IJAAR 3 (2015) 73-82 ISSN 2053-1265

International Journal of Advance Agricultural Research
www.bluepenjournals.org/ijaar

Effects of tillage and *Terminalia catappa* L. leaf compost on soil properties and performance of *Capsicum chinense* Jacq.

Suleiman A. A.[1]*, Aiyelari E. A.[2] and Otene I. J. J.[3]

[1]Faculty of Agriculture, Nnamdi Azikiwe University Awka, Nigeria.
[2]Department of Agronomy, Faculty of Agriculture and Forestry, University of Ibadan, Nigeria.
[3]Institute of Agriculture and Environment, Massey University, New Zealand.

Article History
Received 20 September, 2015
Received in revised form 14 October, 2015
Accepted 19 October, 2015

Keywords:
Almond leaves,
Pepper,
Manure,
Ridge and flat,
Yield.

Article Type:
Full Length Research Article

ABSTRACT

The study was conducted to assess the residual effects of Almond leaves and tillage on soil properties, growth and yield of pepper. In the 2011, treatments comprised of tillage systems [flat (F) and ridge (R)] and application of NPK mineral fertilizer (NPK*F and NPK*R) at 0.25 t ha^{-1}, Almond leaves + swine manure (AS*F and AS*R) at 13 t ha^{-1}, Almond leaves + poultry manure (AP*F and AP*R) at 14.5 t ha^{-1}, Almond leaves + cattle manure (AC*F and AC*R) at 14.3 t ha^{-1} and control plots with no fertilizer or compost application (F and R). Plot size was 4.0 m × 3.0 m (12 m^2) and plant spacing of 60 cm in a randomized complete block design with four replications. Plots treated with Almond leaves composted with poultry manure under ridge tillage system significantly improved soil physical and chemical properties, plant growth and yield with saturated hydraulic conductivity (22.01 cm hr^{-1}), total porosity (51.13%), more stable soil aggregates (1.32 g mm^{-1}), decrease in bulk density (1.26 g cm^{-3}), highest values of soil organic carbon (20.0 g kg^{-1}), N (2.7 g kg^{-1}), P (20.56 mg kg^{-1}), K (0.28 cmol kg^{-1}) and soil pH (6.9). At 12 weeks after transplanting, the same plots produced tallest plants of average height 20.6 cm, highest number of leaves and yield (488 and 7.2 kg/plot, respectively). Microbiological and physico-chemical analysis of Almond leaves composted with poultry, swine and cattle manures before application to the soil is suggested for further studies.

INTRODUCTION

Tillage methods could enhance the sustainable use of soil resources by influencing its properties. Similarly, compost application to soils is a sustainable agricultural practice because it helps to enhance soil fertility, improves soil physical and chemical properties, and also when properly managed before application, is effective in reduction of greenhouse gases (GHG) when compared to the use of synthetic fertilizers. Composting is a natural system for organic waste management, nutrient management, resource reclamation and pathogen control to reduce public health issues (Zhang & He, 2006; Chatterjee et al., 2013).

Tillage practices have effects on soil structure (Afolayan et al., 2010) and influences soil properties such as bulk density, compaction, total porosity, saturated hydraulic conductivity, aggregate stability, moisture content and the ability of the soil to control erosion and sustain nutrients for plant uptake (Angers, & Eriksen-Hamel, 2008; Veiga et al., 2008; Ewulo et al., 2011).

Globally, the improvement of soil fertility and crop performance through agronomic practices such as tillage and application of fertilizers have received increased attention of researchers because inefficient techniques could result in adverse effects on human health and the environment. Depending on soil type, improper tillage

*Corresponding author. E-mail: attahsly@gmail.com. Tel: +2348035339379.

may result to undesirable processes such as destruction of soil structure, accelerated erosion, depletion of organic matter content and limited or unavailability of plant nutrients. The application of compost has long term effects on soil properties contributing to maintenance of soil quality (Ginting et al., 2003) and by increasing the levels of soil N, P, K, pH, and C, it has the potential beyond the application year to increase the yield of the succeeding crops (Eghball et al., 2004).

Pepper (*Capsicum* spp.) is a significant component of many cuisines of the world populations (Wang and Bosland, 2006). *Capsicum*, when compared to other spices have important history and antiquity (Govindarajan and Uwe, 1985). They have conspicuous fruit colour, diverse shapes, taste and biochemical content with potential uses in medicine, cosmetics, plant based insecticides (PBI) and income generation for the farmers (Dagnoko et al., 2013). There are five commonly cultivated species of the genus *Capsicum* (Family: Solanaceae): *C*. *annuum* L., *C*. *frutescens* L., *C*. *chinense* Jacq., *C*. *baccatum* L. and C. *pubescens* Ruiz and Pav. (Antonious et al., 2009). *C. chinense* Jacq. is commonly cultivated in the west Indies, the Amazon basin, Northern-south America, Peru, and Bolivia (Govindarajan and Uwe, 1985). Some abiotic factors that affects the growth, development and fruit yield of pepper include soil salinity (Khan et al. 2009; Zhani et al. 2013), soil moisture and air temperature (Ogunbo et al., 2015). Optimum production of pepper occurs in well–drained soils (loam or silt loam soil) with good water-holding capacity, soil pH of 5.5 to 6.8 (Berke et al., 2005; Ogunbo et al., 2015) and temperature range between 18 and 30°C (Grubben and Tahir, 2004).

Among the cultivars of pepper grown in West Africa, Nigeria accounts for about 200 selections (Idowu-Agida et al., 2012; Dagnoko et al., 2013). The major factor limiting increased pepper production in Nigeria is poor agronomic practices (Olowokere and Tijani-Eniola, 2013). To enhance the performance of diverse varieties of pepper, knowledge on the agronomic practice is essential (Ajjapplavara 2009; Aguilar-Meléndez et al., 2009; Orobiyi et al., 2013).

Almond residues including its shells, hulls, pruning, leaves, skin and kernel have various utilisation ranging from energy uses, animal livestock feed and medical uses. Based on residue type, Cheng et al (2010) reported the following utilization: hulls (feed, antioxidants, fiber, gums/polysaccharides, triterpenoids, filter), pruning (combustion, pyrolysis, gasification, activated carbons), skin (antioxidants). Other utilization in previous studies include the use of sun dried mesocarp of fruits as raw material for livestock feed (Nwosu et al., 2008), the use of the leaves harvested at different stages of growth for the treatment of sickle cell anaemia disease (Moody et al., 2004), the use of the fruit shell as sorbent for heavy metal removal from waste water (Inbaraj and Sulochana, 2006). However, there is limited knowledge on the composting of Almond leaves or its combined effects with livestock manure on soil chemical and physical properties. The study is hinged on the need to investigate the long term mineralisation of Almond leaves composted with poultry, swine and cattle manures on soils planted with pepper (C. *Chinense* Jacq.).

MATERIALS AND METHODS

The study was carried out at the Teaching and Research Farm, University of Ibadan, South West Nigeria (derived savannah) between latitude 7° 26' 50" N and longitude 3° 55' 59" E with annual rainfall between 1250 mm and 1500 mm, annual temperature between 21.3°C and 31.2°C while the average annual humidity is 76%. The area possess two seasonal climate (wet and dry) and moderately the same temperatures in a given season of the year. It experiences marked wet and dry seasons with a bimodal rainfall in May-June-July, which is interrupted by a dry period of two weeks in August. This is followed by another period of heavy rainfall from September to October.

Vegetation in the study area include grasses such as elephant grass (*Pennisetum purpureum*), guinea grass (*Pannicum maximum),* leguminous shrubs like *Leucenea leucocephala*, *Gliricidia sepium Ceasalphinaea pulcherima* and oil palm trees. The soil of the area is an Alfisol, locally classified under Egbeda soil series (Smyth and Montgomery, 1962).

In the previous year (2011), the composting of Almond dry leaves with dry poultry, swine and cattle manures was at mixture ratio 1:1 using static pile method of composting (Yuh-Minghuang, 2005). The mixture were thoroughly wetted with suitable water content, and then piled up in a round heap. Turning of the compost pile was done fortnightly for six times to keep the moisture content at optimum level for biological activities. Finished compost was achieved at 12 weeks after composting. Treatments comprised of flat with NPK at 0.25 t ha^{-1} (NPK*F), ridge with NPK at 0.25 t ha^{-1} (NPK*R), flat with Almond leaves + swine manure at 13 t ha^{-1} (AS*F), ridge with Almond leaves + swine manure at 13 t ha^{-1} (AS*R), flat with Almond leaves + poultry manure at 14.5 t ha^{1} (AP*F), ridge with Almond leaves + poultry manure at 14.5 t ha^{-1} (AP*R), flat with Almond leaves + cattle manure at 14.3 t ha^{-1} (AC*F), ridge with Almond leaves + cattle manure at 14.3 t ha^{-1} (AC*R) and control plots (F and R) with no fertilizer or compost application. Plot size was 4.0 m × 3.0 m (12 m^2) and plants were spaced 60 cm × 60 cm in a randomised complete block design (RCBD) with four replications.

Soil samples were collected from the trial plots to a depth of 30 cm. The samples were crushed, air dried under ambient temperature and sieved through a 2 mm mesh. The sieved samples were stored in polythene bags and transported to Soil Science Laboratory, Department of Agronomy, University of Ibadan, Nigeria.

Soil chemical analysis

Soil reaction (Soil pH)

Soil pH was measured in a 1:1 soil-water ratio using a glass electrode (H19017 Microprocessor) pH meter. 10 g of air-dried soil sample passed through 2 mm sieve was weighed into 50 ml sample beaker and 25 ml of distilled water was added to the soil. The soil-water solution was swirled thoroughly by placing on a mechanical shaker for 10 min and then allowed to stand for 30 min. After calibrating the pH meter with buffers of pH 4.01 and 7.00, the pH was read by immersing the electrode into the upper part of the soil solution and the pH was value recorded.

Soil organic carbon (SOC)

Soil organic carbon was determined by the modified Walkley-Black method as described by Nelson and Sommers (1982). The procedure involved a wet combustion of the organic matter with a mixture of potassium dichromate and sulphuric acid. After the reaction, the excess dichromate was titrated against ferrous sulphate. Approximately 1.0 g of air-dried soil was weighed into a clean and dry 250 ml Erlenmeyer flask. A reference sample and a blank were included. 10 ml 0.1667 M potassium dichromate ($K_2Cr_2O_7$) solution was accurately dispensed into the flask using the custom laboratory dispenser. The flask was swirled gently so that the sample was made wet. Then using an automatic pipette, 20 ml of concentrated sulphuric acid (H_2SO_4) was dispensed rapidly into the soil suspension and swirled vigorously for 1 min. This was allowed to stand on a porcelain sheet for 30 min, after which 100 ml of distilled water was added and stirred. 10 ml of ortho-phosphoric acid and 1 ml of diphenylamine indicator was added and titrated by adding 1.0 M ferrous sulphate from a burette until the solution turned dark green at end-point from an initial purple colour. About 0.5 ml 0.1667 M $K_2Cr_2O_7$ was added to restore excess $K_2Cr_2O_7$ and the titration was completed by adding $FeSO_4$ drop- twice to attain a stable end-point. The volume of $FeSO_4$ solution used was recorded and percentage C calculated.

Mathematically, percentage (%) organic carbon (OC) was calculated using the formula below:

$$Y = \frac{\text{Volume of } K_2Cr_2O_7 \times 0.003}{\text{Blank value}} \times \frac{100 \times 1.33}{\text{weight of sample}} \quad (1)$$

$$\text{Percentage OC} = (\text{blank titre} - \text{sample titre}) \times Y \quad (2)$$

Organic matter of the soils was obtained from OC by multiplying with the conventional ‘van Bemmelen factor’ of 1.724 (van Bemmelen, 1890).

Total nitrogen

Total nitrogen was determined by the Kjeldahl digestion and distillation procedure as described by Bremner and Mulvancy (1982). 0.5 g of 0.5 mm sieved soil was weighed into a Kjeldahl digestion flask and 5 ml distilled water was added. After 30 minutes a tablet of selenium and 5 ml of concentrated H_2SO_4 were added to the soil and the flask placed on a Kjeldahl digestion apparatus and heated gently initially and later vigorously for at least 3 h. The flask was removed after a clear mixture was obtained and then allowed to cool. About 40 ml of distilled water was added to the digested material and transferred into 100ml distillation tube. 20 ml of 40 % NaOH was also added to the solution and then distilled using the Tecator Kjeltec distiller. The digested material was distilled for 4 minutes and the distillate received into a flask containing 20 ml of 4% boric acid (H_3BO_3) prepared with PT5 (bromocresol green) indicator producing 75 ml of the distillate. The colour change was from pink to green after distillation, after which the content of the flask was titrated with 0.02 M HCl from a burette. At the end-point when the solution changed from weak green to pink the volume of 0.02 M HCl used was recorded and percentage N was calculated. A blank distillation and titration was also carried out to take care of traces of nitrogen in the reagents as well as the water used.

Calculation;

$$\text{Percentage N} = \frac{(T-B) \times 14.01 \times 0.01N \times 100 \times 10}{\text{Weight of soil sample x } 1000} \quad (3)$$

Available phosphorus

Available P was determined with spectrophotometer using Mehlich III as extractant (Mehlich, 1984). 2 g of 2 mm sieved soil was weighed into an extractant cup; 10 ml of Mehlich III solution was added. The samples were shaken on the mechanical shaker for 10 min. The mixture was then filtered using a filter paper. 5 ml of the filtrate was measured into an extract- ant cup and 5 ml of colour reagent was added to it. The samples were made up to 50 ml by adding 40 ml of distilled water. The samples were read with the spectrophotometer.

$$\text{Calculation: } P = \text{slope} \times df \times Abs \quad (4)$$

Where:
P=available phosphorus (cmol kg^{-1})
df=dilution factor (10);

Abs=absorbance

Exchangeable bases:

Exchangeable bases (calcium, magnesium, potassium and sodium) in the soil were determined in 1.0 N ammonium acetate (NH_4OAc) extract.

Exchangeable acidity

10 g of 2 mm sieved soil was weighed into an extractant cup, 10 ml of KCl was added. The solution was shaken for 10 min with the mechanical shaker and filtered with a filter paper. 10 ml of the filtrate was weighed into an extractant cup and 3 drops of phenolphthalein indicator was added. The solution was titrated with 0.01 N NaOH. At the end point of the titration, the colour of the solution changed to light pink. The volume of base used (NaOH) for titrating, each sample was multiplied by 0.5 to get the total exchangeable acidity of the soil samples.

Aluminium

After exchangeable acidity of the samples was carried out as described above, the solution (light pink) was decolorized with 5 ml of 0.01 N HCl, 5 ml of NaF solution was added to the samples. The solution was then titrated with 0.01 N HCl. The amount of the acid used for the titration is equivalent to the amount of Aluminium present in the soil sample.

Effective cation exchange capacity (ECEC)

Effective cation exchange capacity was determined by the summation of exchangeable bases (Ca^{2+}, Mg^{2+}, K^+ and Na^+) and exchangeable acidity (Al^{3+} and H^+).

Soil physical analysis

Particle size distribution

The hydrometer method by Bouyoucos (1951) was used to determine particle size analysis.

Soil aggregate stability

The wet sieving technique (Kemper and Rosenau, 1986) was used determining the soil aggregate stability. The procedure is as follows:

(i) The air dried soil samples were sieved using 5.66 mm mesh.
(ii) 100 g of the sample was placed on top most of a nest of sieve with diameter 2 mm, 1 mm, 0.5 mm and 0.25 mm.
(iii) The nest of sieve was oscillated vertically 20 times in water at the rate of 1 oscillation per second.
(iii) The resultant aggregate on each sieve were then oven-dried at 105° C for 24 h.
(v) The resultant aggregate were weighed.
(vi) Aggregate stability was then determine using mean weight diameter:

$$MWD=\sum_1 X_1 W_1 \quad (5)$$

MWD=Mean weight diameter of water stable aggregate.
X_1= Mean diameter of each size fraction
W_1= Proportion of the total corresponding size fraction.

Saturated Hydraulic Conductivity (Ks)

This was determined using the constant head method (Klute and Dirksen 1986); as described by Darcy (1856). This procedure allows water to move through the soil under a steady state head condition, while the quantity (volume) of water flowing through the soil sample is measured over a period of time. The procedure is as follows:

(i) The undisturbed core samples were allowed to saturate for 24 h;
(ii) The saturated soil samples were placed in the permeameter and the water level was maintained at a constant height;
(iii) The steady flow rate for 60 s was measured and this was repeated 5 times;
(iv) The hydraulic conductivity was estimated using.

$$K = V/At \times L/\Delta H \quad (6)$$

Where,
$Q = V/t$
Q = steady flow rate
V = volume of the sample core
A = inner area of the sampler
L = height of sample core
ΔH = constant head

Soil bulk density

This was determined using the core method (Hartge and Horn, 1989).The procedure is as follows:

(i) The undisturbed soil sample was oven dried at 105° C for 24 h.
(ii) The oven-dried soil samples were weighed and the

volume of the core sampler was measured i.e. the inner core volume.

(iii) Bulk density was determined using this formula:

$$\text{Bulk density} = M_s/V_t \quad (7)$$

M_s = mass of oven dried soil;
V_t = Volume of the inner core sampler.

Soil total porosity

Total soil porosity was calculated from particle density of 2.65 gcm^{-3} using the following equation:

$$TP = 1- BD/2.65 \quad (8)$$

Where,
TP = Total porosity
BD = Bulk density

Data collection

Plant height and number of leaves were taken at 6, 8, 10 and 12 weeks after transplanting, while 10 samples per plot of fresh fruits were used to determine the yield of the pepper.

Statistical analyses

The data collected were subjected to analysis of variance (ANOVA) using proc GLM of SAS 9.3 and significant differences among the treatment means were separated using Duncan's Multiple Range Test (DMRT) at 5% level of probability.

RESULTS AND DISCUSSION

Chemical Properties and particle size distribution of experimental soil

Chemical properties and particle size distribution of the soil used for the experiment is shown in Table 1. The result shows that the pH of the soil was slightly acidic with a pH value of (6.1). Organic carbon value of 9.5 g kg^{-1},was greater than the critical level of 8.7 g kg^{-1} for the soil in Western Nigeria (Sobulo and Adepetu, 1987). The total nitrogen content of 1.5 g kg^{-1} was at the critical level of 1.5 g kg^{-1} (Enwenzor et al., 1979). While the available P of 9.0 mg kg^{-1} was below the critical level of 10-16 mg kg^{-1} (Adeoye and Agboola, 1985). The K status of the soil which was 0.1 cmol kg^{-1} also less than the critical level of 0.2 cmol kg^{-1} (Adeoye and Agboola, 1985).

Effective cation exchange capacity (ECEC) was 4.2 cmol kg^{-1}. Mechanical analysis of the soil revealed a sand fraction of 715 g kg^{-1}, silt 182 g kg^{-1}, and clay 103 g kg^{-1} respectively, classified as sandy loam according to the USDA classification.

Residual effects of almond-leaf compost and tillage on soil physical properties

Table 2 shows the residual effects of application of Almond leaves composted with swine, poultry and cattle manures under flat and ridge tillage on soil bulk density, total porosity, saturated hydraulic conductivity and aggregate stability. Plots treated with almond leaves composted with poultry manure under ridge tillage system significantly decreased soil bulk density (1.26 g cm^{-3}) and produced highest total porosity (51.13%), saturated hydraulic conductivity (22.01 cm hr^{-1}) and soil aggregate stability (1.32 g mm^{-1}). This shows that the application of Almond leaves composted with poultry manure under ridge tillage system has the potential to improve soil physical properties. Previous studies by Aggelides and Londra (2000), Nyakatawa et al. (2001); Arriaga and Lowry (2003) and Curtis and Claassen (2009) reported decreased soil bulk density and improved soil total porosity, saturated hydraulic conductivity and aggregate stability as a result of application of compost to soils. Adeli et al. (2010) reported that the application of broiler litter decreased soil bulk density and linearly increased soil aggregate stability compared to the Control. Also long term application (3 years) of poultry litter-yard waste compost in organic vegetable farm significantly improved soil bulk density, porosity, infiltration and water holding capacity (Evanylo et al*.,* 2008).

Residual effects of Almond-leaf compost and tillage on soil chemical properties

The residual effects of application of Almond leaves composted with swine, poultry and cattle manures under flat and ridge tillage on soil pH, soil organic carbon (SOC), N, P and K is presented in Table 3. Application of Almond leaves composted with poultry manure under the two tillage systems (F and R) significantly improved the soil pH (AP*F: 6.8 and AP*R: 6.9) followed by Almond leaves composted with cattle manure (AC*F: 6.0 and AC*R: 6.2). Plots treated with Almond leaves + poultry manure under the ridge tillage system significantly produced highest SOC (20.0 g kg^{-1}), N (2.7 g kg^{-1}), P (20.56 mg kg^{-1}), and K (0.28 cmol kg^{-1}). This was also followed by plots treated with Almond leaves and cattle manure under ridge tillage with 17.4 g kg^{-1}, 2.3 g kg^{-1}, 16.56 mg kg^{-1} and 0.20 cmol kg^{-1} for SOC, N, P and K, respectively. The results implies that the long term application of almond leaves composted with poultry or

Table 1. Chemical Properties and particle size distribution of soil used for the experiment.

Soil properties	Soil test value
pH (H_2O)	6.1
Organic Carbon (g kg^{-1})	9.5
Total Nitrogen (g kg^{-1})	1.5
Available Phosphorus (mg kg^{-1})	9
Exchangeable Cations (cmol kg^{-1})	
Ca	1.8
Mg	1.5
K	0.1
Na	0.4
Exchangeable Acidity (cmol kg^{-1})	0.5
Effective C.E.C (cmol kg^{-1})	4.2
Mechanical analysis (g kg^{-1})	
Sand	715
Silt	182
Clay	103
Textural Class (USDA)	Sandy Loam

Table 2. Residual effects of almond-leaf compost and tillage on soil physical properties (15 weeks after transplanting).

Treatment	Rate (t ha^{-1})	Soil bulk Density (g cm^{-3})	Soil total porosity (%)	Saturated hydraulic Conductivity (cm hr^{-1})	Soil mean weight diameter (g mm^{-1})
F	0	1.80a	31.10f	12.24d	0.85bc
NPK*F	0.25	1.61b	34.53e	12.66d	0.84c
AS*F	13	1.60b	38.88d	16.01c	0.97b
AP*F	14.5	1.43c	42.45c	16.65bc	1.06b
AC*F	14.3	1.56b	41.66c	16.04c	1.00b
R	0	1.50b	39.88cd	17.82bc	0.88c
NPK*R	0.25	1.43c	42.52c	18.05b	0.86c
AS*R	13	1.32bc	48.77b	18.45b	1.16a
AP*R	14.5	1.26c	51.13a	22.01a	1.32a
AC*R	14.3	1.30c	49.29b	20.86a	1.23a

Means with the same letter along the columns indicates no significant difference (P=0.05).
F: Flat R: Ridge AS: Almond leaves + swine manure, AP: Almond leaves + poultry manure, AC: Almond leaves + cattle manure.

cattle manures had effects on the soil chemical properties. This confirms previous studies (Ginting et al., 2003; Adeli et al., 2010; Baldi et al., 2010) that the application of compost has long term effects on soil chemical properties contributing to maintenance of soil quality by increasing the levels of soil N, P, K, pH and C. Furthermore, studies by Aggelides and Londra (2000), Angers and Eriksen-Hamel (2008), Veiga, et al. (2008) and Ewulo et al. (2011) revealed that soil tillage system influences the availability of soil nutrients. In this study, it is important to link the results of soil chemical properties such as SOC and N of plots treated with poultry manure under ridge tillage system (Table 3) with the improved soil physical properties produced by same treatment (Table 2).

Residual effects of Almond-leaf compost and tillage on growth and yield of pepper

Plant height

The height of pepper plants at 6, 8, 10 and 12 weeks after transplanting (WAT) is shown in Figure 1. The results reveal that at 12 WAT, the combined application of Almond leaves composted with poultry and cattle

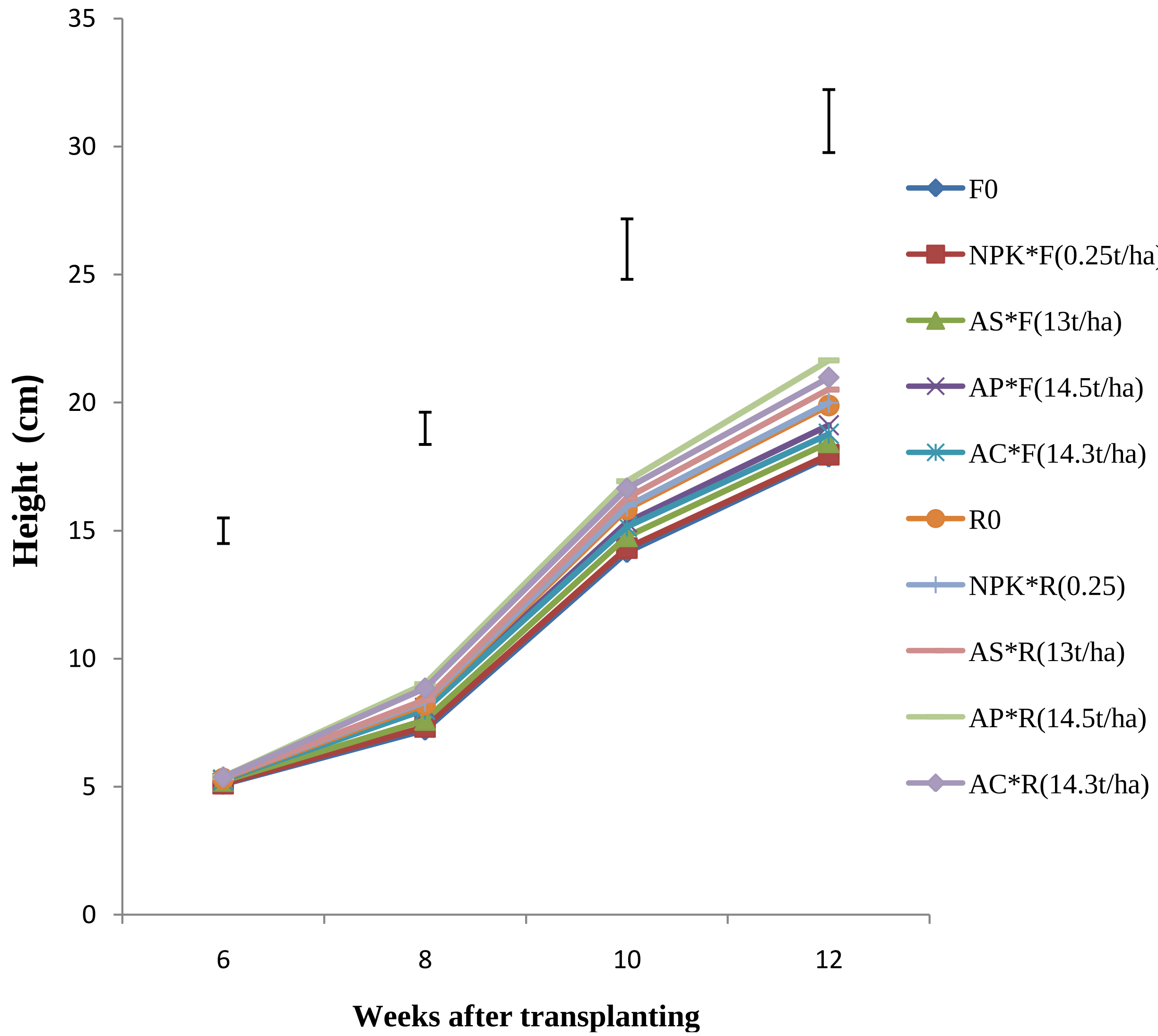

Figure 1. Residual effects of almond-leaf compost and tillage on plant height of pepper.
F0: Flat tillage system, R0: Ridge tillage system, AS: Almond leaves + swine manure, AP: Almond leaves + poultry manure, AC: Almond leaves + cattle manure.

Table 3. Residual effects of almond leaf compost and tillage on soil chemical properties.

Treatment	Rate (tha^{-1})	pH (H_2O)	SOC ($g\ kg^{-1}$)	N ($g\ kg^{-1}$)	P ($mg\ kg^{-1}$)	K ($cmol\ kg^{-1}$)
F	0	5.9bc	4.9d	0.1e	5.65e	0.04e
NPK*F	0.25	5.2d	8.5c	2.0cd	10.23d	0.09dc
AS*F	13	5.7c	13.1c	2.0cd	12.62cd	0.11c
AP*F	14.5	6.8a	16.5b	2.3b	16.05b	0.16b
AC*F	14.3	6.0b	16.0b	2.1c	14.35c	0.12c
R	0	5.6c	9.6c	0.9e	9.86d	0.09dc
NPK*R	0.25	5.4c	13.0c	2.0cd	13.22c	0.16b
AS*R	13	5.4c	16.6b	2.0cd	15.08b	0.19b
AP*R	14.5	6.9a	20.0a	2.7a	20.56a	0.28a
AC*R	14.3	6.2b	17.4b	2.3b	16.56b	0.20b

Means with the same letter along the columns indicates no significant difference (P=0.05). F: Flat R: Ridge AS: Almond leaves + swine manure, AP: Almond leaves + poultry manure, AC: Almond leaves + cattle manure.

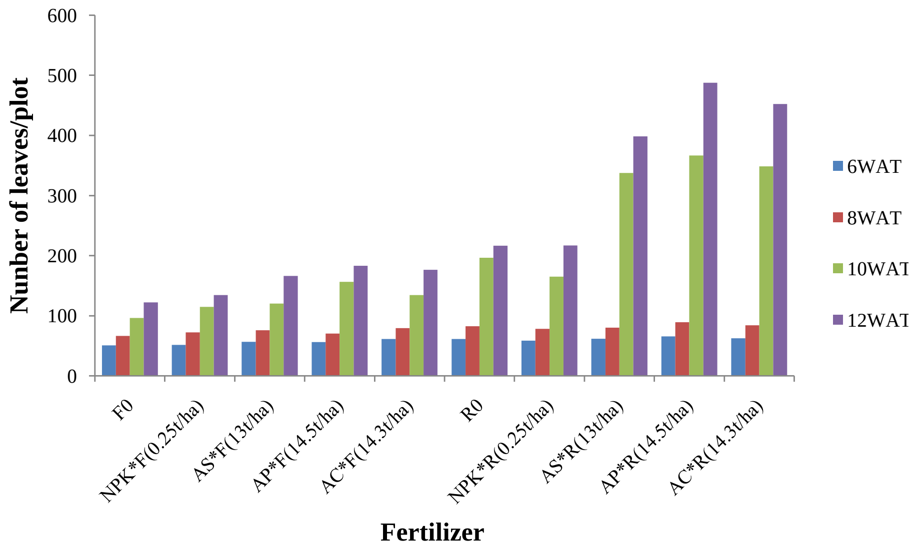

Figure 2. Residual effects of almond-leaf compost and tillage on number of leaves of pepper plants.
F0: Flat tillage system, R0: Ridge tillage system, AS: Almond leaves + swine manure, AP: Almond leaves + poultry manure, AC: Almond leaves + cattle manure.

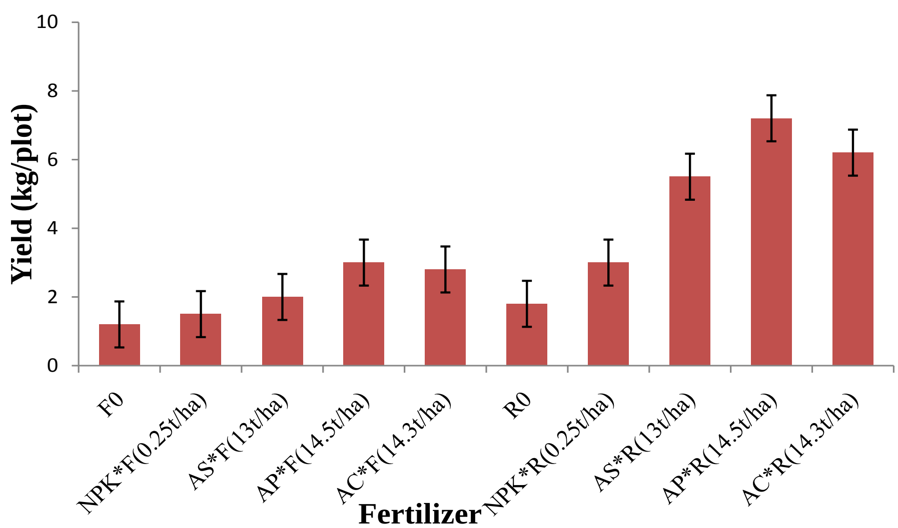

Figure 3. Residual effects of almond-leaf compost and tillage on fruit yield of pepper.
F0: Flat tillage system, R0: Ridge tillage system, AS: Almond leaves + swine manure, AP: Almond leaves + poultry manure, AC: Almond leaves + cattle manure.

manures under ridge tillage systems (AP*R) significantly increased plant growth (21.6 cm) followed by AC*R (20.9 cm) and AS*R (20.52). Control plots (F0 and R0) had heights of 17.9 cm and 19.9 cm, respectively.

Number of leaves

Figure 2 shows that at 12 WAT, highest number of leaves (488) were recorded in plots treated with AP*R followed by AC*R (452) and AS*R (398). The number of leaves recorded from the control plots (F0 and R0) were 122 and 216, respectively.

Fruit yield

The results on the residual effects of Almond leaves composted with swine, poultry and cattle manure on fruit yield of pepper under flat and ridge tillage systems is shown in Figure 3. The results reveal that plots treated with AP*R significantly produced highest fruit yield (7.2

kg/plot) followed by plots treated with AC*R and AS*R with yield of 6.2 kg and 5.5 kg/plot, respectively. Fruit yield of 1.2 and 1.8 kg/plot was record from the Control plots (F0 and R0, respectively).

The best performance of pepper plants in terms of vegetative growth and yield as observed in plots treated with Almond leaves composted with poultry manure under ridge tillage system (AP*R) can be attributed to improved soil condition (total porosity and saturated hydraulic conductivity (Table 2) and improved N uptake provided by the same treatment (Table 3). Adequate N is required for optimum growth, development and yield of pepper (Aminifard et al., 2012). Agele (2010) reported that increases in N uptake and utilization efficiencies in crops through management practices would reduce quantity of fertilizer requirements without deleterious effects on crop yield. In semi-arid tropics of Nigeria, over two years cropping seasons, the application of poultry manure significantly increased growth and yield of pepper compared to mineral nitrogen fertilization (Aliyu, 2000).

The significant fruit yield of pepper on Alfisols under ridge tillage system in this study agrees with the report of Samuel and Ajav (2010) that soil tillage (Plough-Ridge Till – PRT) is required for optimum production of pepper in Alfisol of South-western Nigeria. In another study (Ewulo et al., 2011) in South-west Nigeria, Tillage plus mulching significantly increased the growth and yield of pepper.

Conclusion

The results from this study reveals that Almond leaves composted swine, poultry and cattle manures under ridge tillage system had significant effect on performance of pepper and on soil properties. Plots treated with Almond leaves composted with poultry manure under ridge tillage system (AP*R) at 14.5 t ha^{1} significantly improved soil chemical properties (SOC, N, P and K) and also produced pepper plants with best performance in terms of growth and yield. Therefore, for improved soil properties and optimum yield of pepper for Alfisols in the study area, AP*R at 14.5 t ha^{-1} is recommended.

Microbiological and physico-chemical analysis of Almond leaves composted with poultry, swine and cattle manures before application to the soil is suggested for further studies. In addition, to improve and validate the findings in this study, it is suggested that seasonal variations in weather and climatic conditions should be incorporated in further studies.

REFERENCES

Adeli A., Tewolde H., Sistani K. & Rowe D. (2010). Comparison of broiler litter & commercial fertilizer at equivalent N rates on soil properties. Communications in Soil Science and Plant Analysis. 41(20):2432-2447.

Adeoye G. O. & Agboola A. A. (1985). Critical levels for soil pH, available P, K, Zn and maize ear leaf content of P, Cu and Mn in sedimentary soils of South Western Nigeria. Fert. Res. 6:65-71

Afolayan S. O., Oladapo M. O. Olaosebikan F. O. & Muibi E. F. (2010). Effects of tillage systems and four fertilizer rates on growth parameters and fruit yield of okra (*Abelmoscus esculentus*) and pepper (*Capsicum annum*). World J. Agric. Sci. 6(1):23-28.

Agele S. (2010). Dynamics of soil properties, soil fauna activity, pepper nutrition and fruit yield under plantain based intercropping system in a humid rainforest environment. Arch. Agron. & Soil Sci. 56(3):265-283.

Aggelides S. M., & Londra P. A. (2000). Effects of compost produced from town wastes and sewage sludge on the physical properties of a loamy and a clay soil. Bioresour. Technol. 71(3):253-259.

Aguilar-Meléndez A., Morrell P. L., Roose M. L. & Kim S. C. (2009). Genetic diversity and structure in semiwild and domesticated chiles (*Capsicum annuum*; Solanaceae) from Mexico. Am. J. Bot. 96(6):1190-1202.

Ajjapplavara P. S. (2009). Genetic diversity in chilli (*Capsicum annuum* L.). Asian J. Horticult. 4(1):29-31.

Aliyu, L. (2000). Effect of organic and mineral fertilizers on growth, yield and composition of pepper (*Capsicum annuum* L.). Biol. Agric. & Horticult. 18(1):29-36.

Aminifard M. H., Aroiee H., Nemati H., Azizi M. & Khayyat M. (2012). Effect of nitrogen fertilizer on vegetative and reproductive growth of pepper plants under field conditions. J. Plant Nutr. 35(2):235-242.

Angers, D. A., & Eriksen-Hamel N. S. (2008). Full-inversion tillage and organic carbon distribution in soil profiles: A meta-analysis. Soil Sci. Soc. Am. J. 72(5):1370-1374.

Antonious G. F., Berke T., & Jarret R. L. (2009). Pungency in *Capsicum chinense*: Variation among countries of origin. J. Environ. Sci & Health Part B 44(2):179-184.

Arriaga F. J. & Lowery B., (2003). Soil physical properties and crop productivity of an eroded soil amended with cattle manure. Soil Sci. 168(12):888-899.

Baldi E., Toselli M., Marcolini G., Quartieri M., Cirillo E., Innocenti A. & Marangoni B. (2010). Compost can successfully replace mineral fertilizers in the nutrient management of commercial peach orchard. Soil Use Manage. 26(3):346-353.

Berke T., Black L. L., Talekar N. S., Wang J. F., Gniffke P., Green S. K., & Morris R. (2005). Suggested cultural practices for chili pepper. AVRDC pub, 05-620.

Bouyoucos, G. H. (1951). A rehabilitation of the hydrometer method for making mechanical analysis of soils. Agron J. 43:434-438.

Bremner J. M. & Mulvancy C. S. (1982). Total nitrogen. In: Page, A.L et al. (Eds), Methods of soil analysis part 2, Agron Monogr. 9 (2nd edition) ASA & SSSA, Madison, Wsc, pp. 403-430.

Chatterjee N., Flury M., Hinman C. & Craig G. C. (2013). Chemical and physical characteristics of compost leachates: A review. Department of Crop and Soil Sciences: Washington State University. 54p.

Cheng P., Yanling C., Shaobo D., Xiangyang L., Guangwei H., & Ruan R. (2010). Utilization of almond residues. Int. J. Agric & Biol. Eng. 3(4):1-18.

Curtis M. J. & Claassen V. P. (2009). Regenerating topsoil functionality in four drastically disturbed soil types by compost incorporation. Restorat. Ecol. 17(1):24-32.

Dagnoko S., Yaro-Diarisso N., Sanogo P. N., Adetula O., Dolo-Nantoumé A., Gamby-Touré K. & Diallo-Ba D. (2013). Overview of pepper (*Capsicum* spp.) breeding in West Africa. Afr. J. Agric. Res. 8(13):1108-1114.

Darcy H. (1856). Les fontaines publiques de la ville de Dijon: Exposition et application des principes a suivre et des formules a employer dans les questions de distribution d'eau; ouvrage terminé par un appendice relatif aux fournitures d'eau de plusieurs villes au filtrage des eaux et a la fabrication des tuyaux de fonte, de plomb, de tole et de bitume. Libraire des Corps imperiaux des ponts et chaussées et des mines, Paris 647p.

Eghball B., Ginting D. & Gilley J. E. (2004). Residual effects of manure and compost applications on corn production and soil properties. Agron. J. 96(2):442-447.

Enwenzor W. O., Udo E. J., Usoroh N. J., Ayotade K. A., Adepetu J. A., Chude U. O. & Udegbe C. J. (1979). Fertilizer use and management practices for crops in Nigeria (series No 21) produced by fertilizer procurement and distribution division of the Federal Ministry

of Agriculture, Water Resources and Rural Development, Lagos.
Evanylo G., Sherony C., Spargo J., Starner D., Brosius M., & Haering K. (2008). Soil and water environmental effects of fertilizer-, manure-, and compost-based fertility practices in an organic vegetable cropping system. Agric. Ecosyst. & Environ. 127(1):50-58.
Ewulo B. S., Ojeniyi S. O., & Morenikeji C. I. (2011). Tillage and mulch influence on soil physical properties, plant nutrient composition and performance of pepper (*Capsicum annum* L) and sorghum (*Sorghum bicolor* L). Int. Res. J. Agric. Sci. & Soil Sci. 1(11):485-490.
Ginting D., Kessavalou A., Eghball, B. & Doran J. W. (2003). Greenhouse gas emissions and soil indicators four years after manure and compost applications. J. Environ. Quality. 32:23–32.
Govindarajan V. S. & Uwe J. S. (1985). *Capsicum*-production, technology, chemistry, and quality part 1: History, botany, cultivation, and primary processing, C R C Crit. Rev. Food Sci. & Nutr. 22(2):109-176.
Grubben G. J. H. & Tahir, I. M. (2004). *Capsicum* species, p. 154–163. In: G. J. H. Grubben & O. A. Denton (eds.). Plant resources of tropical Africa 2, Vegetables. PROTA Foundation, Wageningen, The Netherlands. Retrieved from http://www.prota4u.org/protav8.asp
Hartge, K. H., & Horn, R. (1989). Die physikalische Untersuchung von Böden(Vol. 2). Stuttgart: Enke.
Idowu-Agida O. O., Ogunniyan D. J., Ajayi E. O. (2012). Flowering and fruiting behavior of long Cayenne pepper (*Capsicum frutescens* L.). Int. J. Plant Breed. Genet. 6(4):228-237.
Inbaraj B. S., & Sulochana N. (2006). Mercury adsorption on a carbon sorbent derived from fruit shell of *Terminalia catappa*. J. Hazard. Mater. 133(1):283-290.
Kemper F. J & Rosenau G., (1986). Soil mean weight diameter determination (Wet sieve tec). In: A. L. Page, R. H. Miller & D. R. Keeney (Eds). Methods of soil analysis. Part 2. Agronomy 9, (2nd edn). American Society of Agronomy, Madison, USA. pp. 539-579.
Khan, H. A., Ayub, C. M., Pervez, M. A., Bilal, R. M., Shahid, M. A., Ziaf, K. (2009). Effect of seed priming with NaCl on salinity tolerance of hot pepper (*Capsicum annum* L.) at seedling stage. Environ. Exp. Bot. 60:77- 85
Klute A., & Dirksen C. (1986). Hydraulic conductivity and diffusivity: Laboratory methods. Methods of soil analysis: Part 1—Physical and Mineralogical Methods, (methodsofsoilan1), 687-734.
Mehlich A. (1984). Mehlich 3 soil test extractant: A modification of Mehlich 2 extractant. Commun. Soil Sci. Plant Anal. 15(12):1409-1416.
Moody J. O., Segun F. I., Aderounmu O., & Omotade O. O. (2004). Antisickling activity of *Terminalia catappa* leaves harvested at different stages of growth. Niger. J. Nat. Products & Med. 7(1):30-32.
Nelson D. W. & Sommers L. E. (1982). Total carbon, organic carbon and organic matter. In: A. L. Page, R. H. Miller & D. R. Keeney (eds). Methods of soil analysis. Part 2. Agronomy 9, (2nd edn). American Society of Agronomy, Madison, USA. pp. 539-579.
Nwosu, F. O., Dosumu, O. O., & Okocha, J. O. C. (2008). The potential of *Terminalia catappa* (Almond) & Hyphaene thebaica (Dum palm) fruits as raw materials for livestock feed. Afr. J. Biotechnol. 7(24).
Nyakatawa E. Z., Reddy K. C., & Sistani K. R. (2001). Tillage, cover cropping and poultry litter effects on selected soil chemical properties. Soil Tillage Res. 58(1):69-79.
Ogunbo M. M., Ayinde I. A., Afolami C. A., & Banmeke T. O. A. (2015). Technical efficiency of pepper production under tropical conditions. Int. J. Veg. Sci. 21(1):21-27.
Olowokere F. A. & Tijani-Eniola H. (2013). Pepper response to inorganic and organomineral fertilizers in Southwestern Nigeria. Commun. Soil Sci. & Plant Anal. 44(6):1127-1139.
Orobiyi A., Dansi A., Assogba P., Loko L. Y., Dansi M., Vodouhè R., Akouègninou A. & Sanni A. (2013). Chili (*Capsicum annuum* L.) in southern Benin: Production constraints, varietal diversity, preference criteria and participatory evaluation. Int. Res. J. Agric. Sci. Soil Sci. 3(4):107-120.
Samuel T. M., & Ajav E. A. (2010). Optimum tillage system for pepper production in an alfisol of South-western Nigeria. Afr. J. Agric. Res. 5(19):2647-2652.
Smyth A. J. & Montgomery R. F. (Eds) (1962). Soils and Land use in central Western Nigeria. The govt. of western Nig. Ibadan. 50p.
Sobulo R. A. & Adepetu J. A, (1987). Soil testing and fertilizer formulation of crop production in Nigeria. In: Proceedings of the National Fertilizer Seminar, Portharcourt , Nigeria, 28-30 October, 1987, 93-105.
van Bemmelen J. M. (1890). Über die Bestimmung des Wassers, des Humus, des Schwefels, der in den colloïdalen Silikaten gebundenen Kieselsäure, des Mangans u.s. w. im Ackerboden. Die Landwirthschaftlichen Versuchs-Stationen 37: 279–290.
Veiga M. D., Reinert D. J., Reichert J. M. & Kaiser D. R. (2008). Short and long-term effects of tillage systems and nutrient sources on soil physical properties of a southern Brazilian Hapludox. Revista Brasileira de Ciência do Solo. 32(4):1437-1446.
Wang D. & Bosland P. W. (2006). The genes of *Capsicum*. Hort. Sci. 41(5):1169-1180.
Yuh-minghuang (2005). Composting methods. Food and Fertilizer Technology Center for the Asian & Pacific Region.
Zhang Y., & He Y. (2006). Co-composting solid swine manure with pine sawdust as organic substrate. Bioresour. Technol. 97(16):2024-2031.
Zhani K., Hermans N., Ahmad R. & Hannachi, C. (2013). Evaluation of salt tolerance (NaCl) in Tunisian chili pepper (*Capsicum frutescens* L.) on growth, mineral analysis and solutes synthesis. J. Stress Physiol. & Biochem. 9(1):209-228.