchange acidity. The micro nutrients (Fe, Cu, Zn, Mn) were extracted with 1.0N HCl and determined on Perkin Elmer 20 AAS.

Data Analysis:

Data on the soil physical, soil chemical, plant growth and yield were subjected to analysis of variance using Statistical Analysis System Institute Package (SAS) and the mean values were compared using the Least Significant Difference (LSD) at $P<0.05$.

3. Results

The data on initial physico-chemical properties of soils at the sites of experiment are presented in Table 1. The data indicated that the soils were sandy loam with high sand particles. The soils were slightly acidic, low in organic matter (OM), available phosphorus (P), cation exchange capacity (CEC) exchangeable calcium (Ca) and potassium K. Exchangeable magnesium (Mg) was adequate. Micronutrients such as iron (Fe) manganese (Mn), copper (Cu) and zinc (Zn) were high.

Table 2 shows the influence of poultry manure on some soil physical properties. Plots amended with poultry manure had significantly ($P< 0.05$) higher soil moisture content than plots without poultry manure application. For the two planting seasons, at Adeyemi Site, plots amended with poultry manure had a mean moisture content value of 72.29 g kg^{-1} and plots without poultry manure application had a mean moisture content value of 53.74 g kg^{-1}.

At Gbajia site, poultry manure amended plots had a mean moisture content value of 73.07 g kg^{-1} and plots without poultry manure had a mean moisture content value of 56.36 g kg^{-1} for the two planting seasons. Poultry manure treated plots had relatively lower soil temperature compared with plots without poultry manure application. Influence of poultry manure on soil temperature was not significant ($P < 0.05$). At Adeyemi site, for two cropping seasons, plots with poultry manure application had a mean temperature value of 31.1^{o}C and plots without poultry manure had a mean temperature value of 32^{o}C. the corresponding mean soil temperature value at Gbajia were 30.9^{o}C and 31.8^{o}C respectively. Poultry manure amended plots had relatively lower soil bulk density compared with plots without poultry manure application. At Adeyemi site, application of poultry manure reduced soil bulk density by 4.23% in the first cropping (2007) and 3.85% in second cropping (2008); while at Gbajia site, application of poultry manure reduced soil bulk density by 6.29% in the first cropping (2007) and in the second cropping (2008) by 5.3%. Soil bulk density and total porosity were significantly ($P< 0.05$) influenced by the application of poultry manure. Plots amended with poultry manure had higher soil total porosity than plots without poultry manure application. Poultry manure application increased soil total porosity by 4.87% and 7.36% in the first cropping (2007) at Adeyemi and Gbajia sites respectively. In the second cropping (2008), poultry manure application increased soil total porosity by 5.52% and 8.4% for Adeyemi and Gbajia sites respectively.

Tables 3 and 4 show the influence of poultry manure on soil chemical properties. Application of poultry manure increased soil pH, organic matter content, total –N, available P, exchangeable cations (Ca, Mg, and K), cation exchange capacity and percent base saturation. It also reduced exchange acidity and the concentration of micro-nutrients when compared with plots without poultry manure. The improvements in the soil chemical characteristics in plots amended with poultry manure at the end of the first cropping (2007) were marginal. However, at the end of the second cropping (2008), the improvement in soil chemical characteristics of plots amended with poultry manure when compared with plots without poultry manure application were more pronounced. Also, there were reductions in most of the soil chemical characteristics except exchange acidity and the micro-nutrients in plots without poultry manure application at the end of the second cropping (200).

Table 5 shows the influence of poultry manure on leaf nutrients concentration of yam. Plots amended with poultry manure had higher concentration of leaf nutrient than plots without poultry manure application. At Adeyemi site, poultry manure application increased leaf N, P, K, Ca and Mg concentration by 25%, 27% 18%, 20% and 21% respectively over plots without poultry manure application. At Gbajia site, leaf N, P, K, Ca and Mg increased by 42%, 8%, 17%, 16% and 25% respectively when compared to leaf nutrients concentration of yam grown on plots without poultry manure application. Leaf nutrients concentration of plots amended with poultry manure in the second cropping (2008) were higher than those of first cropping (2007), while yam leaf nutrients concentration of plots without poultry manure decreased in the second cropping (2008).

Table 6 shows the influence of poultry manure on the vegetative parameters of yam. Vegetative parameters of yam were significantly ($P< 0.05$) influenced by the application of poultry manure at both sites and cropping seasons. Vegetative growth parameters were better enhanced in plots amended with poultry manure than plots without poultry manure application. Table 7 shows the influence of poultry manure on yam yield parameters. Poultry manure significantly enhanced yam yield parameters of yam at both sites and cropping seasons. Plots amended with poultry manure had higher yield parameters than plots without poultry manure

application. At second cropping (2008), yam tuber yield in plots amended with poultry manure were better than the first cropping (2007) although at marginal degree. However, the tuber yields from plots without poultry manure application at second cropping (2008) were poorer than the yield at first cropping. At Adeyemi site, yam tuber yield at the second cropping from plots without poultry manure application reduced by 10.22% whereas yam tuber yield from plots amended with poultry manure increased by 1.50%. Also, at Gbajia site, yam tuber yield from plots without poultry manure application reduced by 17.06% and the increase in yam tuber yield from plots amended with poultry manure was 3.87%.

4 **Discussion**

The soils at the sites of experiment contained less than 2%N, 25 mg kg^{-1} available P, 0.40 $cmolkg^{-1}$K, 0.65 $cmolkg^{-1}$ Ca nutrients critical levels determined for yam in the southwestern Nigeria (Ibedu et al, 1988). Soils below these critical levels are regarded being low in these nutrients for optimum yam production. The low fertility level of these soils justifies the need for appropriate soil management techniques for sustaining soil and yam productivity.

Poultry manure application improved the soil moisture content this improvement in soil moisture content might be due to the colloidal and hydrophobic nature of the poultry manure. This finding is line with the finding of Mbah and Mbagwu (2006). Similarly, enhancement of soil water retention capacity due to animal manure, according to Khaleel et al (1981) could be probably be due to structural improvement i.e. increase in total porosity and the fraction of porosity involved in soil water storage. Plots amended with poultry manure had lower soil temperature compared with plots without poultry manure application. This could be related to the improved soil organic matter content of plots amended with poultry manure which might have enhanced water retention capacity of the soil and consequently reduced soil temperature of the plots. Organic matter is known to improve soil physical properties (Adesodun et al, 2005, Aluko and Oyeleke, 2005). Addition of poultry manure to the plots reduced the soil bulk density; this reduction in soil bulk density could make appreciable difference in the root growth and proliferation of yam. This is in line with the reports of Obi and Ebo (1995)., Obi and Ofonduru (1997). Improvement in soil total porosity due to poultry manure application might be as a result of the improved soil particle aggregation brought about by the improved soil organic matter content of the plots amended with manure. Addition of poultry manure improved the soil physical properties; it reduced the soil bulk density and also increased porosity and water holding capacity of the soils. These findings confirmed the earlier reports of Lombin et al (1991); Mbal et al (2004) that application of organic manures improve and ameliorate several soil physical properties such as bulk density, total porosity, penetration resistance and cohesion force.

Addition of poultry manure brought about improvement in most of the soil chemical properties. Soil pH, organic matter, total nitrogen, available phosphorus, exchangeable cations and percent base saturation were improved. Improvement in nutrient status of poultry manure amended plots implies that poultry manure could be used for soil management for sustainable production of yam. In support of this, Ano and Agwu (2006) had found that animal manure increased soil pH and macronutrients of soil in southern Nigeria. Also, Bahl and Torr (2002); Salako (2008) reported that poultry manure improved surface P and other major nutrients and yield of maize. These findings confirmed earlier report by Lombin et al (1991) that animal manure improved soil productivity in two ways; through improvement of the physical conditions of the soil and through the nutrient it supplies to the soil. The reduction in exchange acidity in plots amended with poultry manure suggests the ability of poultry manure in lowering soil Al^{3+} and Fe^{2+} concentration in the soil. The higher pH of poultry manure amended plots compared to plots without poultry manure application might partially be due to the calcium supplied to the soil by poultry manure (Cooper and Warman, 1997). In support of these findings, recent studies had shown that poultry manure increased soil organic matter, nitrogen, pH, phosphorus, CEC (Adeniyan and Ojeniyi, 2003; Mbah and Mbagwu, 2006; Ayeni et al, 2008).

Poultry manure improved leaf nutrient concentration significantly. Cumulative effect of poultry manure application was observed in the leaf nutrient concentration during the second cropping. This observation is in agreement with the reports of Colacicco (1982) and Adenawoola and Adejoro (2005) that the cumulative agronomic value of some organic manure applied to agricultural soils could be more than five times greater in the post-application period than the value realized during the year of application. Poultry manure influenced the yam growth parameters significantly and this could be attributed to the ability of poultry manure in supplying nutrients and organic matter to the soil and in improving the soil physical conditions. Better yield parameters obtained in poultry manure amended plots might also be due to the improved soil physical properties and nutrients status.

This finding is also in agreement with the findings of Salako (2008) and Ayeni et al (2008) that plots amended with poultry manure produced the highest grain yield of maize when compared with plots with no manure treatments.

Table 1: Pre-treatment Soil Chemical Properties at the Sites of Field Experiment.

Soil Parameters	Adeyemi College	Gbajia
pH (H_20)	5.73	5.92
Org. M. (%)	2.45	3.26
Total N (g/kg)	3.50	4.60
Av.P (mg/kg)	9.11	5.41
Ca (cmol/kg)	0.59	0.13
Mg "	1.36	1.36
Na "	0.52	0.55
K "	0.23	0.34
Ex. Ac "	0.60	0.60
CEC "	3.30	2.98
B.Sat. (%)	81.82	79.86
Mn (mg/kg)	3.60	4.70
Fe "	9.60	4.80
Cu "	1.60	4.70
Zn "	10.00	8.80
Sand (%)	75.80	79.80
Clay "	10.80	10.80
Silt "	13.40	9.40

Table 2: Effect of Poultry Manure on Soil Physical Properties

Year	Treatment	Moisturecontent (g/kg)		Temperature (^oC)		Bulk density (g/cm^3)		Total Porosity (%)	
		Adeyemi	Gbajia	Adeyemi	Gbajia	Adeyemi	Gbajia	Adeyemi	Gbajia
2007	No manure	51.93	55.14	31.97	32.24	1.42	1.43	46.42	46.04
	10 t/ha manure	73.80	74.71	30.89	31.18	1.36	1.34	48.68	49.43
	LSD (0.05)	5.43	5.68	NS	NS	0.03	0.04	1.24	1.24
2008	No manure	55.56	57.32	32.09	31.36	1.56	1.58	41.13	40.38
	10 t/ha manure	70.78	71.42	31.26	30.79	1.50	1.49	43.40	43.77
	LSD (0.05)	6.01	6.23	NS	NS	0.01	0.03	0.58	0.58

Table 3: Effect of Poultry Manure on Soil Chemical Properties at Adeyemi Site.

Treatment	**pH (H_20)**	**O.M (%)**	**Tot.-N (%)**	**Av. P mg/kg**	**Ca**	**Mg**	**Na**	**K**	**Ex.Ac.**	**CEC**	**B.S (%)**	**Mn**	**Fe mg/kg**	**Cu**	**Zn**
							cmol/k								
2007															
No manure	5.86	2.63	0.34	19.80	0.73	1.50	0.61	0.13	0.80	3.77	78.77	4.93	6.61	2.89	8.63
10 t/ha manure	6.03	3.00	0.43	25.30	0.96	1.73	0.67	0.23	0.51	3.14	83.76	4.13	6.00	3.27	8.90
LSD (0.05)	0.01	0.03	0.05	1.21	0.01	0.05	0.01	0.04	0.02	0.03	1.01	0.04	0.01	0.03	0.01
2008															
No manure	5.43	2.41	0.31	31.oo	0.93	1.19	0.53	0.19	1.46	4.30	66.05	4.02	7.00	3.57	8.70
10 t/ha manure	6.20	3.32	0.50	44.45	1.00	1.34	0.51	0.23	0.74	3.82	80.63	3.58	6.46	4.05	7.40
LSD (0.05)	0.01	0.04	0.06	2.14	0.01	0.02	NS	0.02	0.06	0.02	3.64	0.21	0.01	0.04	1.01

Table 4: Effect of Poultry Manure on Soil Chemical Properties at Gbajia Site

Treatment	pH (H_20)	O.M (%)	Tot.-N (%)	Av.P (mg/kg)	Ca	Mg	Na	K	Ex.Ac.	CEC	B.S (%)	Mn	Fe	Cu	Zn
					cmol/kg							mg/kg			
2007															
No manure	6.01	2.62	0.32	14.90	0.84	1.04	0.54	0.22	0.84	3.48	75.86	4.32	7.28	3.70	8.49
10 t/ha manure	6.45	3.62	0.44	22.68	0.95	1.24	0.58	0.24	0.48	3.49	89.25	3.76	5.78	3.66	8.87
LSD (0.05)	0.01	0.06	0.01	5.06	0.01	0.04	S	NS	0.03	NS	1.21	0.01	0.02	NS	0.02
2008															
No manure	5.88	2.44	0.29	35.09	0.78	1.08	0.59	0.18	0.37	3.00	87.67	5.27	7.00	3.38	8.18
10 t/ha manure	6.36	3.42	0.47	94.05	0.91	1.47	0.52	0.21	0.36	3.47	89.62	5.06	6.55	2.86	9.38
LSD (0.05)	0.01	0.04	0.06	12.01	0.02	0.03	NS	0.01	NS	0.01	0.03	0.01	0.01	0.05	0.48

Table 5: Effect of Poultry Manure on Leaf Nutrient Concentration of Yam (*Dioscorea rotundata*)

Treatment	N (%)		P (%)		K (%)		Ca (%)		Mg (%)		Na (%)	
	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008
Adeyemi Site												
No manure	4.13	3.88	0.22	0.21	0.48	0.41	0.14	0.15	0.14	0.14	0.10	0.11
10 t/ha manure	4.80	5.26	0.25	0.30	0.50	0.56	0.16	0.19	0.16	0.18	0.11	0.14
LSD (0.05)	0.21	0.56	0.01	0.01	NS	0.03	NS	0.01	NS	0.01	NS	NS
Gbajia Site												
No manure	3.14	3.21	0.23	0.23	0.39	0.41	0.12	0.13	0.15	0.13	0.11	0.11
10 t/ha manure	3.53	5.48	0.24	0.26	0.42	0.51	0.13	0.16	0.17	0.18	0.12	0.13
LSD (0.05)	0.02	0.58	NS	0.01	0.01	0.03	NS	0.01	0.01	0.01	NS	NS

Table 6: Effect of Poultry Manure on Vegetative Growth Parameters of Yam (*Dioscorea rotundata*)

Treatment	Vine Length (cm)		Vine Girth (cm)		Leaves /plant		Branches/plant		Leaf Area	
	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008
Adeyemi Site										
No manure	198.32	181.78	1.41	1.39	358.24	334.61	26.24	27.71	28.34	24.28
10 t/ha manure	245.15	251.01	1.68	1.65	498.93	453.17	34.61	36.84	34.67	33.89
LSD (0.05)	28.32	32.04	0.07	0.03	34.68	31.81	0.24	0.18	0.68	0.64
Gbajia Site										
No manure	217.65	213.44	1.54	1.47	368.89	366.16	26.02	24.68	26.01	25.67
10 t/ha manure	231.15	241.63	1.56	1.66	380.47	493.56	29.91	32.20	26.21	28.11
LSD (0.05)	4.28	5.71	NS	0.02	6.27	12.48	0.10	0.12	NS	0.34

Table 7: Effect of Poultry Manure on Yield Parameters of Yam (*Dioscorea rotundata*)

Treatment	Tuber length (cm)		Tuber Girth (cm)		Tuber weight (kg/stand)		Tuber Yield (t/ha)	
	2007	2008	2007	2008	2007	2008	2007	2008
Adeyemi Site								
No manure	29.13	25.53	34.71	31.67	2.71	2.43	27.11	24.34
10 t/ha manure	35.26	30.03	37.01	41.71	3.26	3.31	32.63	33.12
LSD (0.05)	1.58	1.53	0.78	1.24	0.32	0.34	0.64	0.71
Gbajia Site								
No manure	24.13	22.79	31.27	29.56	2.39	1.98	23.91	19.83
10 t/ha manure	26.87	29.34	33.53	34.69	2.68	2.58	25.84	26.84
LSD (0.05)	0.46	2.68	0.37	0.43	0.13	0.18	0.73	1.71

5. Conclusion:

The use of poultry manure in crop production on alfisols located in southwestern Nigeria is considered desirable. The use of poultry manure will ensures stability of soil structure; improve soil organic matter status, nutrients availability and high crop yield.

About Authors

Adeleye, E.O is the Dean of School of Vocational and Technical Education, Adeyemi College of Education, Ondo while Dr Ayeni, L.S is at present a lecturer in the Department of Agricultural Science of the same College. His former address was University of Agriculture, Abeokuta, Ogun State, Nigeria. Professor SO Ojeniyi is a Professor of Soil Fertility at the Federal University of Technology, Akure, Nigeria and the current Editor-in-Chief of Nigerian Journal of Soil Science.

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