International Journal of Manures and Fertilizers Vol. 1 (8), pp. 144-154, August, 2012. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

Effects of Farm practices and manure application on soil physicochemical properties and Proceeds of maize grown on a degraded intensively tilled alfisol in southwestern Nigeria

Tosin A. George and Jamal O. Alade

Department of Crop and Soil Management, Federal University of Technology, Akure, Nigeria.

Accepted 4 July, 2012

Intensive tractorised tillage practices especially in the tropical and subtropical climate produces compaction in crop root zone (20 to 30 cm depth), degradation of soil quality, loss of organic matter and declining soil and crop productivity. The effects of tillage and manure application on soil physical and chemical properties, growth and yield of maize grown on an intensively mechanized and degraded Alfisol was investigated on the field in 2006 and 2007. The treatments consisted of 3 x 3 factorial combinations of tillage methods and manure application rates arranged in a split -plot design. The three tillage methods were: manual clearing (M_C), ploughing at 10 cm followed by harrowing (P_1H_1) and ploughing at 20 cm followed by harrowing (P_2H_1) while manure application at 10 t. ha^{-1} farm yard manure (FYM) and 200 kg.ha^{-1} NPK fertilizer (a compound mineral fertilizer which contain N, P and K in the ratio 20:10:10). The tillage constituted the main plot while farm yard manure and NPK fertilizer were the subplots. There was an unmanured control. Ploughing was carried out using mouldboard plough mounted on a tractor and harrowing was carried out after ploughing. There were no significant differences ($P < 0.05$) in soil moisture contents and bulk densities (0 to 60 cm depth) between tillage alone and tillage systems combined with manure application at 4 and 10 weeks after planting. The tillage- manure combination produced higher values of soil organic matter (1.3, 1.6%), total N (0.08, 0.11%) and available P (14.5, 18.9 mg/g) over tillage alone. Compared with tillage systems alone, application of manure significantly increased ($P = 0.05$) root and shoot dry weights, leaf area (0.11and 0.25 m^2), cob and seed yield of maize. The increases in grain yield due to manure (10 tha^{-1} FYM) and 200 $Kgha^{-1}$ NPK fertilizers were 10, 13 and 12%, respectively.

Key words: Alfisol, degradation, tillage, manure, soil, physico-chemical, maize.

INTRODUCTION

Soil compaction is a major cause of soil degradation in most agricultural soils (Van Lynden, 2000). In a compacted soil, the particles are pressed together, thus reducing pore spaces which contain air and water necessary for good plant growth (Aina et al., 1985). Compaction can be caused by the use of heavy machinery, ploughing at the same depth for many years and trampling by animals, reduced use of organic matter, frequent use of chemical fertilizers (Ohu et al., 1994; Lampurlanes and Martinez, 2003).

Intensive soil tillage practices especially in the tropical and subtropical climate accelerate soil erosion, cause compaction (between 20 to 30 cm depth), degradation of soil and loss of organic matter (Lal, 1976; Ojeniyi, 1982). These may result in declining soil productivity (Sobulo and Osiname, 1986).

Tractorized multi-pass tillage practices destroys soil structure such as aggregates and cause compaction within the plough layer which further deteriorate soil conditions (Lupwayi et al., 2001). Any increased bulk density from such practices could explain the adverse effect of land ploughing and harrowing on crop performance

*Corresponding author. E-mail:oTosincares@yahoo.com.

(Ojeniyi, 1986; Agele et al., 2005). Compaction also results in soil aggregate fragmentation involving the break down of large structural units into smaller frag-ments which further reduces the air space (Kay, 1990; Ojeniyi and Agboola, 1995). Intensive soil compaction has adverse effect on soil water flow and storage, impedes root growth and therefore limits the volume of soil explored by roots. This in turn can decrease the plant's ability to take up nutrients and water (Stewart and Vyn, 1994; Zhang et al., 1997).

A wide range of special tillage operations involving soil inversion, chiseling, subsoiling or deep tillage (for soils with an impeding layer within rooting depth) have been found to be beneficial by minimizing soil hardening or bulk density, improving soil porosity, infiltration, soil water storage, and root development (Lal, 1984; Ogunremi et al., 1986). Soil tillage (seedbed preparation) methods in addition to manure use are basic practices involved in crop production. These practices are known to influence soil physical conditions, nutrient availability, growth and yield of crops (Ojeniyi and Agboola, 1995). Tillage operation tends to modify soil bulk density and pore size distribution, loosens, granulates, crushes and even compacts soil particles (Klute, 1982). Bennie and Botha (1986) found that tillage reduces soil bulk density by breaking the aggregates into smaller particles and increasing aeration. It enhances rapid root elongation with depth, induces a high root density in the subsoil and increases final yield.

Degraded soils are usually characterized by low organic matter contents, superficial effective rooting depth, high bulk densities and compaction and exposed subsoil (Agele, 2007). Such soils can be reclaimed via amendment or enrichment with commercial fertilizers, and/or organic waste materials such as domestic refuse and farmyard manure (Wong and Wong, 1989; Raymond and Roy, 1992; Chu and Bradshaw, 1996; Agele, 2000). Improved understanding is required on the efficacy of these materials when used on degraded lands (Kamamori and Yasuda, 1979; Agele 2007) . In addition to the provision of essential plant nutrients to soils, organic manure improves soil structure through enhanced soil water holding capacity, aeration and drainage which encourage good root formation and plant growth (Cooke, 1975). Elmar and Wolfgang (1990) attributed the promotion of biological activities, nutrient exchange capacity and organic matter content that lessen soil erosion to the use of organic manure. Brady (1990) established the relationship of soil aggregate stability to its organic matter content. In crop production, soils must be loose enough to allow root penetration and seedling emergence. Appropriate soil tillage (seedbed preparation) methods in addition to manure use are basic practices required for maximum crop yield. These practices are known to influence soil physical conditions, nutrient availability, growth and yield of crops (Ojeniyi and Agboola, 1995).

Maize (*Zea mays* L.), is an important food crop grown in Nigeria. The crop is grown as food component of human diet as well as livestock feed, and has various industrials uses such as in the production of corn oil, sugar and alcohol. This study examines the effects of tillage methods, manure and mineral fertilizer application and their combinations on some soil properties, growth and yield performance of maize grown in an intensively tilled alfisol in Nigeria.

MATERIALS AND METHODS

Site for the experiment

This study was carried out at the Teaching and Research Farm of the Federal University of Technology (FUTO) Akure (lat.7º15' N, Long. 5º10' E) in a tropical rainforest zone of Nigeria. The trial was carried out during the late season (September-December) and early season (March to June) of 2006 and residual study conducted in 2007. Table 1 presents meteorological variables at the study site during maize growth in the respective late and early rainy seasons of 2006 and 2007. The sandy loam soil at the study site is an Alfisol classified as clayey skeletal Oxic-Paleustalf (USDA, 1999). The experiment was sited within a 20 ha agricultural field that has been mechanically tilled and cropped with tropical arable crops (maize, cowpea and cassava) continuously for over fifteen years.

Treatments

Treatments were a 3 x 3 factorial combination of seedbed types and manure application, arranged in a split-plot design. Tillage constitutes the main plot while manure application is split within the main plots as subplot and was randomized within the main plot. In each year, the experimental site was therefore divided into three blocks (5 x 20 m, main plot treatment; constituted by the seedbed types and were split into subplots (5 x 5 m, fertilizer treatments). There were 3 m guard rows between plots and 3 m between blocks. The tillage methods were manual clearing (Mc) and mechanised tillage involving ploughing at 10 cm depth plus one pass harrowing (P_1H_1) and ploughing at 20 cm depth plus one pass harrowing (P_2H_1). Ploughing and harrowing were accomplished using a 72 hp, 2 wheel drive, 2590 kg tractor (Marsey Ferguson MF, UK). Manual clearing (Mc) treatment consisted of a seedbed was manually cleared of existing vegetation using cutlass and the cleared residues were left in situ. The tillage treatments were amended with 10 tha^{-1} farm yard manure (FYM) and NPK (a compound fertilizer containing NPK in the ratio 20: 10:10) was applied at 200 $kgha^{-1}$ and an unfertilized control (where neither farm yard manure nor NPK fertilizer was applied). Farmyard manure (FYM) consisted of partially decomposed cow dung and poultry droppings plus bedding materials. The main plot was constituted by tillage methods while fertilizer (farm yard manure and NPK fertilizer) were the subplots. Treatments were replicated three times and were arranged in a split- plot design. Table 1 presents some meteorological conditions at site of experiment during maize growth in 2006 and 2007. Maize (*Z. mays* L.) were planted at two seeds per hole at the spacing of 60 x 30 cm. Weed was controlled manually (hand weeding) at 3 and 7 WAP for all treatments.

Determination of soil properties

Pre-planting soil samples were collected using core samplers (steel corers -10 cm diameter and depth), from selected depths (0 - 20,

Table 1. Meteorological conditions at the site of the experiment during maize growth.

	2006					2007				
	Aug.	Sept.	Oct.	Nov.	Dec.	Mar.	Apr.	May	June	July
Rainfall (mm)	327	271	193	68	23	19	39	189	257	288
Min. Temp(°C)	20.8	21.5	21.8	20.9	19.5	22.3	22.9	21.3	20.8	21.2
Max. Temp(°C)	28.7	29.6	30.3	31.7	30.6	33.3	32.9	31.6	30.3	29.6
Rel. humidity (%)	82	63	52	48	43	48	55	63	67	73
Total sunshine (h)	93	138	219	235	193	238	206	183	177	128
Solar radiation ($MJ/m^2/day$)	9.8	12.4	13.8	15.8	14.1	17.8	17.1	17.2	15.9	12.9
Open water Evap. (mm)	86	97	102	130	148	238	132	108	98	91

Table 2. Selected profile characteristics of the soil before commencement of the experiment.

Horizontal depth (cm)	Sand (%)		Silt (%)		Clay (%)		Bulk density ($g.cm^{-3}$)		Total porosity (%)	
	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
0-20	40	39	31	33	29	28	1.32	1.32	47	47
20-35	30	27	35	41	35	32	1.39	1.39	45	45
35-50	28	30	38	40	34	30	1.43	1.43	43	43
50-65	29	39	31	30	40	31	1.47	1.47	42	42

20- 35, 35-50 and 50-65 cm) from profile pits dug at two points within the experimental plot. The depth-wise samples were analysed for physical properties of bulk density and textural class (percent of sand, silt and clay) using standard methods. Starting from 2 weeks after planting (WAP), and at weekly intervals thereafter, measure-ments were made on soil temperature using soil thermometer. The soil thermometer was inserted to 5 cm depth and three determinations were made per treatment replicate. Soils were sampled at 4 and 10 WAP from three randomly selected sampling points from each treatment replicates within the field and from depths similar to those of pre-planting. From these sampling points, soil samples were collected using core samplers (steel corers – 10 cm diameter and depth) at soil depths of (0-20, 20-35, 35-50 and 50-65 cm) for the determination of soil moisture contents and bulk density. The field moist soil samples were oven-dried for 24 h and at 105°C for the determination of soil moisture contents (gravimetric method). Bulk density values were obtained from the weight of oven-dried soil samples and volume of the soil corer while total porosity was calculated from bulk density using particle density of 2.65 cm^{-3}. Volumetric soil moisture was obtained from the product of gravimetric moisture contents and bulk density. Particle size analysis was carried out using hydrometer method (Bouyoucos method).

Surface (0 to 20 cm) soil samples were collected from each site at start of experiment and at crop harvest from each treatment plot for chemical analysis. On each treatment replicate, five sites were randomly located as sampling points. Soil samples collected from sampling points in each replicate were bulked per treatment and were analyzed in the laboratory for chemical properties. Soil organic carbon (SOC) was analyzed by the Warkley and Black method (Warkley and Black, 1934) and soil organic matter was computed by multiplying the values of SOC by 2.72. Total N after Kjeldahl digestion. Phosphorus (P) was extracted using Bray-P1 solution and determined using molybdenum blue colorimetry. Exchangeable K, Ca and Mg were determined by EDTA titration method (Jackson, 1962) . Soil pH was determined in soil-water medium at ratio 1:2 using the digital electronic pH meter.

Growth and yield parameters

Root and shoot biomass, plant height, days to 50% flowering, yield and yield components were monitored. Five plants were randomly sampled from 2 m^2 at the center of each plot at 12 weeks after planting (WAP) for the determination of root and shoot dry matter yields obtained from oven-dried plant samples at 80°C for 48 h. For root biomass determination, a cubic coring tool (10 x 10 x 10 cm) was drill inserted into the soil and to a depth of 40 cm within the circumference of 5 sampled plants per plot. The excavated roots from the soil samples were put in 2 mm sieves and were gently washed free of soil in the laboratory using moderate jets of water. The values of plant height, leaf area, number of leaves per plant and stem girth were determined at 12 weeks after planting. Leaf area was calculated as number of terminal leaflets (N) x 2.7 x 1/37 cm^2 (Nangju and Wanki, 1980). Ten maize plants were harvested per plot at harvest for yield components determination. The components were as follows: weight of cob per plants (g), number of cobs per plants, seed weight per plant, 100 seed weight and shoot weight. Afterwards, the entire plots were separately harvested and cobs were air-dried and weighed.

Statistical analysis

Data collected from the field were subjected to analysis of variance for a split-plot design (Steel et al., 1997) to determine the separate and interaction effects of the main plot and subplot treatments on some soil physical properties, growth and yield characteristics of maize.

RESULTS

Effects of seedbed types on soil physical properties

Table 2 presents the results of some selected profile

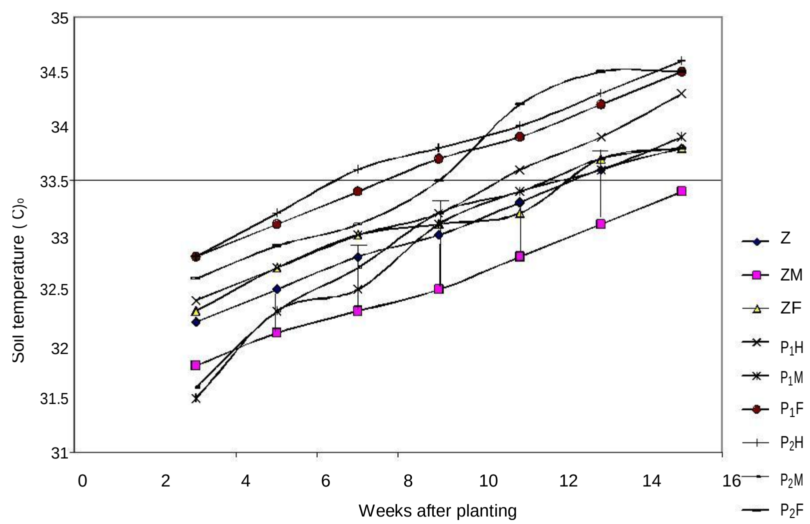

Figure 1a. Trends in soil temperature during growth of late season maize. Vertical lines are LSD bar. Z: manual clearing; P_1H: ploughing 10 cm depth; P_1HM: ploughing at 10 cm + farm yard manure; P_1HF: ploughing at 10 cm + fertilizer; P_2H: ploughing 20 cm depth; P_2HM: ploughing at 20 cm + farm yard manure; P_2HF: ploughing at 20 cm + fertilizer.

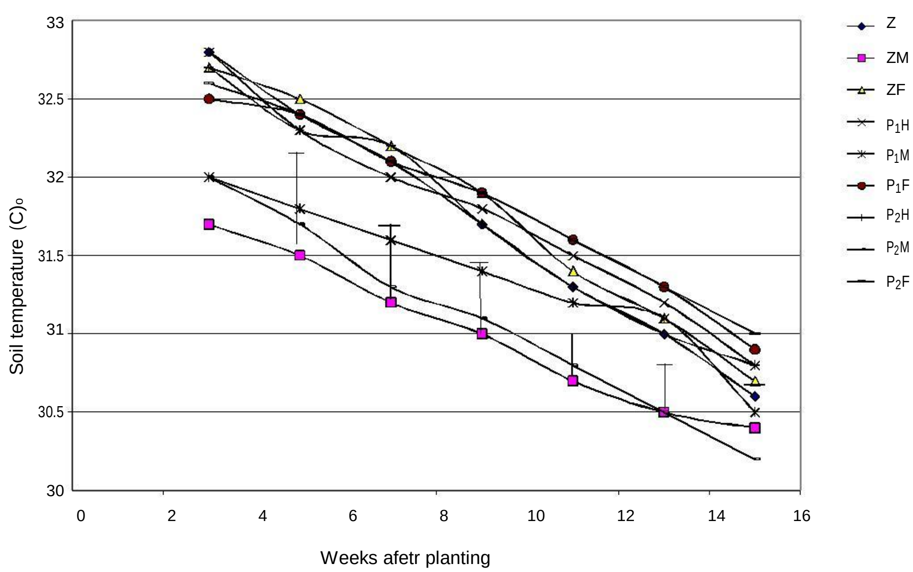

Figure 1b. Trends in soil temperature during growth of late season maize. Vertical lines LSD bar (P = 0.05). Z: manual clearing; P_1H: ploughing 10 cm depth; P_1HM: ploughing at 10 cm + farm yard manure; P_1HF: ploughing at 10 cm + fertilizer; P_2H: ploughing 20 cm depth; P_2HM: ploughing at 20 cm + farm yard manure; P_2HF: ploughing at 20 cm + fertilizer.

characteristics of the soil at the site of the experiment before the commencement of the experiment is presented. There were increases in bulk density and this possibly was as a result of the cofounding effects of natural and tillage-induced compaction. Increases were found for bulk density and this situation possibly resulted from cofounding effects of natural and tillage-induced compaction.

Effect of tillage methods and manure on soil physical properties

The dynamics of soil moisture and temperature regimes at the experimental site are shown in Figures 1a and b respectively. Tillage alone produced higher ranges of soil temperatures over tilled soil amended with FYM and NPK

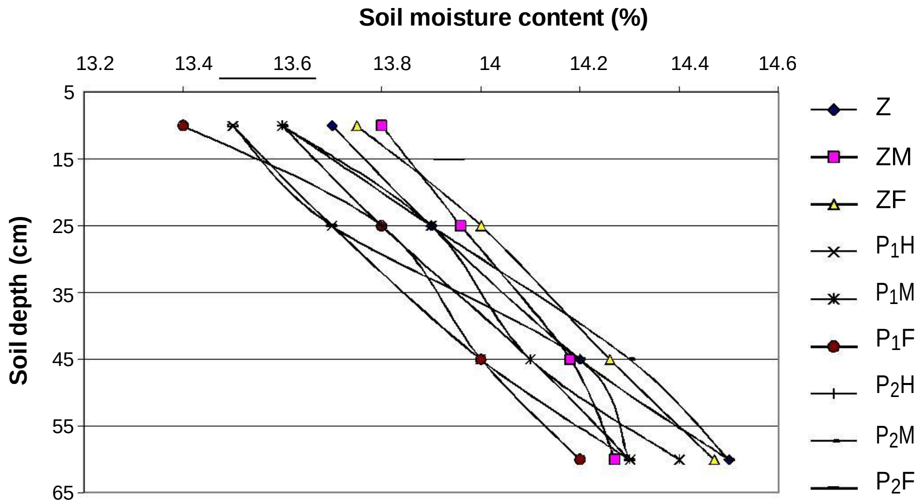

Figure 2a. Dynamics of gravimetric moisture contents (4 WAP). Horizontal lines are LSD bar (P = 0.05). Z: manual clearing; P_1H: ploughing 10 cm depth; P_1HM: ploughing at 10 cm + farm yard manure; P_1HF: ploughing at 10 cm + fertilizer; P_2H: ploughing 20 cm depth; P_2HM: ploughing at 20 cm + farm yard manure; P_2HF: ploughing at 20 cm + fertilizer.

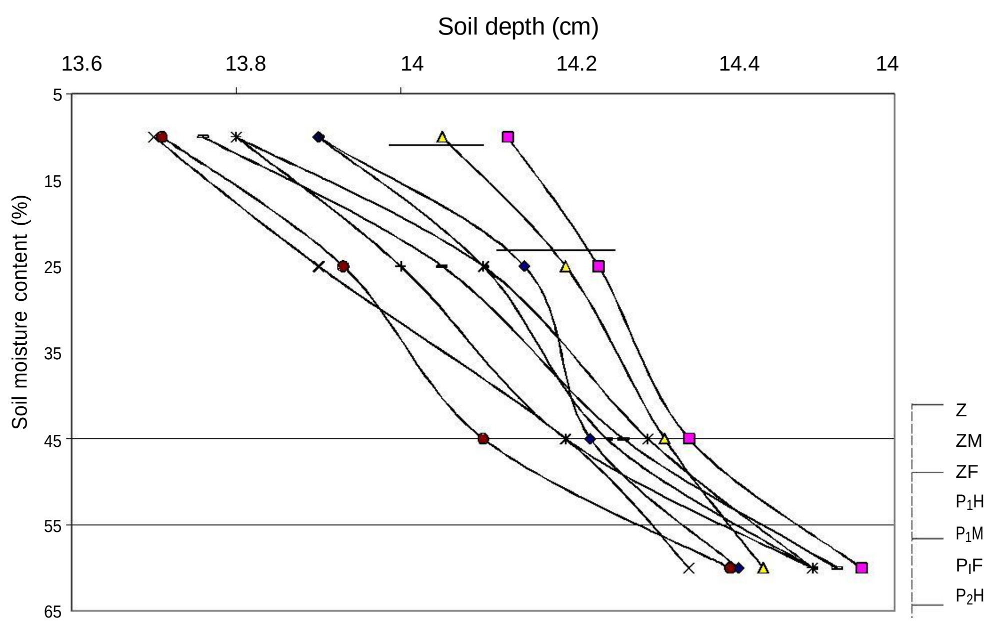

Figure 2b. Dynamics of gravimetric moisture contents (10 WAP). Horizontal lines are LSD bar (P = 0.05). Z: manual clearing; P_1H: ploughing 10 cm depth; P_1HM: ploughing at 10 cm + farm yard manure; P_1 HF: ploughing at 10 cm + fertilizer; P_2H: ploughing 20 cm depth; P_2HM: ploughing at 20 cm + farm yard manure; P_2HF: ploughing at 20 cm + fertilizer.

fertilizers across all sampling dates. The lower soil temperatures under FYM incorporation could have stemmed from lower bulk density (improved total porosity) enhanced soil water infiltration. The differences at times attain significance level, were obtained in the values of soil temperatures in the respective tillage methods alone and tillage combined with manure application. There were differences in gravimetric moisture content among treatments and in the different sampling dates within 0 to 60 cm depth (Figures 2a and b). Mean soil moisture content was higher under manual clearing and deep tillage (P_2H_1), little variations in soil moisture

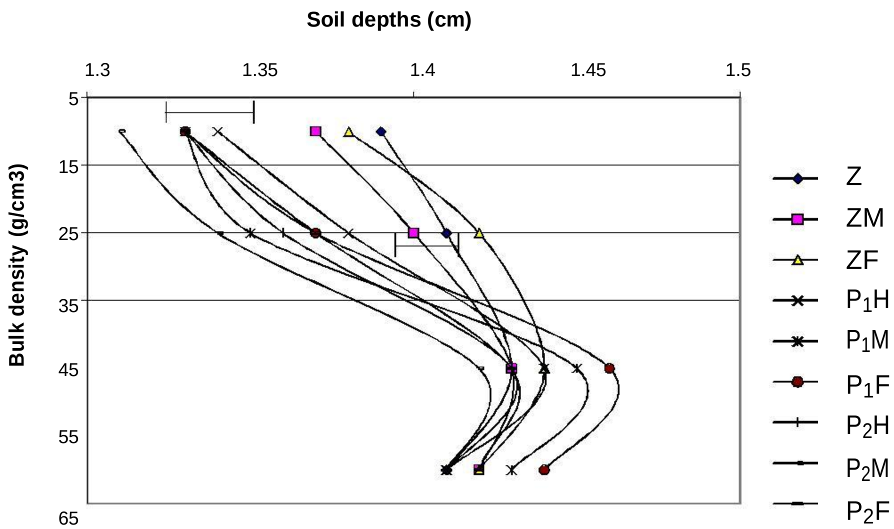

Figure 3a. Dynamics of bulk density as affected by tillage and organic waste incorporation (4 WAP). Horizontal lines are LSD bar (P = 0.05) . Z: manual clearing; P_1H: ploughing 10 cm depth; P_1HM: ploughing at 10 cm + farm yard manure; P_1HF: ploughing at 10 cm + fertilizer; P_2H: ploughing 20 cm depth; P_2HM: ploughing at 20 cm + farm yard manure; P_2HF: ploughing at 20 cm + fertilizer.

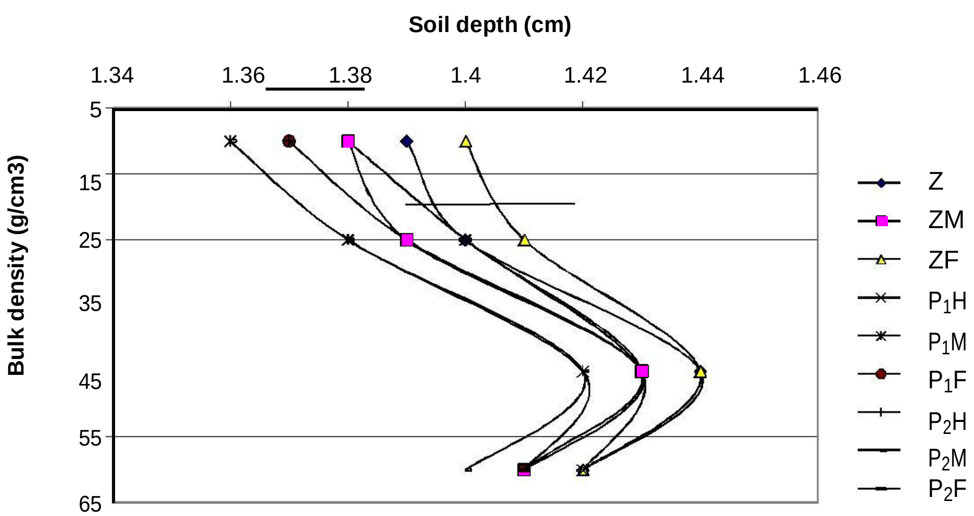

Figure 3b. Dynamics of bulk density as affected by tillage and organic waste incorporation (10 WAP). Horizontal lines are LSD bar (P = 0.05) Z: manual clearing; P_1H: ploughing 10 cm depth; P_1HM: ploughing at 10 cm + farm yard manure; P_1 HF: ploughing at 10 cm + fertilizer; P_2H: ploughing 20 cm depth; P_2HM: ploughing at 20 cm + farm yard manure; P_2HF: ploughing at 20 cm + fertilizer.

storage in tillage alone and tillage-manure combinations were obtained. This trend connotes differences in the magnitudes of soil moisture storage within the root zone and at different phases of maize growth under the different treatments. Manure improved organic matter status and total porosity, this might have favourably impacted soil water holding capacity and modify rainfall infiltration. The values of bulk density taken at 4 and 10 WAP within the crop root zone (0 to 60 cm) varied among the treatments -ploughing depths and manure (Figures 3a and b), The results of soil bulk densities as affected by tillage methods and manure application show that the tillage- manure combinations had lower bulk density values compared treatments involving tillage alone within depth of soil sampled (0 to 60 cm) (Figures 2a and b).Bulk densities values were about half the values obtained under tillage alone treatment, however, bulk densities obtained under P_1H_1 and P_2H_1 in combination

Table 3. Effect of tillage methods and manure application on soil bulk density and moisture contents (0 to 60 cm) and temperature (0-5cm) at crop maturity. (The values of bulk density and moisture contents were mean of 0 to 60 cm sampling depths, soil temperature at 5 cm depth)

Treatments	Bulk density ($g.cm^{-3}$)		Total porosity (%)		Volumetric moisture (%)		Temperature (°C)	
	2006	2007	2006	2007	2006	2007	2006	2007
Z	1.38	1.39	41.9	40.0	15.8	23.9	29.8	28.2
Z_1M	1.27	1.27	46.0	47.0	19.8	25.4	27.0	26.0
Z_1F_1	1.36	1.40	42.0	41.0	16.1	24.6	29.2	28.0
P_1H_1	1.28	1.29	48.5	46.4	11.7	19.6	31.2	29.4
P_1HM	1.24	1.23	52.9	54.0	16.3	21.9	28.6	27.8
P_1HF	1.29	1.28	47.6	46.8	12.3	20.5	30.8	28.0
P_2H_1	1.36	1.38	43.7	41.0	11.7	19.9	32.5	30.1
P_2HM	1.25	1.27	48.0	48.0	14.8	21.7	30.0	28.6
P_2HF	1.35	1.41	44.0	40.1	12.2	20.9	32.0	29.0
LSD (0.05)	0.17	0.27	1.8	2.4	3.3	4.1	1.6	1.5
Unmanured	1.36	1.38	44.7	42.5	13.2	21.5	31.2	29.2
FYM	1.22	1.25	48.9	49.7	16.8	22.9	28.5	27.5
NPK	1.32	1.36	44.6	42.6	13.6	20.0	30.7	28.3
LSD (0.05)	0.11	0.17	0.9	1.0	1.2	1.4	0.9	0.9

Legend: Z (manual clearing); P_1H (ploughing 10 cm depth) plus harrowing; P_2H (ploughing 20 cm depth) plus harrowing; F (200 kg NPK); M (10 t FYM).

with FYM were similar. Lower bulk densities were obtained under tillage at 10 and 20 cm depths (P_1H_1 and P_2H_1) compared to the manually cleared plots. Bulk density values differed between sampling dates (4 and 10 WAP) within the sampling depth, especially for the manured plots. The lower soil strength could have enhanced rainfall infiltration, soil water storage and root development of maize.

Tillage methods combined with FYM application produced lower soil temperatures (Table 3). In all manured plots, lower soil temperatures were attained using 10 $t.ha^{-1}$ FYM compare to NPK application. The significantly lower soil temperatures in treatments where FYM was incorporated into the soil could have stemmed from livestock manure enhanced soil moisture storage. Bulk density, total porosity, moisture content and temperature of the soil are affected by tillage treatments. Ploughing at 10 cm and at 20 cm depth (in addition to one pass harrow) produced relatively lower bulk density, higher total porosity, lower moisture content and higher temperature compared with manual clearing. However, lower values of bulk density, higher total porosity and moisture content and soil temperature were produced by P_2H_1 compared with P_1H_1. In both years of experiment, manually cleared plots produced bulk density and soil moisture content which were significantly (P = 0.05) higher than P_2H_1 (Table 3). Application of manure in combination with tillage systems improved soil physical conditions as indicated by reduced soil bulk density and soil temperature and increased moisture content and total porosity in 2006 and 2007 respectively across the tillage treatments.

Effects of tillage methods and manure on soil chemical properties

The results of the chemical analysis of soil samples surface soil (0-15 cm) at the end of 2006 and 2007 experiments are shown in Tables 4a and b respectively. Manual clearing produced the highest values of soil organic matter (SOM), N, P and exchangeable K and Ca compared with mechanized tillage (P_1H_1 and P_2H_1). Ploughing 10 cm plus harrowing had higher values of soil organic matter (SOM), N, P, exchangeable K, Ca and Mg compared to ploughing at 20 cm. Tillage had no significant (P = 0.05) effect on soil pH in 2006 (Table 4a) but the effect of tillage on soil pH in 2007 (rainy season) was significant (Table 4b). The pH values decreased at the end of 2007 experiment (Table 4b). The decline was less for manual clearing plots compared with ploughing at 10 and 20 cm depth. Application of manure significantly increased (P = 0.05) soil organic matter, total N, available P, exchangeable K, Ca and Mg. Application of 10 t/ha FYM increased soil pH, statistically significant soil pH in both 2006 and 2007 experiments. In general, soil nutrient concentrations in FYM treated plots were higher than in no manure (control).

Among the tillage treatments, the soil nutrient status after harvest in 2006 and 2007 decreased in the order:

Table 4a. Effect of tillage methods on surface soil (0 to 20 cm) chemical properties (2006).

Tillage methods	pH (1:2)	SOM (%)	N (%)	P (mg/Kg)	K (cmol/kg)	Ca (cmol/Kg)	Mg (cmol/Kg)
Manual clearing (MC)	6.17	1.43	0.09	18.7	0.77	4.7	1.52
Ploughing 10 cm + harrowing (P_1H_1)	6.09	1.28	0.1	18.5	0.78	4.6	1.50
Ploughing 20 cm + harrowing (P_2H_1)	6.05	1.24	0.09	17.8	0.71	4.5	1.46
LSD (0.05)	0.1	0.1	0.01	0.2	0.06	0.09	0.02

Table 4b. Effect of tillage methods on surface soil (0 to 20cm) chemical properties (2007).

Tillage methods	pH (1:2)	SOM (%)	N (%)	P (mg/Kg)	K (cmol/kg)	Ca (cmol/Kg)	Mg (cmol/Kg)
Manual clearing (MC)	6.03	1.41	0.10	17.54	0.75	4.56	1.51
Ploughing 10 cm + harrowing(P_1H_1)	5.85	1.22	0.094	16.81	0.70	4.48	1.52
Ploughing 20 cm + harrowing (P_2H_1)	5.81	1.19	0.091	17.48	0.71	4.45	1.48
LSD (0.05)	0.05	0.06	0.004	0.19	0.06	0.07	0.01

MC, P_1H_1 and P_2H_1 (Tables 4a and b). Tillage alone reduced the values of organic matter, total N, available P and exchangeable K, Ca and Mg contents after the first and second seasons of maize cultivation, whereas, application of manure in combination with tillage significantly increased (P = 0.05) values of these parameters at crop maturity in both 2006 and 2007 experiments. The fertility of the soil in the tillage- manure combination increased significantly (P = 0.05), manual clearing plus 10 t/ha FYM recorded the highest values of soil chemical properties measured. Organic matter decreased by 37, 47 and 49.5% in manual clearing, P_1H_1 and P_2H_1 respectively, but percentage increase in organic matter contents under the various combinations involving tillage plus manure ranged from 76 to 45%. Total N decreased in both years under manual clearing, P_1H_1 and P_2H_1 contrasting the increase in values when FYM was applied (Tables 4a and b). Available P decreased by 12, 14 and 13% for manual clearing, P_1H_1 and P_2H_1 respectively, while increases under the various combinations involving the tillage plus manure ranged from 13 to 2%. Percentage decreases in exchangeable K under the different tillage systems were 27, 37 and 37% for manual clearing, P_1H_1 and P_2H_1, which was in contrast to increases ranging from 40-29 % for the various tillage-FYM combinations (Tables 4a and b).

Effect of tillage methods and manure on growth and yield components of maize

The tillage methods influence growth parameters of maize (Table 5). The highest values of plant height, leaf area and stem girth were obtained from manual clearing which was significantly higher (P = 0.05) than values obtained at 10 cm plus harrowing. But in 2007 experiment (rainy season crop), stem girth and 50% flowering recorded the highest values under manual clearing and this was not significantly higher (P = 0.05) from other tillage treatments. In both 2006 and early 2007 cropping seasons, neither number of leaves per plant nor 50% flowering date was significantly higher (P = 0.05) except in the late 2006 where ploughing 20 cm plus harrowing (P = 0.05) than manual clearing. Manure improved growth components of maize over unmanured plots and there were significant (P = 0.05) treatment differences for most of the parameters. The application of manure slightly reduced the number of days to attain 50% flowering and significantly increased (P = 0.05) plant height, stem girth over the unmanured plots in both experiments (Table 5) . The values of maize growth components under the various methods of tillage alone were lower than under the various combinations of tillage and manure combinations. The combination of manure and tillage did produce significantly increases (P = 0.05) in number of leaves per plant and 50% days to flowering. Manual clearing plus manure gave the highest values of growth components at different levels of farmyard manure and NPK fertilizer followed by P_1H_1 and P_2 H_1. However, in 2007 experiments, the highest values of plant height were obtained in ploughing at 10 cm depth plus manure.

The effects of tillage were significant on root and shoot dry weights, 100 seed weight and grain yield of maize in both 2006 and 2007 experiments (Table 6). Maize grown under manual clearing produced the highest grain yield in 2006 followed by ploughing at 20 cm depth plus harrowing. Manual clearing and ploughing at 20 cm depth plus harrowing out yielded ploughing at 10 cm depth plus harrowing by 17.4 and 2.1%, respectively. Application of manure significantly increased (P < 0.05) root dry weight, dry matter yield, 100 seed weight and grain yield of maize

Table 5. Effect of tillage methods and manure on growth characters of maize.

Tillage methods	Plant height (m)		Stem girth (cm)		No. of leaves		Flowering days	
	2006	2007	2006	2007	2006	2007	2006	2007
Z	1.43	1.63	4.5	6.8	3.5	3.5	55	54
ZM	1.81	1.86	5.3	7.1	3.6	3.8	55	52
ZF	1.84	1.92	5.5	7.3	3.7	3.9	57	53
P_1H_1	1.41	1.63	4.3	6.7	3.3	3.5	54	54
P_1HM	1.77	1.92	5.1	7.2	3.7	4.1	56	53
P_1HF	1.82	1.88	5.6	7.5	3.9	4.4	58	54
P_2H_1	1.25	1.55	3.6	6.4	3.3	3.4	56	55
P_2HM	1.51	1.75	4.2	6.6	3.6	3.8	53	55
P_2HF	1.49	1.84	4.8	7.0	3.8	4.1	58	54
LSD (0.05)	0.03	0.1	0.21	0.31	0.26	0.32	2.33	2.22
Unmanured	1.36	1.54	4.13	6.29	3.36	3.46	51	54
10 t/ha FYM	1.7	1.81	4.83	6.81	3.51	3.69	55	55
200 kg/ha NPK	1.69	1.89	4.97	6.90	3.52	3.73	55	56
LSD (0.05)	0.02	0.06	0.13	0.18	0.15	0.19	1.44	1.29

Legend: Z (manual clearing); P_1H (ploughing 10 cm depth) plus harrowing; P_2H (ploughing 20 cm depth) plus harrowing; F (200 kg NPK); M (10 t FYM).

Table 6. Effect of tillage methods and manure on yield components of maize.

Tillage methods	Root dry wt (g)		Shoot dry wt (g)		Leaf area (m^2)		100 grain wt (g)		Grain Yield (t/ha)	
	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
Z	6.8	8.4	48.6	54.8	0.12	0.12	19.9	20.6	4.11	4.32
ZM	8.0	9.3	58.4	65.7	0.19	0.15	21.3	20.9	4.42	4.51
ZF	7.6	10.2	54.5	68.3	0.28	0.22	20.59	22.1	4.34	4.60
P_1H_1	5.5	7.2	42.5	57.4	0.11	0.11	16.23	16.9	3.43	3.52
P_1HM	6.5	8.2	46.2	63.7	0.15	0.14	17.97	18.7	3.78	3.90
P_1HF	7.3	8.8	52.3	60.5	0.31	0.24	18.13	19.1	3.75	3.81
P_2H_1	6.5	7.8	44.1	59.6	0.08	0.10	17.18	17.5	3.58	3.67
P_2HM	7.7	9.4	50.8	67.3	0.12	0.13	18.63	18.83	3.93	4.01
P_2HF	7.4	9.7	47.2	70.5	0.15	0.17	18.20	18.90	3.73	3.82
LSD (0.05)	0.6	0.9	1.7	1.6	0.02	0.03	1.94	1.37	0.07	0.13
Unmanured	6.28	9.43	43.73	64.87	0.1	0.11	17.79	18.31	3.71	3.87
FYM	7.40	10.33	51.80	71.27	0.20	0.18	19.29	19.90	4.05	4.19
NPK	7.43	10.23	50.67	68.05	0.22	0.20	18.97	19.73	3.94	4.05
LSD (0.05)	0.38	0.63	1.03	0.71	0.01	0.02	0.8	0.51	0.03	0.06

Legend: Z (manual clearing); P_1H (ploughing 10 cm depth) plus harrowing; P_2H (ploughing 20 cm depth) plus harrowing; F (200 kg NPK); M (10 t FYM).

(Table 6). The increases between unmanured and manured tilled plots 10 t/ha FYM and 200 kg/ha NPK were 13 and 12% respectively. The increases in the values for grain yield were 6, 9 and 5 % respectively. Relative to unmanured plots (control), 10 t/ha FYM and 200 Kg/ha NPK treated plots increased grain yields by 8.7 and 5.3%, respectively. In both trials, application of manure in combination with tillage significantly affected the growth and yield components of maize (Table 6). Among tillage plus manure combination, manual clearing plus manure (10 t/ha FYM and 200 Kg/ha NPK) gave the highest values of root dry weight, shoot dry weight, dry cob weight, dry grain weight per cob, 100 grain weight and grain yield of maize in 2006 and 2007. This was followed by ploughing at 20 cm depth plus harrowing plus manure combinations (P_2H_1 + 10 t/ha FYM and P_2H_1+ 200 Kg NPK). Ploughing at 10 cm depth plus harrowing plus manure (P_1H_1 + 10 t/ha FYM and P_1H_1 + 200 Kg/ha NPK) gave the least values of yield components (Table 6).

Non-significant interactions between seedbed type and manure application were found for some soil physical and chemical properties, growth and yield of maize. The independent effects of these factors (treatments) also indicate that the seedbed types responded same way to types of manure applied.

DISCUSSION

In this trial the treatments applied produced the changes in soil chemical (fertility) and physical (hydrothermal, porosity and soil water storage) properties and the improvement in soil conditions enhanced maize performance. Tillage practices and soil amendment using organic wastes are known to lead to improvement in soil conditions (Stamatiadis et al., 1997; Wilson et al., 2000; Agele, 2007). The mechanized tillage resulted into disturbance of the soil, and this has been reported to lead to the destruction of soil aggregates (Hulugalle et al., 1985; Ohu et al., 1994). Application of FYM and NPK fertilizer improved the soil physical conditions and nutrients status presumably due to the supplied plant nutrients from the materials (Eaton, 2001; Agele et al., 2006).

The lower soil bulk density and high porosity produced by ploughing at 20 cm plus harrowing could be attributed to the loosening effects of tillage (Hulugalle et al., 1985; Lal, 1997) . Although, higher soil bulk density produced by ploughing at 10 and 20 cm depth plus harrowing could be due to effects of tractor wheel- traffic and implement passes and lower macro-porosity and evaporation rate (Donahue et al., 1990; Agbede, 2006), however, Ojeniyi (1981) found that for sandy soils of southwest Nigeria that manual clearing had higher mean soil bulk density and lower total porosity at soil surface over tractorised tillage. Hulugalle et al. (1985) and Ike (1986) reported that higher bulk density for soils under zero tillage is due to soil compaction of untilled soil in southern Nigeria soils. This observation implies that in the tropics, continuous exposure of untilled soil to rainfall without mechanical tillage impacts the soil (Ojeniyi, 2003). Increased machinery traffic on agricultural soil associated with increased compaction has been attributed to increases in the number of wheel traffic passes (Hulugalle et al., 1985; Voorhees, 1987; Zhang et al., 1997).

Soil amended with FYM had lower bulk density and higher total porosity possibly due to increases in the proportion of macro-aggregates and soil organic (Agele et al., 2005). Bulk density is important to rainfall infiltration, root distribution and root function, which in turn affect plant water uptake and growth (Graecen and Gardner, 1982). Soil at the experimental site had high bulk density before planting maize. Meinke et al. (1993) reported the association of increasing dryness, high soil strength, and penetration resistance with increasing bulk density with depth. Application of manure reduced soil bulk density and temperature and increased moisture content and porosity in both years of experiment. The widely reported influence of manure application on soil physical conditions had been attributed to the enhancement of soil organic matter and possible improvements in soil porosity and structure (Hulugalle et al,. 1985; Agele et al., 2006).

The manually cleared soils had higher moisture content and lower soil temperature in both experiments compared with soils that were ploughed to at 10 cm or 20 cm depth. The highest moisture status of manual clearing could be adduced to the minimum soil disturbance with little exposure of the soil surface to the atmosphere and consequent reduction in water evaporation, therefore conserving soil temperatures and the available water in the soil (Maurya and Lal, 1979; Ghuman and Lal, 1984, Agele et al., 2000). Soil profile characteristics (moisture and density) are important to root distribution and root function, which in turn affect plant water uptake and growth (Graecen and Gardner, 1982).

Ploughing at 10 and 20 cm depth plus harrowing expose organic materials which were formerly inaccessible to microbial decomposition. Ploughing is known to accelerate mineralization rate of organic materials (Grace et al., 1993; De Neve and Holfman, 1997). The enhanced mineralization is necessary to sustain increased microbial activities due to the incorporated organic substrates especially plant residue of high C:N ratio (Grace et al., 1993; Mazzarino et al., 1993; Agele et al., 2006). The soil at the site of the experiment was deficient in organic matter, total N, available P, exchangeable K and Ca. Nottidge et al. (2005) also found that Alfisol was low in organic matter, N, P and exchangeable cations. Therefore, it is expected that maize grown on the soil at site of experiment would require amendments such as farmyard manure and inorganic fertilizer application in order to attain optimum productivity.

Lal (1979) in experiments conducted using different tillage techniques on an Alfisol in south western Nigeria, found that maize under non-tillage treatment with relatively high bulk density out yielded those planted under conventional tillage for two consecutive seasons. The range of bulk density recorded for the manual tillage methods (1.33 to 1.45 g/cm^3) was not limiting maize growth. Our results suggest that increase in soil bulk density up to 1.45 g/cm^3 did not reduce nutrient uptake, root penetration, dry matter and grain yields of maize. Combination of farmyard manure and NPK (a mineral fertilizer) with manual clearing (10 t/ha FYM and 200 kg/ha NPK) gave higher values for soil nutrient (N, P, K, Ca and Mg) contents, growth and grain yield parameters compared with other tillage-manure treatments such as P_1H and P_2H (10 t/ha FYM and 200 kg/ha NPK). This finding attests to the positive cumulative effect of manual clearing methods and manure on soil productivity.

In this study, while the effects of tillage and manure were independently noticed, the tillage-manure combinations improved soil physical and chemical conditions and in addition affected the growth and yield of maize.

Conclusion

Field experiments were conducted to study the effect of tillage and manure application on soil physical and chemical properties, growth and yield of maize grown on a degraded Alfisol following several years of intensive mechanized tillage. The treatments brought about improvement in soil physical and chemical properties and enhanced growth and seed yield of maize in a humid zone of Nigeria. The manually cleared soil had higher moisture content and lower soil temperature in both experiments compared with soils that were ploughed to 10 or 20 cm depth (P_1H_1 and P_2H_1). The highest moisture status of manual clearing could be adduced to the minimum soil disturbance with little exposure of the soil surface to the atmospheric demand and consequent reduction in soil water evaporation could have conserved soil water. However, the mechanized tillage treatments (involving plough at 10 and 20 cm depth plus ploughing) reduced bulk density and enhanced porosity compared with manual clearing. However, the range of bulk density recorded for the manual tillage methods (1.33 to 1.45 g/cm^3) was not limiting to maize. Favorable bulk density and hydrothermal regime in the root zone and improved soil fertility can be advanced for the improved performance of maize under tillage combined with livestock manure application. Soil amendment with farmyard manure and inorganic fertilizer brought about improvement in soil fertility status of organic matter, N, P and exchangeable cations. Tillage depths and manuring appeared to have resulted in improved soil physical conditions (soil porosity and structure and reduced soil bulk density and temperature and increased moisture content) and enhanced growth and seed yield of maize in both years of experiment. The results of this study showed that manual clearing was the most productive soil in terms of performance of maize and soil fertility. The treatments also conserved soil water and reduced soil temperatures relatively to mechanized tillage systems.

REFERENCES

Agbede TM (2006). Effect of tillage on soil properties and yam yield on an Alfisol in Southwestern Nigeria. Soil Till. Res., 86:1-8.

Agele SO (2000). Effects of animal manure and NPK fertilizer on simulated erosion and maize yield. J. Environ. Educ. Inf., 19(2): 131-138.

Agele S O, Ewulo BS, Oyewusi IK (2005). Effect of some management systems on soil physical properties, microbial biomass and nutrient distribution under rainfed maize production in a humid rainforest Alfisol. Nutr. Cycling Agroecosyst., 72: 121-134.

Agele SO (2007). Efficacy of organic amendments on the establishment and biomass yield of grass species on adegarded alfisol. J. Plant Interactions, 2(3): 195-201.

Aina PO, Fapohunda H, Idowu J (1985). Compaction and moisture suction effects on soil strength and crop emergence. Ife J. Agric., 7: 16-25.

Bennie ATP, Botha FJP, (1986). Effect of deep tillage and controlled traffic on root growth, water use efficiency, and yield of irrigated wheat and maize. Soil Till. Res. 17: 85-95.

Brady NC (1990). Soil organic matter and organic soils. The nature and properties of soils. Macmillan Publishing Co. New York, p. 279-313.

Chu CM, Bradshaw AD (1996). The value of pulverized refuse fines (PRF) as a substitute for topsoil in land reclamation.1. Field studies. J. Appl. Ecol.. 33: 851-857.

De Neve S, Hofman G (1997). Modelling N mineralization of vegetable residues during laboratory incubations. Soil Biol. Biochem., 28: 1451-1457.

Eaton WD (2001). Microbial and Nutrient activity in soils of Ghana under different. Appl. Soil Ecol., 8: 19-24.

Elmar S, Wolfgang W (1990). Organic manure: No alternative to mineral fertilizers for developing countries. Fertilizer Int. pp. 7-12.

Grace PR, MacRae IC, Myers RJK (1993). Temporal changes in microbial biomass and N mineralization under simulated field condition. Soil Biol. Biochem., 25(12): 1745-1754.

Hulugalle NR, Lal R, Opara-Nadi OA (1985). Effect of tillage system and mulch on soil properties and growth of yam (*Dioscorea rotundata*) and cocoyam (*Xanthosoma sagillifolium*) on an ultisol. J. Root Crops, 11: 9-22.

Ike IF (1986). Soils and crop responses to tillage practices in a ferruginous soil in the Nigeria Savanna. Soil Till. Res. 6: 261-272.

Jackson ML (1962). Soil Chemical analysis. Prentice – Hall Inc. New Jersey, pp. 1-498.

Kanamori T, Yasuda T (1979). Immobilisation, mineralisation and the availability of the fertilizer nitrogen during the decomposition of organic matter applied to soil. Plant Soil, 52: 215-229.

Kay BD (1990). Rates of changes of soil structure under different cropping systems. Adv. Soil Sci., 12:1-52.

Lal R (1976). No-tillage effect on soil properties under different crops in western Nigeria. Soil Sci. Soc. Am. Proc., 40: 762-768.

Lal R (1979a). Influence of six years of no-tillage and conventional ploughing on fertilizer response of maize on an Alfisol in the tropics. Soil Sci. Soc. Am. J., 43: 399-403.

Lal R (1984). Mechanized tillage system effects on soil erosion from an Alfisol in water sheds cropped to maize. Soil Till. Res., 4:349-360.

Lal R (1997). Long-term tillage and maize monoculture effects on a tropical Alfisol in western Nigeria on crop yield and soil physical properties. Soil Till. Res., 42: 145-160.

Lampurlanes J, Martinez CC (2003). Soil bulk density and penetration resistance under different tillage and crop management systems and their relationship with Barley root Growth. Agron. J., 95: 526-536.

Lupwayi NZ, Arshad MA, Rice WA, Clayton GW (2001). Bacterial diversity in water stable aggregates of soils under conventional and zero tillage management. Appl. Soil Ecol., 16(3): 251-261.

Meinke H, Hammer GL, Wart P (1993). Potential soil water extraction by sunflower on a range of soils. Field Crops Res., 32: 59-81.

Maurya PR, Lal R (1980). Effect of no tillage and ploughing on roots of maize and leguminous crops. Exp. Agric., 16: 185-193.

Mazzarino MJ, Szott L, Jimenex JM (1993). Dynamics of total C and N, microbial biomass and water stable C in tropical agroecosystems. Soil Biol. Biochem., 25(2): 205-214.

Nangju D, Wanki SBC (1980). Estimating leaf area of cowpea and soybean using dry weights of terminal leaf lets. Exp. Agric., 16: 149-151.

Ogunremi LT, Lal R, Babalola O (1986). Effect of tillage and seedling method on soil physical properties and yield of upland rice for an ultisol in southeast Nigeria. Soil Till. Res., 6: 223-234.

Ohu JO, Ekwue EI, Folorunso OA (1994). The effect of addition of organic matter on the compaction of a vertisol from northern Nigeria. Soil Technol., 7(2): 155-162.

Ojeniyi SO (1982). Soil structure produced by tillage implements and their effects on soil water. Ghana J. Agric. Sci., 14-19: 45-49.

Ojeniyi SO (1986). Effect of zero tillage and disc ploughing on soil water, soil temperature and growth and yield of maize (*Zea mays*). Soil Till. Res., 7: 173-182.

Ojeniyi SO, Agboola AA (1995). A review of tillage requirement of crops in Africa Soils 28, 259-266.

Raymond WM, Roy LD (1992). Organic Matter and Container Media Soils: An Introduction to soils and Plant Growth, 6th edn. (Delhi: Prentice Hall), pp. 181-224.

Sobulo RA, Osiname OA (1986). Soil properties and Crop yields under continuous cultivation with different management system. In: R. Lal,P.A. Sanchez and R. W. Cunnings (eds). Land clearing and development in the tropics. A. A. Balkama, Rotterdam, Boston, pp. 363-370.

Stamatiadis S, Werner M, Buchanan M (1997). Field assessment of soil quality as affected by compost and fertilizer application in a broccoli field (San Benito Country, California). Appl. Soil Ecol., 12(3): 217-225.

Stewart GA, Vyn TJ (1994). Influence of high axle loads and tillage systems on soil properties and grain corn yield. Soil Till. Res., 29(2-3): 229-235.

Van Landen GWJ (2000). Soil Degradation in Central and Eastern Europe: The assessment of the status of human-induced degradation (ver. 1.0) Wageningen: FAO and ISRC-World Soil information, (ISRIC Report) 2000/5), p.15

Voorhees WD (1987). Assessment of soil susceptibility to compaction using soil and climatic base. Soil Till. Res. 10: 29-38.

Walkley TA, Black IA (1934). An estimation of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. Soil Sci., 37: 29-38.

Wilson CW, Shaw PE, Knight Jr RS (1982). Analysis of Oxalic Acid in Carambola (Averrhoa Carambola L.) and Spinach by high performance liquid Chromatography J. Agric. Food Chem., 30: 1106-1108.

Wilson TC, Paul EA, Harwood RR (2000). Biologically active organic matter fractions in sustainable cropping systems. Appl. Soil Ecol. 16(1): 63-76.

Wong MH, Wong JWC (1989). Germination and seedling growth of vegetable crops in fly ash amended soil. Agric. Ecosyst. Environ., 26: 232-235.

Zhang HQ, Hartge HK, Ringe H (1997). Effectiveness of organic matter incorporation in reducing soil compactibility. Soil Sci. Soc. Am. J. 61(1): 239-245.