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Research Article

Effects of Almond leaf-based compost on Soil properties and Yield of Pepper (*Capsicum chinense* Jacq.) In Ibadan Nigeria

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Abstract: Almonds are deciduous trees which generate a lot of nutrient-rich leaves. Direct utilisation of the leaves as organic manure is hampered by its high C:N ratio which impedes decomposition. Although composting is used to speed up decomposition of organic materials, information on the effects of almond leaf-based compost on soil properties and yield of *Capsicum chinense* is limited. Therefore study were conducted in 2010 and 2011 to evaluate the effects of *almond leaf-based* compost on soil properties and yield of pepper (*Capsicum chinense*) in Ibadan, Nigeria. Two 1:1 (w/w) Almond leaf- based compost types (Almond leaves + Poultry manure (AP, 3.1 g/kg P); Almond leaves + Swine manure (AS, 2.3 g/kg P) were prepared following standard procedures. In the screenhouse, effects of 9 P fertilizer treatments: AP (9.7, 12.1, and 14.5 t/ha); AS (13.0, 16.3, and 19.6 t/ha) and NPK 15-15-15 (0.2, 0.25 and 0.3 t/ha) and a control (without fertilizer) on the growth and fruit yield of pepper was investigated. Treatments were each mixed with 5 kg soil in pots and the experiment arranged in a completely randomised design with four replications. The effects of four treatments: AP (14.5 t/ha), AS (13.0 t/ha), NPK (0.25 t/ha) and a control selected from the screenhouse experiment were investigated in the field. The four treatments were laid as randomized complete block design with four replications. Data were collected on shoot dry matter yield (SDMY), number of fruits (NF) and fruit yield (FY) of pepper. Soil samples were collected and analyzed for changes in nutrient content, porosity, bulk density (BD), temperature and pH.. Data were analyzed using descriptive statistics and ANOVA at $\alpha_{0.05}$. In the screenhouse, significant differences were observed for SDMY and FY of pepper. The SDMY ranged from 1.2±0.6 (control) to 2.9±1.8 g/pot (AP, 14.5 t/ha). The FY ranged from 44.5±1.7 (control) to 60.2±3.5 g/pot (NPK, 0.25. t/ha). The FY increased in the order of AS (13.0 t/ha) < AP (14.5 t/ha) < NPK (0.25 t/ha). In the field, significant differences were not observed for soil pH, C, N, P and K among the treatments investigated. However, the soil pH recorded under AP (6.3±0.1) and AS (6.0±0.1) was significantly higher than NPK fertilizer (5.6±0.1) by 12.5 and 7.1% respectively. While the values of Ca (12.5.±0.7 cmol/kg) and Mg (3.2±0.2 cmol/kg) recorded under AP (14.5 t/ha) were higher than AS and NPK treatments respectively. The SP was increased in the order of AS (51.4±2.7%) < AP (52.4±2.8%) < NPK (52.8±2.5%). The SP and BD were not significantly different under compost and NPK treatments. The soil temperature was lowered under AP (28.1±0.1°C) than under NPK (28.5±0.2°C) and AS (29.1±0.2°C) respectively. The NF increased in the order of AS (13.0 t/ha) < AP (14.5 t/ha) < NPK (0.25 t/ha). Relative to the control; AS, AP and NPK significantly increased FY of pepper by 85, 96 and 111% respectively. There were no statistical significant different with respect to FY of pepper under the application of NPK (5.7±0.8 t/ha) and AP (5.3±0.7 t/ha) respectively. However, an application of 14.5 t/ha almond leaf-poultry manure compost performed better than AS (13.0 t/ha) and comparable to NPK fertilizer in fruit yield and therefore recommended for pepper production in Ibadan.
Keywords: Compost manure, Almond leaves, Pepper fruit yield.

1. INTRODUCTION

Pepper is the world's second most important vegetable crop after tomato (Yoon *et al.*, 1989). It accounts for about 20% of the average vegetable consumed per person per day in Nigeria (Alegbejo, 2002). They are widely cultivated for their fruits. The fruits constitute an important source of vitamin A, C and E (Ewulo *et al.*, 2007). Above all, it is a source of income for the farmers because it commands high market value especially during the dry season. In view

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of this, adequate nutrients should be supplied to the crop (pepper) in order to increase its production (Peck and MacDonald, 1975).

A major constraint to crop production in Nigeria, including pepper is low soil fertility, which depends largely on soil organic matter that is subject to high rate of mineralization and loss. Hence, the success of pepper production depends largely on high application rates of mineral fertilizers to maximize yields (Agele *et al.*, 2007). Various studies have shown the potential of mineral fertilizer for increased growth and yield of crops (Saxena *et al.*, 1975; Olaniyan *et al*., 2005; Awodun *et al.*, 2007). Nevertheless, the use of mineral fertilizers to enhance crop yield has not been sustainable in Nigeria. Among the reasons for this, are the high cost and lack of accessibility (Scholberg *et al.*, 2000). Even where available and affordable, the continuous use has been reported to result into other problems such as soil acidity, nutrient imbalance and loss of soil organic carbon (Adediran and Banjoko, 2003; Osundare, 2004). This underscores the need to formulate a fertilizer package that will be environment friendly, available and maintain sustainable soil productivity for crop (pepper) production in Nigeria.

There is a worldwide interest in the use of compost to supply nutrients to crops. Several workers have shown the potential of raw organic wastes to improve the soil properties and yield of crops (Ojeniyi and Adejobi, 2002; Alabi, 2006; Ewulo *et al.*, 2007). Their applications to the soil also have residual effects on soil properties and yield of crops (Adeniyan and Ojeniyi, 2003; Adenawoola and Adejoro, 2005; Akanni and Ojeniyi, 2008). However, organic wastes such as almond leaves and animal manure, in their raw form might not be suitable for direct application to the soil owing to their environmental implications and pathogenic content. Processing of these wastes through composting reduces the bulk and odour while increasing their nutrient values (Parr *et al.*, 1986), destroy weed seeds, kills pathogens and break down phytotoxic compounds contained in the compost (Pace *et al.*, 1995). It is a natural process of maintaining soil fertility status with little or no adverse effects on the soil and environment. Composting of leaf litters of almond with animal manure could enhance their rate of decomposition for optimum mineralization for plant use.

Almond (*Terminalia catappa* Linn) trees are abundantly found in major cities, towns and villages in Southern part of Nigeria. They are commonly planted for their shade and edible nuts (Bola *et al.*, 2008). However, the leaves generated by the deciduous nature of almond trees constitute environmental problem. In addition, attempt to dispose of the leaves through open incineration constitutes environmental pollution. The high C: N content of the leaves immobilizes soil nutrients when incorporated raw into the soil. Also, mulching with the leaves may have no direct nutrient effects on crop performance as they take a very long time to decompose in the soil (Aiyelari *et al.*, 2011). However, dropped leaves of almond trees are naturally endowed with soil nutrients that can be made available to crops through composting. Leaf litter of almond trees, when burnt produces gases which are detrimental to human health and the environment. Effects of concentration of these greenhouse gases in the atmosphere over time is global warming which could result to outbreak of agricultural pests and diseases, wild fire, sharp decline in crop yields, famine and starvation (Preston and Leng, 1989; Stefan, 2006). Therefore, application of almond leaf-based compost could provide an alternative and safer way of handling the wastes in the environment. This will likely be an efficient soil management practice for carbon sequestration, thus improving soil physical, chemical and biological conditions for enhanced pepper performance. Therefore effects of almond leaf-based compost on soil properties and yield of pepper were evaluated in Ibadan.

2.0 MATERIALS AND METHODS

2.1The Study Area

The experiment was carried in Ibadan which is located in the Southwest of Nigeria between latitudes $7^{\circ}\ 25^{1}$ and $7^{\circ}\ 31^{1}$ N and longitudes $3^{\circ}\ 51^{1}$ and $3^{\circ}\ 56^{1}$ E in the Rainforest Zone. The soil of the area is Alfisol according to the USDA classification. It is formed from Basement Complex rocks. It is classified locally as Iwo series (Smyth and Montgomery, 1962). The soil of the experimental site has been exhaustively cropped with maize, cassava and vegetables over the years.

2.2 Compost Preparation

Two types' 1:1(w/w) almond leaf-based compost types: Almond leaves + Poultry manure (AP) and Almond leaves + Swine manure compost (AS) was composted in 2009, under a shed located behind the Department of Agronomy, University of Ibadan using a static pile method.

2.3 Screenhouse Studies

The screenhouse experiment was conducted in the screenhouse located behind the Department of Agronomy, University of Ibadan, between March and July, 2010. Effects of nine fertilizer treatments: AP at 9.7, 12.1, and 14.5 t/ha; AS at 13.0, 16.3, and 19.6 t/ha; NPK 15-15-15 at 0.2, 0.25, and 0.3 t/ha and a control (without fertilizer) on the shoot dry matter and fruit yield of *Capsicum chinense* were investigated in the screenhouse. The rate for various compost mixtures was fixed based on P requirements for pepper (20 kg P/ha, NIHORT, 1986) in South western, Nigeria. The P varied in the mature compost accounted for the different rates. Each was mixed with 5 kg soil in pots and the experiment arranged in a completely randomised design with four replications. Soils used for the screenhouse experiment were those collected from the experimental site at the Teaching and Research Farm along the Botanical Garden, University of Ibadan. There were two pots per treatments and 20 pots per replicates. Each of the treatment were thoroughly mixed with 5.0 kg of soil in pots. One seedlings of *Capsicum chinense* was transplanted into each pot at 4 WAS in the nursery, a week after treatments application to enhance mineralization.

2.4 Field Studies

The field experiment was carried out between March and July, 2011 at the Teaching and Research Farm along the Botanical Garden, University of Ibadan. The field was manually cleared, measured and pegged. The size of each plot was 3.0 x 4.0 m (12m2) with plant spacing of 60 x 60 cm. The plant population was 27,778 plants / ha or 33 plants /plot.

The performances of the best rates in each treatment: AP (14.5 t/ha), AS (13.0 t/ha), NPK (0.25 t/ha) and control from screenhouse studies were investigated. The Four treatments were laid as randomised complete block design with four replications.

Pepper seedlings were transplanted at 4 WAS. Almond leaf-based compost treatments were applied using ring method a week after transplanting while NPK 15-15-15 was applied using ring method 2 WAT.

2.5 Plant Analysis

The initial materials (almond leaves, poultry manure, swine manure and cattle manure were analysed for C, N, P, K, Ca and Mg. At maturity the compost was air-dried. Five samples were taken in each of the compost types, milled and sieved with 0.5 mm wire mesh and subjected to chemical analysis. Carbon was determined by ash method using furnace. Nitrogen was determined using Micro-Kjeldahl procedure (IITA, 1975). The mixture of concentrated nitric, perchloric and sulphuric acid in a ratio of 25:4:2 respectively were used to digest 0.5 g of each sample. Phosphorus was determined using Vanadomolybdate yellow colorimetry method (Jackson, 1962). Potassium was determined by flame photometry. Calcium and magnesium was measured with Atomic Absorption Spectrophotometer (Okalebo *et al.*, 1993).

2.6 Soil Analysis

Ten soil samples were randomly collected (0-15 cm) using auger before planting in the field. Samples were air dried, crushed and passed through 2 mm wire mesh for the determination of pH, P, K, Ca, Mg and Na . The soil pH was determined on pH meter using 1:1 soil: water ratio. Phosphorus was determined by Bray P1 method and colour was developed in soil extracts using the ascorbic and acid blue method (Murphy and Riley, 1962). Exchangeable K, Ca, Mg and Na were determined by neutral ammonium acetate extraction method. Potassium and Na concentration in the extract were determined using the flame photometer; while Ca and Mg were determined by atomic absorption spectrophotometer (Okalebo *et al.*, 1993). Organic carbon and total N was determined from the soil sieved with 0.5 mm wire mesh. Soil organic carbon was determined using the Walkley-Black oxidation method (Nelson and Sommers, 1982). Total N was also determined using the Macro kjeldahl procedure (Bremner and Mulvancy, 1982). Particle size analysis was determined using Bouyoucous hydrometer method (Bouyoucous, 1962).

2.7 Data Collection

Data were collected on Plant Height, Number of Leaves, Number of Branches, Stem Girth and Root Length of pepper using ten plants per plant at 12 weeks after transplanting in the field, Plant height was taken from the ground level to the tip of the plant, using a measuring tape, stem girth was measured round the stem with a rope from the ground level while root length of pepper was taken from four plants per plot in each replicate. Each of the pepper plant was uprooted and the main root was measured using a measuring tape. Average fruits weights were determined weekly using weighing balance.

2.8 Chemical Properties of the Soil:

This was determined at 15 weeks after transplanting from five locations per plot per replicate and analysed as described in 2.7.

2.9 Physical Properties of the Soil (0-15 Cm):

This was determined at 15 WAT in five different locations per plot. Soil bulk density was determined by core method (Blake and Hartage, 1986). Total porosity was calculated from bulk density using a particle density of 2.65 Mg m^{-3} (Arshad *et al.*, 1996). Soil temperature was determined using a Glass bulb soil thermometer at 3.00 pm, Nigeria time.

2.10 Stastistical Analysis

The data collected were analysed using descriptive stastistics and ANOVA. The significant difference among the treatment means were separated using DMRT at 5% level of probability.

3.0 RESULTS

Table 3.1 shows the physico-chemical analysis of the soil before planting. The result revealed that the sandy loam soil had pH (6.1), SOC (7.3 g/kg), Total N (0.9 g/kg) and Available P (8 mg/kg). The exchangeable cation of the soil had Ca (1.8 cmol/kg), Mg (1.5 cmol/kg), K (0.1 cmol/kg) and Na Ca (0.1 cmol/kg), while the EA and CEC of the soil gave 0.5 and 4.3 cmol/kg respectively. The micro nutrients content of the soil such as Fe, Cu, Mn and Zn was 5.0, 4.0, 3.0 and 3.0 respectively. The analysis of the soil also gave 1.7 Mg $/m^3$ and 34.7% bulk density and soil porosity respectively.

Table 3.2 shows the results of chemical analysis of the organic wastes before composting. The carbon contents decreased in the order: almond leaves (397 g kg^{-1}) > poultry manure (150.0 g kg^{-1}) > swine manure (112.5 g kg^{-1}). The N status increased in the order: almond leaves (4.0 g kg^{-1}) < swine manure (10.5 g kg^{-1}) < poultry manure (15.2 g kg^{-1}). Carbon-nitrogen (C: N) ratio increased in the order of poultry manure (9.9) < swine manure (10.7) < almond leaves (99.3). The P content increased in the order: almond leaves (0.9 g kg^{-1}) < swine manure (1.1 g kg^{-1}) < poultry manure (3.4 g kg^{-1}). The K increased in the order: poultry manure (5.9 g kg^{-1}) < almond leaves (8.1 g kg^{-1}) < swine manure (14.2 g kg^{-1}) respectively. The Ca increased in the order of almond leaves (36.2 g kg^{-1}) < poultry manure (37.0 g kg^{-1}) < swine manure (39.2 g kg^{-1}) . The Mg increased in the order: almond leaves (1.5 g kg^{-1}) < poultry manure (2.5 g kg^{-1}) < swine manure (17.0 g kg^{-1}).

Table 3.3 shows the chemical compositions of the almond leaves after composting. The carbon increased in the order: AS (114.9 g kg^{-1}) < AP (120.7 g kg^{-1}). The compost N increased in the order: AS (5.2 g kg^{-1}) < AP (5.7 g kg^{-1}). The C: N increased in the order: AP (21.1) < AS (22.0). The P content in the compost increased in the order: AS (2.3 g kg^{-1}) < AP (3.1 g kg^{-1}). The K content increased in the order: AS (2.6 g kg^{-1}) < AP (3.9 g kg^{-1}) . The Ca increased in the order: AS (6.0 g $kg^{-1)}$ < AP (14.4 g kg^{-1}). The Mg was also increased in the order: AS (2.6 g kg^{-1}) < AP (3.9 g kg^{-1})

Table 3.4 Effects of almond leaf-based compost on shoot dry matter yield at 18 WAT of pepper in the screenhouse. All the fertilizer treatments significantly increased (p < 0.05)) shoot dry matter yield of pepper. Relative to the control; AP (9.7, 12.1 and 14.5 t/ha), AS (13.0, 16.3 and 19.6 t/ha) and NPK (0.2, 0.25 and 0.3 t/ha) increased shoot dry matter by 133, 117,142,, 117, 125, 83, 117 and 117 respectively. The shoot dry matter (SDM) increased in the order 0.25 t/ha, NPK (2.6 g/pot) < 13.0 t/ha, AS (2.8 g/pot) < 14.5 t/ha, AP (2.9 g/pot) < 14.3 t/ha.

Table 3.5 shows effect of almond leaf-based compost on fruit yield of pepper in the screenhouse. Relative to the control; AP (9.7, 12.1 and 14.5 t/ha), AS (13.0, 16.3 and 19.6 t/ha) and NPK (0.2, 0.25 and 0.3 t/ha) significantly increased (P < 0.05) number of fruit by 38.5, 52.9, 75.9, 80.8, 71.2, 36.5, 61.5, 55.8, 56.7, 48.1, 77.9 and 49.0% respectively. However, AP rates increased fruit yield in the order 9.7 t/ha, AP (51.7 g/pot) < 12.1 t/ha, AP (53.6 g/pot) < 14.5 t/ha, AP (57.0 g/pot); AS rates increased fruit yield in the order 19.6 t/ha, AS (54.5 g/pot) < 16.3 t/ha, AS (55.3 g/pot) < 13.0 t/ha, AS (56.2 g/pot) and NPK rates increased fruit yield in the order 0.2 t/ha, NPK (51.3 g/pot) < 0.3 t/ha, NPK (55.1 g/pot) < 0.25 t/ha, NPK (60.2 g/pot).

Table 3.1 Physico-chemical properties of the soil of the experimental site

Soil Properties	Soil test value
pH 1:1 (H_2O)	6.1
SOC (g/kg)	7.3
Total N (g/kg)	0.9
Available P (mg/kg)	8
Exchangeable cation (cmol/kg)	
Ca	1.8
Mg	1.5
K	0.1
Na	0.4
Effective CEC (cmol/kg)	4.3
Extractable micronutrients (mg/kg)	
Fe	5.0
Cu	4.0
Mn	3.0
Zn	3.0
Bulk density (Mg/ M^3)	1.7
Total porosity (%)	34.7
Mechanical analysis (g/kg)	
Sand	712
Silt	180
Clay	108
Textural class	Sandy loam

Table 3.2 Chemical properties of raw organic material before composting

*Organic material	C (g / kg)	N (g / kg)	C:N	P (g / kg)	K (g / kg)	Ca (g / kg)	Mg (g / kg)
A	397.0	4.0	99.0	0.9	8.1	36.2	1.5
P	150.0	15.2	10.0	3.4	5.9	37.0	2.5
S	112.5	10.5	11.0	1.1	14.2	39.2	17.0

*A= Almond leaves; P = Poultry manure; S = Swine manure

Table 3.3 Chemical composition of almond leaves after composting

*Organic material	C (g / kg)	N (g / kg)	C:N	P (g / kg)	K (g / kg)	Ca (g / kg)	Mg (g / kg)
AP	120.7	5.7	21.0	3.1	3.9	14.4	3.9
AS	115.2	5.2	22.0	2.3	2.6	6.0	2.6

*AP = Almond leaves + Poultry manure; AS = Almond leaves + Swine manure

Table 3.4 Effects of almond leaf-based compost on shoot dry matter yield at 18 WAT of pepper in the screenhouse

Treament*	Rate (t/ha)	Shoot dry matter yield g /pot	% increase in shoot dry matter yield
Control	0	1.2 b	0
AP	9.7	2.8 a	133.0
	12.1	2.6 a	117.0
	14.5	2.9 a	142.0
AS	13.0	2.8 a	133.0
	16.3	2.6 a	117.0
	19.6	2.7 a	125.0
NPK	0.2	2.2 a	83.0
	0.25	2.6 a	117.0
	0.3	2.6 a	117.0

*AP = Almond leaves + Poultry manure compost at 9.7, 12.1 and 14.5 t/ha; AS = Almond leaves + Swine manure compost at13.0, 16.3 and 19.6 t/ha Means in a column followed by the same letter are not significantly different by Duncan Multiple Range Test at P < 0.05.

Table 3.5 Effects of almond leaf-based compost on fruit yield of pepper in the screenhouse

Treament*	Rate (t/ha)	Number of fruits/pot	% increase in number of fruit	Fresh fruit yield (g/pot)	% increase in fruit yield
Control	0	10.4 c	0	44.5 c	0
AP	9.7	14.4 b	38.5	51.7 b	16.2
	12.1	15.9 ab	52.9	53. 6 bc	20.4
	14.5	18.3 a	75.9	57.0 abc	28.1
AS	13.0	16.8 ab	61.5	56.2 abc	26.3
	16.3	16.2 ab	55.8	55.3 abc	24.3
	19.6	16.3 ab	56.7	54.5 abc	22.5
NPK	0.2	15.4 ab	48.1	51.3 bc	15.3
	0.25	18.5 a	77.9	60.2 ab	35.3
	0.3	15.5 ab	49.0	55.1 abc	23.8

*AP = Almond leaves + Poultry manure compost at 9.7, 12.1 and 14.5 t/ha; AS = Almond leaves + Swine manure compost at13.0, 16.3 and 19.6 t/ha Means in a column followed by the same letter are not significantly different by Duncan Multiple Range Test at P < 0.05.

Table 3.6 shows effect of almond leaf-based compost on morphological trait of pepper at 12 WAT in the field. The plant height, root length, number of branches and number of leaves of pepper were all significantly increased ($p < 0.05$) by the almond leaf-based composts and NPK treatments. The root length (14.1 cm) and number of leaves (60.5) of pepper amended with AP were significantly higher than other treatments. However, stem girth (2.1 cm) and number of branches (11.6) recorded from NPK was significantly increased than control and AS compost.

Table 3.7 shows effect of almond leaf-based compost on soil physical properties at 15 WAT in the field.

Soil porosity under almond leaf-based compost treatments were not significantly different ($p> 0.05$) from NPK. Soil porosity increased in the order control (40.6%) < AS (51.4%) < AP (52.4%) < NPK (52.8%). However, the bulk density and soil temperature were significantly ($p < 0.05$) decreased by the fertilizer treatments.

Table 3.6 Effects of almond leaf-based compost on morphological trait of pepper at 12 WAT in the field

Treatment*	Rate (t/ha)	Plant height (cm)	Stem girth (cm)	Root length (cm)	Number of leaves	Number of branches
Control	0	24.0 b	1.5 b	12.0 b	36.3 b	7.8 c
AP	14.5	29.5 a	1.8 b	14.1 ab	60.5 a	1 1.0 b
AS	13.0	31.0 a	1.8 b	12.9 b	56.9 ab	9.8 bc
NPK	0.25	31.0 a	2.1 a	13.0 b	54.7 ab	11.6 a

*AP = Almond leaves + Poultry manure compost at 14.5 t/ha; AS = Almond leaves + Swine manure compost at13.0 t/ha Means in a column followed by the same letter are not significantly different by Duncan Multiple Range Test at P < 0.05

Table 3.7 Effects of almond leaf-based compost on soil physical properties at 15 WAT in the field

Treatment*	Rate (t/ha)	Soil porosity (%)	Soil bulk density (Mg/m^3)	Soil temperature (℃)
Control	0	40.6 b	1.6 a	29.9 a
AP	14.5	52.4 a	1.3 b	28.1 c
AS	13.0	51.4 a	1.3 b	29.1 b
NPK	0.25	52.8 a	1.3 b	28.5 bc

*AP = Almond leaves + Poultry manure compost at 14.5 t/ha; AS = Almond leaves + Swine manure compost at13.0 t/ha Means in a column followed by the same letter are not significantly different by Duncan Multiple Range Test at $P < 0.05$.

Table 3.8 shows effect of almond leaf-based compost on soil chemical properties at 15 WAT in the field. The soil pH, SOC, N, P and K under AC (14.3 t/ha) were significantly higher ($p < 0.05$) than other treatments. The soil pH (5.6) recorded from NPK was the lowest and was not significantly different ($p > 0.05$) from the control. The SOC increased in the order control (5.7g/kg)< AP (17.0 g/kg) < AS (18.1 g/kg) < NPK (19.5 g/kg). However, Ca (12.5 cmol / kg) and Mg (3.2 cmol / kg) recorded under AP respectively, were significantly higher than other treatments

Table 3.9 shows effect of almond leaf-based compost on yield of pepper in the field. All the composted organic residues and NPK significantly increased ($p < 0.05$) yield of pepper over the control. However, relative to the control, AS, AP and NPK increased the number of fruits of pepper by 59.5, 67.4 and 68.4% and also increased fruits yield by 85.0, 96.0 and 111.0% respectively.

Table 3.8 Effects of almond leaf-based compost on soil chemical properties at 15 WAT in the field

Treatment*	Rate (t/ha)	pH 1:1(H_2O)	SOC	N	P	K	Ca	Mg
			g / kg		Mg/kg	cmol/ kg		
Control	0	5.9 bc	5.7 b	1.8 b	11.5 b	0.2 b	2.2 c	1.3 c
AP	14.5	6.3 b	17.0 a	3.9 a	22.1 a	0.2 b	12.5 a	3.2 a
AS	13.0	6.0 bc	18.1 a	4.1 a	18.2 a	0.2 b	10.2b	2.6ab
NPK	0.25	5.6 c	19.5 a	4.1 a	22.5 a	0.2 b	9.9 b	2.2 b

*AP = Almond leaves + Poultry manure compost at 14.5 t/ha; AC = Almond leaves+ Cattle manure compost at14.3 t/ha; AS = Almond leaves + Swine manure compost at13.0 t/ha Means in a column followed by the same letter are not significantly different by Duncan Multiple Range Test at $P < 0.05$.

Table 3.9 Effects of almond leaf-based compost on yield of pepper in the field

Treatment*	Rate (t/ha)	Number of fruits/plant	% increase in number of fruit	Fruit yield/ plant (t/ha)	% increase in fruit yield
Control	0	19.0 b	0	2.7 c	0
AP	14.5	31.8 a	67.4	5.3 ab	96.0
AS	13.0	30.3 a	59.5	5.0 b	85.0
NPK	0.25	32.0 a	68.4	5.7 ab	111.0

*AP = Almond leaves + Poultry manure compost at 14.5 t/ha; AC = Almond leaves+ Cattle manure compost at14.3 t/ha; AS = Almond leaves + Swine manure compost at13.0 t/ha Means in a column followed by the same letter are not significantly different by Duncan Multiple Range Test at $P < 0.05$

DISCUSSION

The use of plant wastes and animal manures to supply plant nutrients to crop has become a global interest and alternative to mineral fertilizer use. Interestingly, plant residues (Almond leaves) and animal wastes can be composted together to complement each other in terms of nutrient supply to crops. Composting of almond tree leaves and returning them back into the soil is an historic method for maintaining soil fertility through natural recycling process (Inckel, 1996). Hence, it is imperative to explore the huge nutrient potential of almond leaves through composting, instead of burning, to constitute environmental nuisance. Leaf litter from almond trees constitutes a significant litter in the environment. Therefore, it is a source of concern in the areas where the trees are grown. However, the leaves are endowed with essential plant nutrients which when released into the soil during decomposition results in building up soil organic matter (Lex and Barry, 2006). However, almond leaves (dry weight basis) have a high C: N ratio of 99:1. Hence, it takes a very long time to decompose in the soil (Tian *et al.*, 1992). Furthermore, burning a high carbon material like almond leaf has the possibility of releasing volatile organic compounds to the atmosphere which could lead to environmental pollution.

It was based on the above reasons that, Aiyelari *et al.* (2011) conducted a research on dropped leaves of almond. The leaves were used for mulching on okra planted on flat, ridge and heap at the rate of 0, 5 and 10 t $ha^{-1.}$ In spite of carrying out their research during the rainy seasons, the leaves could not decompose on time to release nutrient into the soil. They attributed the cause to the recalcitrant properties of the leaves. This result further attested to the high C: N ratio of the almond leaves. Hence, in this study the leaves were composted with poultry and swine manure noted with low C: N ratio to enhance its decomposition.

Under the screenhouse investigation, all the composted organic residues and the NPK rates significantly ($p < 0.05$) enhanced shoot and fruit yield of pepper. The result may be traced to the fact that C: N ratio of almond leaves were reduced from 99 to 21 and 22 when composted with poultry and swine manure respectively, thereby increasing their rate of mineralization. Yuh-MingHuang (2005) however, reported that C: N ratio 30:1 is good enough for application to the soil.

The results from the field investigations showed that, the experimental soil used for pre-planting analysis was deficient in major nutrients. The sandy-loam soil has low soil porosity and high bulk density. Therefore it is expected that application of almond-leaf based compost will have positive and cumulative effects on the growth, soil properties and yield of pepper. The findings showed that, application of almond leaf-based compost significantly ($p < 0.05$) increased plant height, stem girth, root length, number of leaves and number of branches of pepper. This result corroborated the findings of Alabi (2006) who reported increased in plant height, number of leaves per plant, number of branches per plant and leaf area per plant of pepper. This shows the potential of almond leaf-based compost to improve the growth and performance of pepper. The effects of compost amendments on soil physical properties (soil porosity, soil bulk density and soil temperature) were significantly different ($p < 0.05$) from the control plots. Hence, their applications increased soil porosity while the soil bulk density and temperature were significantly ($p<0.05$) reduced compared to the control. This result was also confirmed by other workers (Akanni and Ojeniyi, 2008). The result could be attributed to the enhancement of soil organic matter which led to improvements in soil porosity and soil structure (Hulugalle *et al.*, 1985).

The result showed that almond leaf-based compost had significant higher ($p<0.05$) effects on soil organic carbon and P content of the soil than the control. Therefore, it may be speculated that soil amendment with almond leaf-based compost has the potential to increase the availability of P content in the soil. The finding was supported by Sarwar *et al.* (2008). They reported that, organic source of nutrition in the soil has the potential to break the bond of phosphorus compounds with $CaCO_3$ and increased the availability of phosphorus in the soil. Previous workers also supported the above results (Parmer and Sharma, 2002; Verma *et al.*, 2002). The increase in the pH of the soil after harvesting is an indication of buffering capacity of the compost applied. The availability of nutrients in the soil was enhanced by the application of almond leaf-based compost. Thereby enhance the fruit yields of pepper which were significantly ($p < 0.05$) higher than the control. This shows that their application enhanced the fertility status of the soil for pepper uptake (Saxena *et al.*, 1975). Therefore, the most effective compost was AP at 14.5 t ha^{-1}. However, this depends on the quality of the compost. Although, all the compost treatments were found to improve significantly soil properties and yield of pepper throughout the study

CONCLUSIONS

This study was carried out to solve some of the problem associated with burning of Almond (*Terminalia catappa)* leaves with the potential of releasing greenhouse gases to the atmosphere resulting in serious environmental problem over time. It also meant to address the non-availability of the mineral fertilizer, to meet the demand of small scale farmers. The study therefore explores the effects of almond leaf-based compost on soil properties and yield of pepper in Ibadan. Previous studies on the use of organic materials had been on the use of freshly collected organic waste products which were allowed to decompose in the soil. Whereas some of these wastes in their raw form may not be suitable for direct application to the soil due to low nutrient availability, environmental and economic implications. Therefore, there is need to develop a new technology through which this waste could be effectively utilized. Hence, composting provides a very good alternative means of removing waste from the environment. In this study, almond leaves composted with animal manure increased its rate of mineralization for optimum soil productivity of pepper in Ibadan, Nigeria. Hence, farmers should exploit the huge nutrient potential of almond leaves wastes, instead of burning them. The leaves should be composted with animal dung. The compost prepared from this source will not only supplement the chemical fertilizers but also reduces the environmental pollution by way of carbon sequestration in the soil, thus, resulting into higher yield and more income for the farmers. In this farming system, the fertility and productivity of the soil can be improved on sustainable basis while employing a low risk mechanisms of waste disposal. Therefore in conclusion almond leaf-based composts enhanced soil fertility. However, application of 14.5 t/ha almond leaf-poultry manure compost was the most effective and therefore recommended for pepper production in Ibadan.

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