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Effects of carbon/nitrogen ratio and particle size of rice husk and sawdust on composting of poultry manure and the performance of *Amaranthuscruentus* on soils of ObioAkpa, Nigeria

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Abstract:

Field experiments were conducted during the 2016 and 2017 planting seasons at the AkwaIbom State University Teaching and Research Farm to evaluate the effects of carbon/nitrogen ratios of three particle sizes (0.5, 1.0 and 2.0 mm) of rice husk (RH) and sawdust (SD) in four composting ratios (1:1, 1:4, 1:8 and 1:16) with poultry manure (BCW) on the performance of Amaranthuscruentus. Twenty five treatments: RH/BCW and SD/BCW composts and the control were applied in RCBD with four replications. Results revealed the C/N ratio of SD (0.5 mm) to be 66:1, SD (1.0 mm) (55:1) and SD (2.0 mm) (43:1). The C/N ratio of RH (0.5 mm) was 16:1, RH (2.0 mm) was 11:1 and RH (1.0 mm) was 10:1 while BCW recorded 8:1.The C/N ratio ofthe compostsat 4 weeks after composting ranged from 14:1 to 24:1 and 10:1 to 22:1 at 8 WAC. The applied composts showed significant ($P < 0.05$) differences in the growth and yield of Amaranthuscruentus. The highest Amaranthus heights at 8 WAT were obtainedwith application of RH/BCW (0.5 mm)1:16 (74 cm) and RH/BCW (0.5 mm) 1:8 (72 cm) in 2016 and 2017 cropping seasons, respectively. The widest stem girths (10 cm) and (9.6 cm) were obtained with application of SD/BCW (1.0 mm) 1:16 in 2016 season and RH/BCW (0.5 mm)1:4 in 2017 season, respectively. The broadest leaf areas (45.3and 45.0 cm^2) were obtainedwith application of SD/BCW (1.0 mm)1:16and SD/BCW (2.0 mm)1:16 in 2016 and 2017 seasons, respectively. The heaviest fresh leaf yields (11.47 and 9.47 t/ha) were obtained in plots fertilized with RH/BCW (0.5 mm)1:1 composts in 2016 and 2017 seasons, respectively. Application of composts to Amaranthuscruentussignificantly ($P < 0.05$) improved yields in both seasons.

Keywords:Carbon/nitrogen ratio, particle size, composts, *Amaranthuscruentus*performance

INTRODUCTION

Carbon/nitrogen ratio and particle size of organic material determine the rate of decomposition and the quality of the cured compost. The initial C/N ratio of organic materials is one of the most important factors influencing compost quality (Michel *et al.*, 1996).Kumar *et al.*, (2010) reported that initial C/N ratios of 25:1 – 30:1 are considered ideal for composting. Agnew and Leonard, (2003) observed that composting process might be efficiently developed when substrates with C/N ratios in range of 25 – 30 are used. Nevertheless, the C/N ratio of organic materials between 25:1 and 40:1 (Dougherty, 1999) can favour high growth of microorganisms and their efficient processing of degradable organics.Decrease in C/N ratio with composting time was reported by Ogunwande, (2011). Mina *et al.*, (2012) evaluated the effect of particle size and composting period on C/N ratio of Date-palm waste and reported that organic carbon content in wastes reduced in 0 - 5 mm compost than in 10 – 20 mm particle size compost. On the other hand, total nitrogen increased in 10 – 20 mm compost than in 0 – 5 mm compost.Theyobserved that particle size of organic materials affect the time required for compost maturity and the quality of the cured compost. Large size particles reduce surface area of composting materials for microbial attack (Zia *et al.*, 2003) which slows down or may stop composting process altogether. Organic materials with medium to coarse texture, equivalent to particle sizes distribution between 0.25 and 2.5 mm was reported by Benito *et al.*, (2005) to be the best as this allow retention of enough available water and adequate air content for composting.

Compostinghas been shown to be useful in providing a stable end product for crop production (John *etal.*, 1996; Amanullah*etal.*, 2010).Several authors found that sawdustcomposts could improve performance and nutrients availability in production of maize, amaranthus, tomato, pepper (Ojeniyi and Adejobi, 2012; Owolabi*et al.*, 2003). Significant (P<0.05) differences were reported in the growth of maize in acid sands soil of Uyo (Effiong*et al.*, 2012) cultivated under palm kernel cake/sawdust composts with initial C/N ratio of 21:1 and 53:1, respectively. Onwudike*et al.*, (2015) reported that rice mill waste with initial C/N ratio of 28:1 combined with poultry manure improved soil quality, growth and yield of maize in acidic soils of Owerri. Composting of rice husk (RH), sawdust (SD) and battery cage waste (BCW) wouldreverse the trend of its indiscriminate disposal, solve the problem of environmental pollution and also improve waste handling. Rice husk, sawdust and battery cage waste are good sources of essential plant nutrients, therefore composts of these materials could improve soil fertility and enhance growth and yield of *Amaranthuscruentus*.

MATERIALS AND METHODS

Location: Composting of RH/BCW and SD/BCW was carried out in 2016 at EfiatOffotin Uyo metropolis.Field trials of the composts on the performance of *Amaranthuscruentus* (Linn) were conducted in 2016 and 2017 planting season at the Teaching and Research Farm of AkwaIbom State University, ObioAkpa Campus. The Farm is located between latitude 4 ^{o} 30 ′ N and longitude 7 ^{o} 30 ′ E of the Greenwich Meridian.The mean annual rainfall ranged from 2000 – 2500 mm in the wet season. Annual temperature rangedfrom 24– 30 ^{o}C while the annual relative humidity ranged between 75 – 79 % (AKSU MET. 2016).

Particle size separation: Rice husk and sawdust were subjected to particle size separation using sieve method. The grain size characteristics of organic materials that are predominantly coarse grained are evaluated by a sieve analysis(Krishna, 2010). A nest of sieve was prepared by stacking test sieves one above the other with the largest (2 mm) opening at the top followed by sieves of successively smaller (1 mm and 0.5 mm) openings and a catch pan at the bottom.Samples of rice husk and sawdust were poured into the top sieve with the nest covered, and then shaken by hand until each particle dropped to a sieve with openings too small for large particles to pass through.

Laboratory Analysis: The chemical properties of the fresh composting materials were determined.Compost pH was determined in 1:4 compost-water ratio using pH meter (Bates, 1954). Electrical conductivity was determined using conductivity bridge (Hanna, 1964). Particle size separation of rice husk and sawdust was determined by sieve method. Organic carbon was determined by wet oxidation method of Walkley and Black as outlined by Nelson and Sommers (1982). Percentage organic matter was obtained by multiplying the value of organic carbon by a factor of 1.724. Total nitrogen was determined by micro-kjeldalh method (Bremner, 1996). Available P was extracted by the Bray P-1 method (Bray and Kurtz, 1945) and P determined by the ascorbic acid molybdate blue method (Murphy and Riley, 1962). Exchangeable cations (K, Mg, Ca and Na) were extracted using 1 N NH_4OAC at pH 7 (Sparks, 1996). Sodium and potassium were readusing flame photometer while calcium and magnesium were read from Atomic Absorption Spectrophotometer (Model 939). Micro-nutrients (Fe, Cu, Mn and Zn) were extracted with double acid (HCl and H_2SO_4) and their concentrations read from AAS (Baker and Amacher, 1982).

Composting process: The C/N ratios of the three particle sizes of rice husk and sawdust as well as theC/N ratio of poultry manurewere used to determine the composting ratios.Three particle sizes of rice husk and sawdust (0.5, 1.0 and 2.0 mm) were combined withpoultry manure in four ratios; 1:1, 1:4, 1:8 and 1:16 given twenty four compost windrows.These composts were kept under zinc roof shade. Turning of compost heaps and sprinkling of water were carried out at three days interval for the first 2 weeks and once a week for the next one month and forth-nightly for the remaining period of composting.

Treatment Application and cultural practices: Twenty (20) ton/ha of the cured composts was applied. Each experimental plot measured 1.5 x 1.5 m and received 4.5 kg of the compost. The compost was thoroughly mixed with the soil two weeks before seedlings were transplanted to it. The nursery and experimental plots were watered to field capacity before the seedlings were transplanted. Two seedlings were transplanted to each stand and thinned to one plant per stand after two weeks of transplanting.The seedlings were transplanted at average height of 2 cm, stem girth of 0.3 cm and leaf area of 1.4 cm^2 at 2 weeks after sowing. The seedlings were spaced at 30 x 30 cm and planted at the depth of 3 cm.Hand pulling of the weeds was carried out on the beds while weeding hoe was used to weed between the beds and the surrounding environment at intervals throughout the growing period.Plant height, stem girth and leaf area were measured using meter tapeat4, 6 and 8 weeks after transplanting of the seedlings. Five plants per plot were randomly selected from the inner rows for the determination of growth parameters and fresh leaf yield in (ton/ha).

Statistical Design and Analysis: The experiments were laid out in a Randomized Complete Block Design (RCBD) with four replicates. The treatments were RH/BCW and SD/BCW composts. Twenty four compost treatments and control were tested on*Amaranthuscruentus*to evaluate its effects on plant height, stem girth and leaf area as well as the fresh leaf yield of the test crop. Data collected were subjected to analysis of variance (ANOVA) and means that showed significant differences were separated using Duncan Multiple Range Test (Duncan, 1995).

RESULTS:

Particle size and nutrient contents of fresh composting materials

The particle size and nutrient contents of fresh composting materials are presented in Tables 1 and 2. The pH of the fresh composting materials rangedfrom slightly acidic (6.20) in RH (0.5 mm) to strongly alkaline (9.93) in BCW while electrical conductivity was low in all the composting materials (0.03 – 0.70 dS/m).Organic carbon ranged from 168.53 in BCW to 351.53 g/kg in RH (0.5 mm). Total nitrogen was high in all the composting materials and ranged from 5.01in SD (0.5 mm) to 22.4 g/kg in RH (0.5 mm).Carbon/nitrogen (C/N) ratio of BCW (8:1) was lower than that of RH (10:1 – 16:1).The C/N ratios of fresh sawdust ranged from 43:1 – 66:1. Potassium ranged from 3089.2in SD (1.0 mm) to 4990.8 mg/kg in BCW. Calcium ranged from 2188.3 in RH (1.0 mm) to 13,637 mg/kg in BCW. Magnesium ranged from432.7 in RH (2.0 mm) to 2736 mg/kg in BCW. Sodium content in BCW(307.7 mg/kg) was higher than those in the three particle sizes of rice husk (212.0 – 219.3 mg/kg) and sawdust (89.8 – 92.3 mg/kg). Phosphorus in BCW (67.1 mg/kg) was lower than the values recorded in rice husk (160.3 – 162.5 mg/kg) and sawdust (204.3 – 212.2 mg/kg).Micronutrient contents in the composting materials were all high except iron. The zinc content ranged from 123.0 in BCW to 133.5 mg/kg in rice husk(0.5 mm).Manganese ranged from 80.3 in sawdust (0.5 mm) to 86.3 mg/kg in rice husk(0.5 mm).Copper ranged from 57.7 in BCW to 65.9 mg/kg in rice husk(0.5 mm)and iron ranged from 1.36 in sawdust (2.0 mm)to 1.81 mg/kg in rice husk (0.5 mm).The cured composts were applied to *Amaranthuscruentus.*

***Amaranthuscruentus* performance**

Plant Height: At 8 weeks after transplanting (WAT), *Amaranthus* plants grown on soils treated with RH/BCW (0.5 mm) 1:16 compost and RH/BCW (0.5 mm) 1:8 compost in 2016 and 2017 seasons, respectively were significantly (P < 0.05) taller than the ones grown on SD/BCW compost and the control.Onwudike*et al.*, (2015) reported that rice mill waste with initial C/N ratio of 28:1 combined with poultry manure improved soil quality, growth and yield of maize in acidic soils of Owerri.Generally, RH/BCW and SD/BCW composts produced significantly (P < 0.05) taller plants compared to the control (Figure 1 and 2) and (Tables 3 and 4).

Stem Girth: At 8 weeks after transplanting (WAT) the stem girth of *Amaranthus* was significantly (P < 0.05) higher on plot treatedwith SD/BCW (1.0 mm) 1:16 compost in 2016 cropping season but in 2017 season it was significantly (P < 0.05) higher on plot treatedwith RH/BCW (0.5 mm) 1:4 compost than the ones grown on the control (Figure 3 and 4) and (Tables 3 and 4). Swine waste with initial C/N ratio of 16:1 composted with sawdust with initial C/N ratio of 64:1 was reported (Ekong*et al.*, 2017) to significantly (P<0.05) increased the growth parameters and yield of eggplant in acid soils of ObioAkpa, AkwaIbom State.

Leaf Area:*Amaranthus* grown on SD/BCW (2.0 mm) 1:16 compost had significantly (P < 0.05) larger leaf area in 2016 and 2017 cropping seasons than the ones produced on RH/BCW composts and the control (Figures 5 and 6) and (Tables 3 and 4). The increase in leaf area had been claimed to be directly influenced by nitrogen supply in the organic fertilizer applied (Ehigiator, 1990)..

Fresh Leaf Yield: The fresh leaf yields of *Amaranthus* grown on RH/BCW (0.5mm) 1:1 compost in 2016 and 2017 cropping seasons were significantly (P < 0.05) heavier than those produced on SD/BCW composts and the control (Table 5). Therefore, organic manure (Eghareyba and Ogbe, 2002) has been found to sustain yield under continuous cropping and improve the fertility of a degraded soil.The highest fresh leaf yieldof 11.47 and 9.47 ton/ha in 2016 and 2017 seasons were obtained when RH/BCW (0.5mm) 1:1 compost was applied.

DISCUSSION

The significant differences in the growth and yield of *Amaranthuscruentus*with application of RH/BCW and SD/BCW composts relative to the control could be attributed to the initial C/N ratios and particle sizes of the compostingmaterials. Plant heights, stem girths and yields were highly influenced with application of RH/BCW (0.5 mm) composts in 2016 and 2017 cropping seasons. The extraordinary performance of *Amaranthuscruentus* grown on RH/BCW (0.5 mm)compost compared to other treatments couldbe attributed to the C/N ratio (16:1) of RH (0.5 mm) which was twice the C/N ratio of BCW (8:1) ideal for composting.It could also be attributed to the minimum particle size of rice husk (0.5 mm) with wide surface area for nutrient adsorption and release. Ogbodo (2012) observed increased yields of Lettuce grown on alternative media and mixes that involved top soil, sawdust, rice husk and other mixes with poultry manure, urea and NPK 15:15:15 and reported that rice husk/poultry droppings gave the highest Lettuce yields followed by sawdust/poultry droppings then thecontrol. Jenny and Malliga, (2014) reported that minimum particle size (0.01 – 0.1 mm) of organic manure enriched nutrient status of soil and also induced plant growth and gave good yield of tomato plants compared to other particle sizes and the control.

CONCLUSION

The result shows that RH/BCW and SD/BCW composts could be used for the production of *Amaranthus* with comparable yields. The three particle sizes of rice husk had the most suitable C/N ratiosfor composting with poultry manure. However, composting of RH/BCW and SD/BCW enhanced decomposition, conserved plant nutrients and improved soil fertility for *Amaranthus* production. Generally, the performance of *Amaranthus*on different treatments are arranged in the order; RH/BCW composts > SD/BCW composts > Control in in 2016 and 2017 seasons, it is therefore recommended that RH/BCW(0.5 mm) 1:1 compost be used to ensure sustainable *Amaranthuscruentus*production.

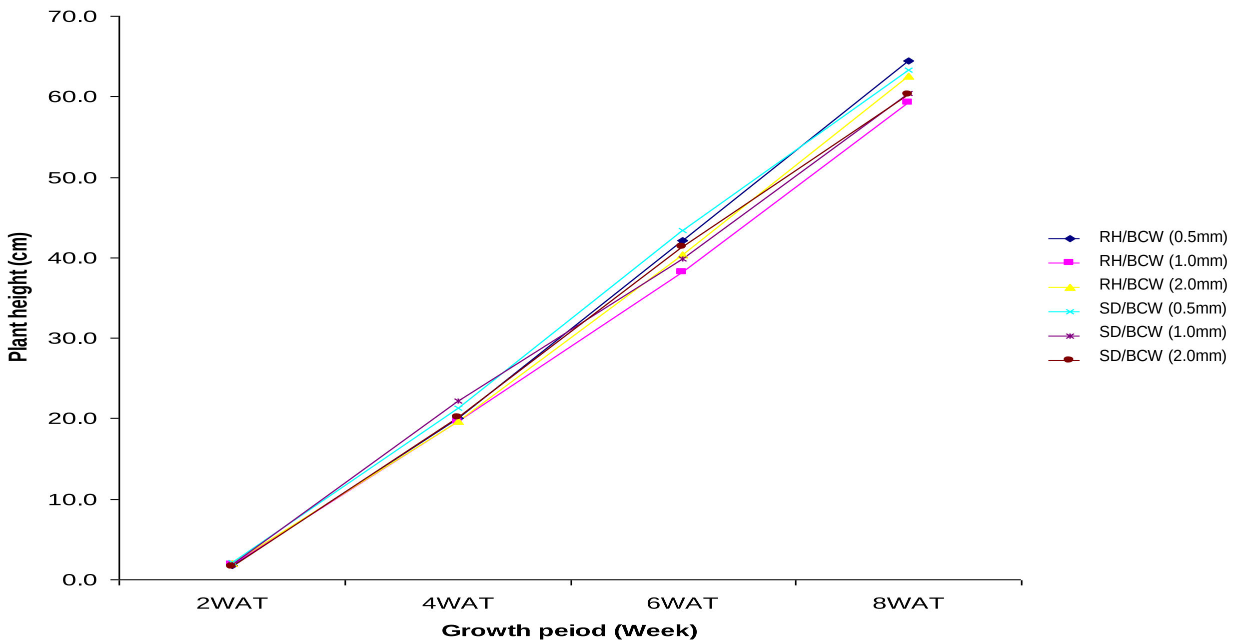


FIGURE 1: Effects of compost treatments on plant height in 2016 season

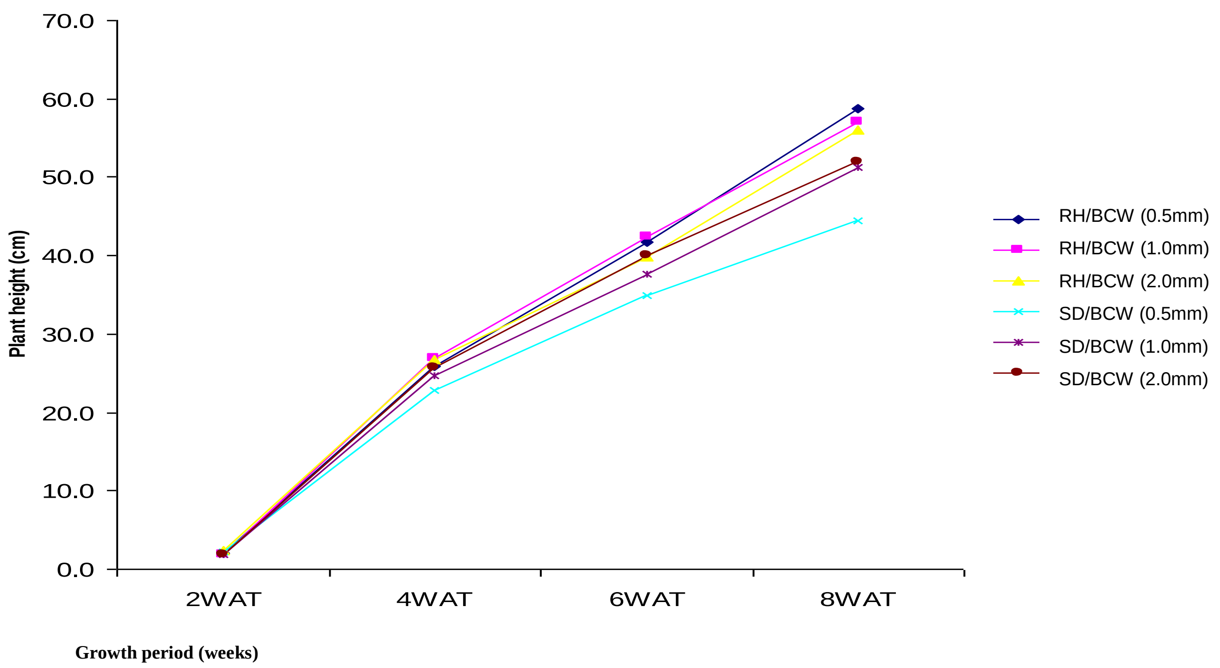


FIGURE 2: Effects of compost treatments on plant height in 2017 season

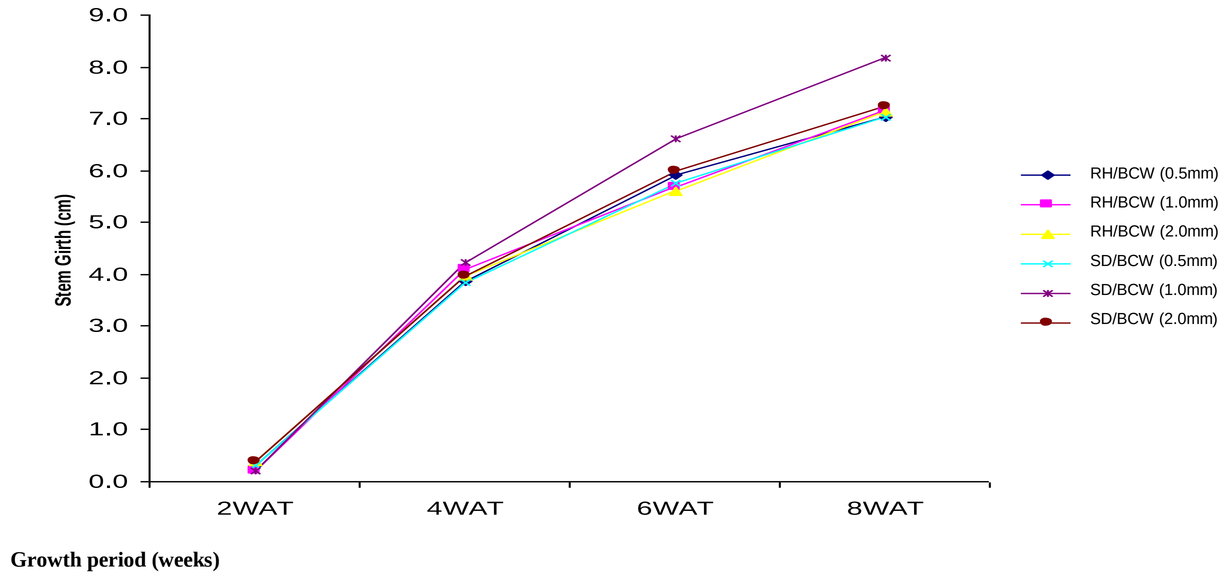
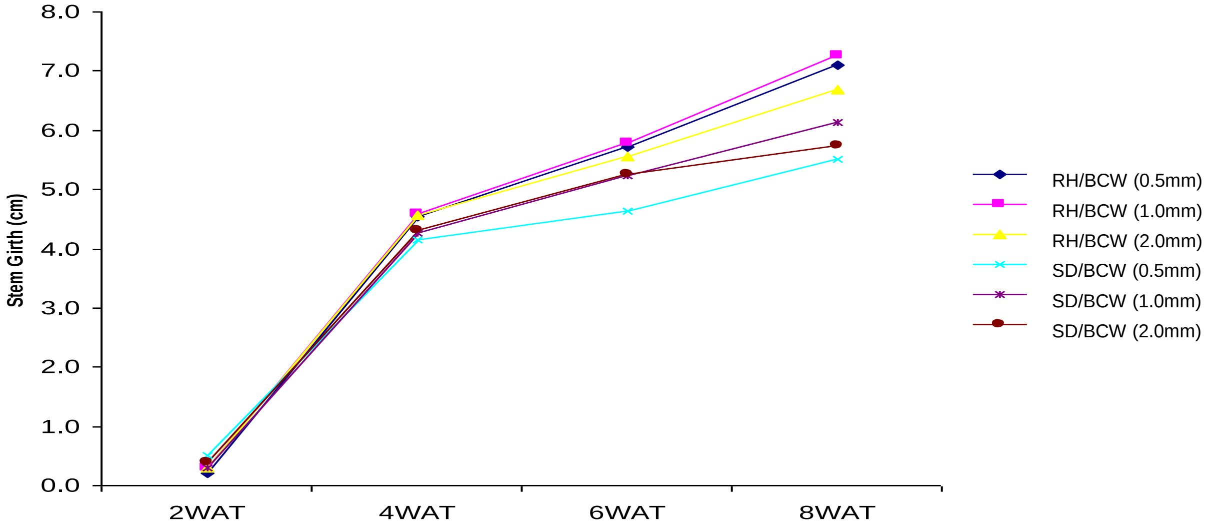
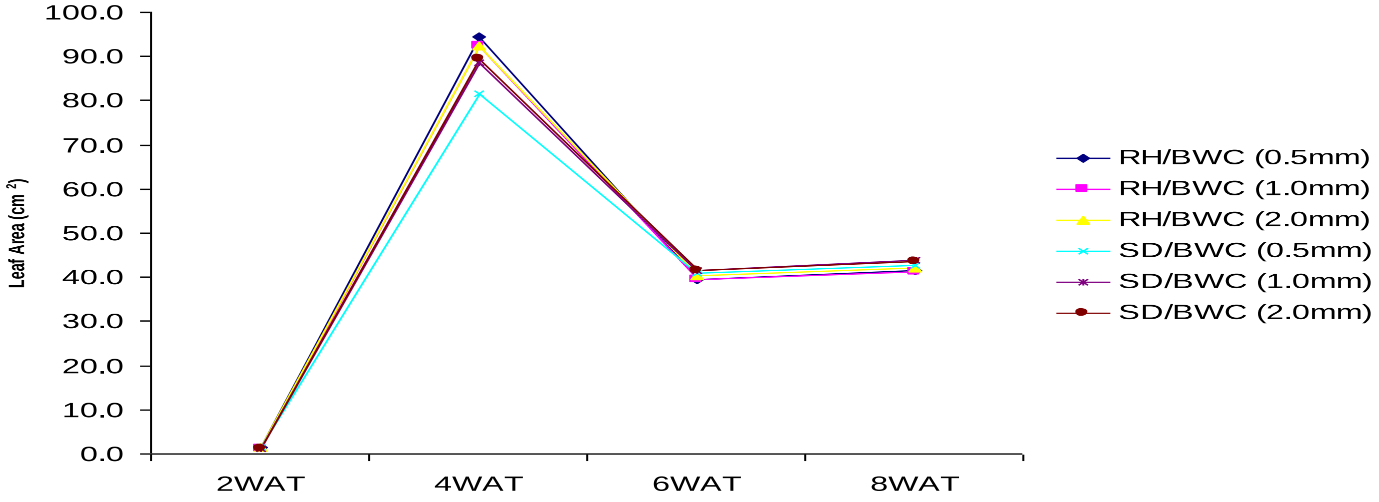


FIGURE 3: Effects of compost treatments on stem girth in 2016 season



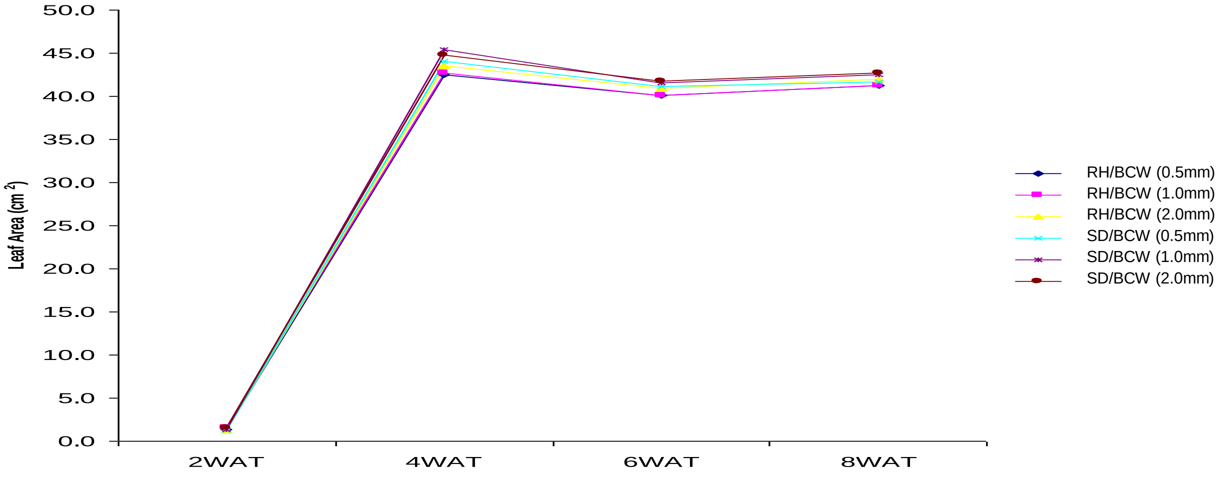
Growth period (weeks)

FIGURE 4: Effects of compost treatments on stem girth in 2017 season



Growth period (weeks)

FIGURE 5: Effects of compost treatments on leaf area in 2016 season



Growth period (weeks)

FIGURE 6: Effects of compost treatments on leaf area in 2017 season

TABLE 1

Particle size and nutrient contents of fresh rice husk, sawdust and battery cage waste used in the composting process

	pH	EC (dS/m)	Org. C (g/kg)	TN (g/kg)	C/N	Ca	Mg	Na (mg/kg)	K	P
Rice Husk (RH)										
0.5mm	6.20d	0.09b	351.53a	22.40a	16:1d	2193.33c	435.0c	214.33b	3401.0b	160.40b
1.0mm	6.30d	0.08c	224.20f	22.10a	10:1e	2188.33c	439.0c	219.33b	3475.67b	162.50b
2.0mm	6.30d	0.06d	235.60e	22.30a	11:1e	2196.33c	432.67c	212.0b	3336.33b	160.27b
Saw Dust (SD)										
0.5mm	7.43b	0.03f	322.90b	5.01d	66:1a	3650.0b	716.67b	89.77c	3236.67b	212.17a
1.0mm	6.90c	0.03f	311.70c	5.67c	55:1b	3636.33b	720.67b	92.33c	3089.20b	204.27a
2.0mm	6.37d	0.04e	247.30d	5.70c	43:1c	3566.67b	728.33b	92.27c	3182.33b	204.33a
Battery Cage Waste (BCW)	9.93a	0.70a	168.53g	20.96b	8:1f	13637.0a	2736.0a	307.73a	4990.80a	67.07c

Means with the same superscripts along the same column are not significantly different ($p < 0.05$), RH = rice husk, SD = sawdust, BCW = battery cage waste

TABLE 2

Particle size and micronutrient contents of rice husk, sawdust and battery cage waste used in the composting process

	Zn	Mn (mg/kg)	Cu	Fe
Rice Husk (RH)				
0.5mm	133.50a	86.27a	65.86a	1.81a
1.0mm	132.07a	86.07a	65.44a	1.80a
2.0mm	129.27b	85.27a	63.60b	1.77a
Saw Dust (SD)				
0.5mm	126.23c	80.27c	62.44c	1.46c
1.0mm	125.17cd	83.21b	61.57c	1.40c
2.0mm	125.30cd	80.33c	61.23c	1.36c
Battery Cage Waste (BCW)	123.0d	82.82b	57.7d	1.58b

Means with the same superscripts along the same column are not significantly different ($p < 0.05$), RH = rice husk, SD = sawdust, BCW = battery cage waste

TABLE 3
Growth parameters of*Amaranthus* plant in 2016 cropping season.

Treatments	Plant Height (cm)			Stem Girth (cm)			Leaf Area (cm^2)		
	4WAT	**6WAT**	**8WAT**	**4WAT**	**6WAT**	**8WAT**	**4WAT**	**6WAT**	**8WAT**
RH/BCW 0.5 mm 1:1	21.325f	43.725f	72.425bc	4.255cde	5.925de	7.305f	80.575mn	41.005bcdefg	42.675cdefg
RH/BCW 0.5 mm 1:4	13.53m	31.4o	42.57o	2.88k	4.6h	4.9k	97.45c	38.13k	39.85j
RH/BCW 0.5 mm 1:8	17.4j	39.1jk	68.73f	3.48hij	6.12cde	7.35ef	108.15a	39.23ijk	41.87fgh
RH/BCW 0.5 mm 1:16	27.755a	54.425a	74.125a	4.885ab	7.005b	8.555cd	91.175hi	39.135ijk	41.255hij
RH/BCW 1.0 mm 1:1	24.05c	49.35c	72.55b	4.11cdefg	6.11cde	7.27f	77.75op	40.61cdefghi	42.61defgh
RH/BCW 1.0 mm 1:4	16.115k	27.775p	47.725m	3.355ijk	4.695h	5.325k	90.975hi	38.855jk	40.195ij
RH/BCW 1.0 mm 1:8	17.15j	36.15m	57.65j	3.92defghi	6.13cd	8.03cd	97.15cd	39.42hjk	41.63ghi
RH/BCW 1.0 mm 1:16	21.525f	39.775i	59.025i	4.975ab	5.805de	8.055cd	104.275b	39.475ghijk	40.305ij
RH/BCW 2.0 mm 1:1	19.2i	46e	69.8e	3.7efghi	5.89de	7.04fg	91.85gh	41.45bcde	43.64cde
RH/BCW 2.0 mm 1:4	20.375h	36.075m	46.825n	4.195cdef	5.515efg	6.275hi	93.375fg	40.195defghi	41.515gih
RH/BCW 2.0 mm 1:8	18.73i	39.55ijk	70.52d	3.95defghi	5.87de	8.58c	94.9ef	39.7ghij	41.62gih
RH/BCW 2.0 mm 1:16	20.45h	39.7ij	62.95g	4.05cdefgh	5.15fgh	6.64gh	89.7ij	40.05efghij	41.15hij
SD/BCW 0.5 mm 1:1	18.615i	41.325gh	59.225i	3.625efghij	5.155fgh	6.295hi	79.075nop	40.875bcdef	42.405efgh
SD/BCW 0.5 mm 1:4	23.3d	46.6de	63.15g	3.77efghij	5.85de	6.53ghi	83.15m	40.52cdefghi	42.6defgh
SD/BCW 0.5 mm 1:8	20.57gh	43.7f	59.15i	3.43ijk	4.79h	5.95ij	76.95q	40.68cdef	42.04fgh
SD/BCW 0.5 mm 1:16	22.625e	41.925g	71.875c	4.525bcd	7.255b	9.345b	86.875lm	41.275bcde	44.005bcd
SD/BCW 1.0 mm 1:1	21.13fg	41.25h	59.95h	4.46bcd	5.81de	7.09fg	82m	41.71bcd	43.06cdefg
SD/BCW 1.0 mm 1:4	21.275f	37.675l	57.645j	3.505ghij	6.675bc	8.545cd	89.225j	39.755ghij	42.925cdefg
SD/BCW 1.0 mm 1:8	19.98h	38.95k	54.65k	3.81efghi	5.95de	6.93fg	95.7de	42.06bc	44.2bc
SD/BCW 1.0 mm 1:16	26.575b	41.775gh	69.445e	5.175a	8.055a	10.155a	87.325k	42.425ab	45.305ab
SD/BCW 2.0 mm 1:1	26.58b	47.1d	69.3ef	4.43bcd	6.09cde	7.04fg	79.55no	39.68ghij	41.34hij
SD/BCW 2.0 mm 1:4	14.435l	32.575n	49.575l	3.175jk	5.015gh	5.405jk	78.625op	41.425bcde	43.265cdef
SD/BCW 2.0 mm 1:8	16.18k	32.55n	50.1l	3.67efghij	5.65def	7.95de	103.6b	40.92bcdefg	42.9cdefg
SD/BCW 2.0 mm 1:16	23.37d	53.4b	72.1bc	4.61abc	7.17b	8.58c	96.25cde	43.86a	46.42a
Control	11.05n	20.95q	21.05p	1.71l	2.92i	3.04l	23.21r	36.0l	27.60k

Mean with the same superscript along the same column are not significantly different (p>0.05)

TABLE 4

Growth parameters of *Amaranthus* plant in 2017 cropping season.

	Plant Height (cm)			Stem Girth (cm)			Leaf Area (cm^2)		
Treatments	**4WAT**	**6WAT**	**8WAT**	**4WAT**	**6WAT**	**8WAT**	**4WAT**	**6WAT**	**8WAT**
RH/BCW 0.5 mm 1:1	23.575ij	32.825mn	43.825m	3.975fgh	4.555efg	4.775h	44.055defg	40.725c	41.305defgh
RH/BCW 0.5 mm 1:4	22.65l	43.15d	62.2d	4.53cdef	6.85ab	9.58a	40.15j	39.78e	42.1bcde
RH/BCW 0.5 mm 1:8	30.4b	52.4a	72.4a	5.15ab	6.05b	7.2bcde	43.1fgh	40.9c	41.8cde
RH/BCW 0.5 mm 1:16	26.625e	38.375i	56.925f	4.555bcdef	5.405cd	6.855cdef	42.805fgh	38.805f	39.655i
RH/BCW 1.0 mm 1:1	19.45n	27.95p	41.25n	4.15efgh	4.8ef	6.43efgh	43.77efg	40.65cd	41.3defgh
RH/BCW 1.0 mm 1:4	27.975d	41.725f	55.475g	4.545bcdef	5.675bcd	7.305bcde	40.825ij	40.045e	41.175def
RH/BCW 1.0 mm 1:8	27.65d	47.4b	61.65d	4.05efgh	5.55c	6.55efgh	43.53efgh	39.55efgh	41.05def
RH/BCW 1.0 mm 1:16	32.275a	52.275a	69.775b	5.575a	7.105a	8.725ab	42.555gh	40.075e	41.605cde
RH/BCW 2.0 mm 1:1	23.3jk	35.3k	54.1h	4.8bcd	5.75bc	7.45bcd	44.79cde	42.55b	43.5abc
RH/BCW 2.0 mm 1:4	28.825c	40.575g	57.375f	4.925bc	5.925bc	6.805cdef	42.275hi	40.925c	41.925cd
RH/BCW 2.0 mm 1:8	28.6c	44.35c	59.15e	4.65bcd	5.48c	6.43efg	44.33def	40.4def	41.23defgh
RH/BCW 2.0 mm 1:16	26.2ef	39.45h	53.7h	3.9hg	5.1cd	6.03fgh	42.64gh	39.9e	41.1defg
SD/BCW 0.5 mm 1:1	21.325m	28.825o	41.825n	3.705h	3.755h	4.755h	43.545efgh	40.955c	41.005defg
SD/BCW 0.5 mm 1:4	26.4l	41.65f	46.4k	4.4 cdefg	4.9ef	5.85fgh	43.28efgh	41.1bc	41.65cdeg
SD/BCW 0.5 mm 1:8	22.65l	29.4o	39.7p	4.15efgh	4.88ef	5.67gh	43.2fgh	41.4bc	42.13bcde
SD/BCW 0.5 mm 1:16	20.875m	39.625h	50.125j	4.375cdefg	5.025cd	5.805fgh	46.095bc	41.125bc	41.775cdef
SD/BCW 1.0 mm 1:1	22.7kl	32.25n	44.75l	3.95fgh	4.1fgh	4.63h	44.34def	41.2bc	41.35dcef
SD/BCW 1.0 mm 1:4	25.725fg	40.725g	52.975i	4.555bcdef	5.675bcd	6.575efg	44.795cde	40.805c	41.925cd
SD/BCW 1.0 mm 1:8	26.4e	43.15d	57.45f	4.65bcde	6.13b	7.63bc	45.18cd	42.9ab	44.38ab
SD/BCW 1.0 mm 1:16	24.025hi	34.275l	50.075j	3.905gh	5.025cd	5.675gh	47.405ab	41.155bcd	42.275bcd
SD/BCW 2.0 mm 1:1	25.3g	33.3m	44.3lm	4.1efgh	4.68efg	4.8h	42.29hi	39.35ef	39.93hi
SD/BCW 2.0 mm 1:4	24.575hi	36.575j	40.375o	4.255defgh	4.905ef	5.455ghi	43.7 defgh	42.505b	43.155abc
SD/BCW 2.0 mm 1:8	26.1ef	42.35e	66.35c	4.5cdef	5.65bcd	6.88cdef	45.2cd	41.75bc	42.9bcd
SD/BCW 2.0 mm 1:16	26.7e	47.7b	57f	4.38cdefg	5.78bc	5.83fgh	47.83a	43.63a	45.03a

Control	14.70o	17.35q	21.20q	1.53i	1.72i	2.32i	6.24k	7.86g	11.80j

Mean with the same superscript along the same column are not significantly different (p>0.05)

TABLE 5
Fresh Leaf Yield (ton/ha) of *Amaranthus* in 2016 and 2017 cropping seasons

Treatment	2016	2017
RH/BCW 0.5 mm 1:1	11.47a	9.47a
RH/BCW 0.5 mm 1:4	9.71cd	6.6h
RH/BCW 0.5 mm 1:8	9.12ef	6.76h
RH/BCW 0.5 mm 1:16	8.64g	6.15j
RH/BCW 1.0 mm 1:1	9.24e	7.82f
RH/BCW 1.0 mm 1:4	9.79cd	7.21g
RH/BCW 1.0 mm 1:8	8.27h	6.18j
RH/BCW 1.0 mm 1:16	9.03f	7.12g
RH/BCW 2.0 mm 1:1	6.73l	5m
RH/BCW 2.0 mm 1:4	9.83c	9.03c
RH/BCW 2.0 mm 1:8	9.14ef	8.61d
RH/BCW 2.0 mm 1:16	8.17h	6.66h
SD/BCW 0.5 mm 1:1	7.61j	6.19j
SD/BCW 0.5 mm 1:4	6.15n	4.77n
SD/BCW 0.5 mm 1:8	5.96o	4.81n
SD/BCW 0.5 mm 1:16	8.72g	6.59i
SD/BCW 1.0 mm 1:1	8.22h	6.57i
SD/BCW 1.0 mm 1:4	7.84i	6.77h
SD/BCW 1.0 mm 1:8	7.02k	5.56k
SD/BCW 1.0 mm 1:16	9.83c	7.96f
SD/BCW 2.0 mm 1:1	9.66d	8.42e
SD/BCW 2.0 mm 1:4	6.01o	4.63o
SD/BCW 2.0 mm 1:8	6.38m	5.14l
SD/BCW 2.0 mm 1:16	10.43b	9.32b
Control	4.64p	3.49p

Mean with the same superscript along the same column are not significantly different ($p < 0.05$)

REFERENCES

Agnew, J. M. and Leonard, J. J. (2003).The physical properties of compost.*Compost Science and Utilization*, 11: 238-264.

AKSU MET. (2016). AkwaIbom State University meteorological station.Department of Crop Science, Faculty of Agriculture, ObioAkpa campus, OrukAnam, AkwaIbom State.

Amanullah, M. M., Sekar S. and Muthukrishnan P. (2010).Prospects and Potential of Poultry Manure.*Asian Journal of plant Sciences*. 9(4): 172-182.

Baker, D. E and Amacher M. C. (1982).Nickel, Copper, Zinc and Cadmium. In: Method of Soil Analysis part 2. Pp 323 – 326. Agronomy 9.*Soil Sci. Soc.* Amer. Madison, Wisc. U.S.A.

Bates, R. G. (1954).*Electronic pH determination*.John Wiley and Sons.Inc. New York.

Benito, M., Masaguer, A., Moliner, A. and Antonio, R. D. (2005). Chemical and physical properties of pruning waste compost and their seasonal variability. *Bioresource Technology*. 97: 2071-2076.

Bray, R. A. and Kurtz L. T. (1945). Determination of total and available forms of phosphorus in soils.Soil Science. 53: 39-45

Bremner, J. M. (1996). Inorganic forms of Nitrogen. In: C. A. Black, D.D. Evans, J. L. White. L. E. Ensminger and F. E. Clark (eds) *Methods of soil analysis: part 2 agronomy monograph 9*, American Society of Agronomy, Madison, 117 – 123.

Dougherty, M. (1999).Field guide to on-farm composting.NRAES-114.Natural Resource, Agriculture, and Engineering Service. Ithaca, New York.

Duncan, D. B. (1995).Multiple range and Multiple T. Test. Biometrics. 11: Pp 1 – 42.

Effiong, G. S, Ekong, U. J., IbiaT. O. and John, N. M. (2012). Palm kernel cake and sawdust composts: chemical properties and effects on maize growth in acid sands of Uyo, Nigeria. Scholars Research Library, *Archives of Applied Science Research*, 2012, 4(3): 1255-1260.

Egharevba, R. K. A, and Ogbe F. M. (2002). The effects of different levels of organic and mineral fertilizers on the yield performance of two *Amaranthuscruentus*cultivars.*The Plant Scientists*. 3: 62-72.

Ehigiator, J. O. (1990). Farm yard manure: Need for its adoption as an alternative to chemical fertilizer uses in Nigeria. *Nigerian Journal of Horticultural Science* 3: 1-9.

Ekong, U. J., Effiong, G. S. and Etim, I. A. (2017).Effects of swine waste and sawdust composts on the performance of eggplant (*Solanumaethiopicum*) on sandy coastal plain soils of AkwaIbom State, Nigeria. *International Journal of Science and Energy Research*, 4 (1): 114-124.

Hanna, W. J. (1964). *Chemistry of the soil*. F. E. Bear (ed). Am. Chem. Soc. Monograph.

Jenny, S. and Malliga, P. (2014). Influence of organic manure on growth and yield attributes of Solanumlycopersicum (tomato) plants. *International Journal of Innovative Research in Science and Engineering*, 2 (8): 1-6.

John, N. M., Adeoye G. O. and Sridhar M. K. C. (1996). Compost Pelletilization Eases end use in Nigeria. Journal of Composting and Recycling, 37 (7): 55-56.

Krishna, R. (2010). Representation of results of particle size analysis, Part 2: Calculation of average particle sizes/diameters and moments from particle size distributions. University of Nebraska, Lincoln, 44-59.

Kumar, M., Ou-Yan, L. and Lin, J. G. (2010).Co-composting of green waste and food waste at low C/N ratio.*Waste Management*. 30: 602-609.

Michel, F. C., Forney, L. J., Huang, J. F., Drew, S., Czuprenski, M., Lindeberg, J. D. and Reddy, C. A. (1996). Effects of turning frequency, leaves to grass mix ratio and windrow versus pile configuration on the composting of yard trimmings. *Compost Science and Utilization*. 4: 26 – 43.

Mina, M., Ahmad, M. G. and Mahmoud, K. (2012).The effect of particle size and composting period on C/N ratio of date-palm waste. The 1st International and 4th National Congress on Recycling of Organic Waste in Agriculture held on 26-27 April, 2012 in Isfahan, Iran.

Murphy, J. and Riley, J. P. (1962).A modified single solution method for the determination of phosphate in natural water.*Anal.Chem. Acta*. 27:31-36.

Nelson, D. W. and Sommer, L. E. (1982).Total organic matter. In: A. L. Page, R. H. Miller and Keenay (eds). *Methods of soil analysis*, part 2, Agronomy. A chemical and microbiological properties.

Ogbodo, E. N. (2012). Alternative media and mixes suitable for growing container vegetables.*American-Eurasian Journal of Agronomy* 5(2): 24-29.

Ogunwande, G. A. (2011). Feasibility study of a v-shaped pipe for passive aeration composting.*Waste Management Resources*, 29 (3), 240-248.

Ojeniyi, S. O. and Adejobi, K. B. (2012).Effect of ash and goat dung manure on leaf nutrient composition, growth and yield of *Amaranthus.Nigerian Agricultural Journal*, 33:46-47.

Onwudike, S. U., Asawalam, D. O. and Ano A. O. (2015). Influence of agro-wastes on soil properties, growth and yield of maize (*Zea mays L.*) in an acid ultisol of Owerri, Imo State. *In:* Proceedings of the 39th Annual Conference of the Soil Science Society of Nigeria, 409-424.

Owolabi, A. O., Adeyeye, A., Oladejo, B. T. and Ojeniyi, S. O. (2003).Effect of wood ash on soil fertility and crop yield in South West Nigeria.*Nigerian Journal of Soil Science*, 3: 323-326.

Sparks, D. L. (1996).*Methods of soil analysis*, part 3. Chemical methods, SSSA book series No. 5.

Zia, M. S., Khali, S., Aslam, M. and Hussain, F. (2003). Preparation of compost and its use for crop production.*Science Technology Development*, 22: 32-44.