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Effect of Solid and Liquid tea compost on the Growth , Yield of *Amaranthus cruentus* and Soil Properties in Ekpoma, Delta State.

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ABSTRACT

Improvement of soil nutrient and organic matter contents is essential to enhance the growth and yield of crops. Two seasons experiment were conducted to evaluate the effect of solid and liquid compost on the growth, yield of *Amaranthus* and soil properties in Ambrose Alli University Teaching and Research Farm, Ekpoma. The treatments (control, compost tea, solid compost) were laid out in Randomized Complete Block Design (RCBD) and replicated thrice. Data on soil nutrient content, growth and yield parameters were analyzed statistically. The application of compost significantly ($p \leq 0.05$) improved the soil nutrient content, organic carbon and increased the pH to near neutral. The total isolate of fungi species (*Aspergillus, Penicillium* and *Fusarium*) was higher in solid compost than other treatments. The fresh and dry yield of *Amaranthus* leaves obtained were significantly ($p \leq 0.05$) higher with the application of compost compared to the control. The fresh leaf weight of *Amaranthus* obtained were 3.56, 16.11 and 18.12 t ha^{-1} from the control, compost tea and solid compost treated soil respectively. In the second season, the fresh leaf weight was; 2.70, 10.17 and 10.69 t ha^{-1} from the application no compost, compost tea and solid compost respectively. The application of compost tea initially increased the growth of *Amaranthus*. However, the highest leaf yield of *Amaranthus* was obtained from the application of solid compost.

1. Introduction

High nutrient and organic matter content characterize good soil, and these qualities can be devoid due to degradation. Soil degradation is the temporary or permanent decline in the productive capacity of the land . It is the result of complex inter-relationships between biophysical and socio-economic issues that affect people and land primarily in the tropics and developing countries (Abdi *et al.,* 2013). Soil degradation rendered vast agricultural land unproductive and resulted in nutrient and organic matter depletion, reduction of water holding capacity and nutrient release (Stoorvogel and Smaling, 1990; Akinbola, 1999).

Ameliorating degraded soil is a significant concern due to its inability to sustain crop production. Moreover, various methods such as the application of animal manure, crop residues, and mineral fertilizers have been employed to sustain crop production. Application of mineral fertilizers has been reported to increase crop yield. However, it reduces colonization of plant root with mycorrhizae and inhibits symbiotic N fixation due to high N fertilization. Also, the use of synthetic fertilizer to sustain crop production was found to increase yield only for a few years but not on a long-term or sustainable basis (Ojeniyi, 2000). In highly weathered soil, the use of synthetic fertilizer has not fully sustained soil due to induced soil acidity, nutrient imbalance and does not improve the physical and biological properties of soil. These emphasized the use of organic fertilizers input as it improves physical, chemical and biological properties of the soil. Linger and Critchdey (2007), also reported that organic fertilizer is preferred to synthetic fertilizer as it improves the nutrient content, better nutrient recycling, activating the microbial biomass and soil tilth. Considering the scale of poultry rearing and wood industries in Nigeria, utilization of poultry manure in combination with wood shaving or sawdust as compost in crop production is an efficient method of disposing of large amounts of organic waste which would have constituted a nuisance to the environment (Ayeni, 2010).

Water-based extract of compost (compost tea) has a relatively long history in agriculture as it helps to improve the soil structure and water holding capacity. According to Arancon, *et al.* (2007), compost tea contains many trace elements and plant grown in it might be more disease resistant than in soil with artificial fertilizer only. Compost teas have been found to increase organic matter content, nutrient availability and microbial activity (Gómez-Brandón *et al.,* 2015). Nutrient in compost teas has been detected in plant root as early as an hour immediately after application (Michael, 2001).

Amaranthus (*Amaranthus cruentus)* is a dual purpose crop with edible leaves and seed. The crop plays both nutritional and medical role in human development. One of the significant constraints to *Amaranthus* production in Nigeria is low soil native fertility. The use of fertilizer, (organic or inorganic) supplements the soil with nutrient, especially nitrogen for lush green leafy growth (Olufolaji and Dimakin, 1988) has been reported by Marere *et al.* (2001). They reported an increase in biomass yield of *A. cruentus* when compost was applied. It is, therefore, necessary to investigate the effects of compost on the soil properties and yield of Amaranthus.

2. Materials and Methods

2.1 Description of Experimental site

The experiment was carried out at the Teaching and Research Farm of Ambrose Alli University, Ekpoma, Edo State, Nigeria. Ekpoma is in the humid rainforest vegetation belt of Nigeria, lying between latitude $6^0 42^1$ North and longitude $6^0 8^1$ East, with an average annual rainfall of 1500 mm and temperature between 15 ^{0}C - 34 ^{0}C. The first season was in May - July 2015; second season May - July 2016.

2.2 Collection of soil for analysis

The topsoil (0-15cm), were collected from the experimental site before the experiment. The soil was air dried, sieved and the samples were analyzed for both chemical and physical properties. Particle size analysis was carried out using (Bouyoucos, 1962), hydrometer method. The pH was determined in water (ratio 1:1, soil: water) (IITA 1979). Organic carbon was determined by wet dichromate method (Nelson and Sommers, 1975), and available phosphorus in the soil was determined using the Bray-1 extraction method (Bray and Kurtz, 1945). Total nitrogen was determined by the Kjeldahl method (Bremner and Mulvaney, 1982). Exchangeable cations, (Potassium, Calcium and Ammonium acetate), Potassium was determined using atomic absorption spectrophotometer (IITA, 1979). Effective cation exchange capacity was determined by the summation of the total exchangeable base and exchangeable acidity.

Nutrient uptake = Dry matter yield (kg) x nutrient content (%).

2.3 Experimental Design

The experimental design was Randomized Complete Block Design (RCBD) with three treatments, replicated three times. The treatments were; Control, Compost tea and Solid compost and *Amaranthus cruentus were used* as a test crop. The Data were analyzed using analysis of variance (ANOVA) and the Least Significant Difference (LSD) at 5 % probability was used to separate means.

2.4 Planting and Management operation

Land preparation (clearing, packing and mapping) was done manually. Planting area was 17.64m^2. The trial was laid in 9 plots with each plot measuring 1.4m x 1.4m and consisted of flatbeds. The *Amaranthus cruentus* seeds were sown and thin to a plant per stand at a planting distance of 30cm x 30cm within and between rows and later thinned two weeks after planting to one per stand with a plant population 81,500 plants per hectare. Weeding was done manually using hoe and cutlass thrice at 2nd, 4th and 6th weeks after planting. Insecticide was applied at the 2nd and 4th weeks after planting to control pests.

2.5 Compost tea material and preparation

Preparation of Compost tea from already made compost: materials required: a drum, muslin bag and a rope. Dried compost of 10 tonnes was suspended in a drum of water for 10 days and cover to prevent excessive evaporation.

2.6 *Application of compost*

The compost tea was applied at the rate of 1litre per plant twice a week from 2nd - 5th week and reduced to once a week at the 6th -7th week after planting. The solid compost was 10 tonnes per hectare and the soil allowed to equilibrate three weeks before planting. The *Amaranthus cruentus* was obtained from the Department of Agronomy, University of Ibadan.

2.7 Collection of data

The following data were collected: Plant height, number of leaves and stem girth and reading was taken at four to seven weeks after planting (4th -7th WAP). Plant height and stem girth were measured with measuring tape and Vernier caliper respectively while the leaves were counted.

Isolation of Fungi

Potato Dextrose Agar and saline were sterilized at 121 ^{0}C for 15 minutes. The saline was used to carry out 10 fold serial dilution of the soil samples. 1ml of dilution 10^{-3}, 10^{-4} and 10^{-5} was inoculated by pour plate method in duplicate in Petri dishes. Incubation was carried out at 37 ^{0}C for 3-5 days.

Identification: Conventional culture and morphological characteristics identified the isolates. Macroscopic identification was made by visualizing surface and reverse pigments on PDA plates while microscopic characterization involved shape, colour and structure of conidia, hyphae, conidiophores and conidial head using lactophenol cotton blue according to the methods of Raper and Fennell (1987).

3. Results and Discussion

The pH value of soil after application of compost tea and solid compost were slightly acidic tending to neutral; 6.50 and 6.60 respectively compared to the initial soil pH of 4.70 (Table 1). This corresponds with the earlier work of Robert (2015), who reported that organic matter application could buffer pH of the soil. The near neutral pH observed in soil treated with compost tea and solid compost also agrees with the findings of Whalen (2000), who reported a similar result that organic manure reduces soil acidity. The total Organic carbon in soil with the application of compost tea and the solid compost were higher than the control. Total nitrogen was higher in soil with the application of solid compost than compost tea and the control. The nitrogen content of 0.85g/kg for the control was below the critical level of 1.20g/kg (Abbet, 2012). The values of available phosphorus and potassium in control were below the critical levels of 15 mg/kg and 0.24 cmol/kg respectively. This shows that available phosphorus and potassium were deficient in the soil and the amending soil with compost improved their status. Calcium and magnesium values in soil without amendment (control) and compost tea amended soil were below the critical level of 3.8 and 2.00 cmol/kg respectively. This indicated that the solid compost has more calcium and magnesium content compared to other treatments. Sodium content in control, compost tea, and solid compost were 0.37, 0.47 and 0.35 cmol/kg which was below the critical level of 10 cmol/kg. According to Isitekhale *et al.* (2013), the application of compost increased the nutrient values of soil above the critical levels which was confirmed by the results obtained.

Table 1: Physical-Chemical Properties of Experimental Soil in First and Second Growth seasons in 2015

Parameters	Units	Control		Compost tea		Solid compost		Compost
		Ist	2nd	Ist	2nd	Ist	2nd	
pH (1:1) H_2O		4.70	4.60	6.50	6.30	6.60	6.70	7.65
Total nitrogen	(g/kg)	0.85	0.58	0.96	1.19	1.23	1.78	4.50
Total organic carbon	(g/kg)	11.20	8.10	13.80	19.70	20.80	22.40	48.50
Available P	(mg/kg)	12.59	10.78	37.97	49.82	53.18	48.81	0.80
Exchangeable cations	(cmol/kg)							
Potassium	(K)	0.15	0.10	0.66	0.11	0.31	0.11	1.87
Calcium	(Ca)	3.36	3.12	3.60	3.92	7.52	5.68	1.28
Sodium	(Na)	0.37	0.25	0.47	0.29	0.35	0.25	0.08
Hydrogen	(H^+)	0.60	0.20	0.20	0.30	0.10	0.10	
Aluminium	(Al^{3+})	–		–		–		
ECEC		5.36	4.95	6.37	6.38	10.28	7.50	
Particle size analysis	g/kg							
Silt		19.00	18.00	21.00	25.00	25.00	35.00	-
Clay		35.00	27.00	47.00	31.00	37.00	27.00	-
Sand		946.00	955.00	932.00	944.00	938.00	938.00	-
Textural class		Sand	Sand	Sand	Sand	Sand	Sand	

Table 2: Effect of Compost manure on height (cm) of *A. cruentus*

	Weeks After planting							
	2015 First season				2015 Second season			
Treatments	**4**	**5**	**6**	**7**	**4**	**5**	**6**	**7**
Control	14.67b	23.22b	35.11b	50.94b	13.78a	16.84b	21.33b	50.94b
Compost tea	35.17a	56.50a	86.50a	118.00a	15.86a	25.98a	44.99a	104.11a
Solid compost	30.67a	55.33a	76.67a	104.11a	20.17a	27.08a	46.66a	116.00
LSD	10.18	9.56	17.35	32.28	7.31	4.96	5.59	10.04

Means followed by the same letters (s) within a column are not significantly ($P \leq 0.05$) different using LSD.

The low fertility status of the control could be attributed to intense weathering, cropping, with high temperature and leaching (Gordon *et al.,* 1993).

3.1 Plant Growth Parameters

It was observed that throughout the growth season, *A. cruentus* grown on soil amended with Compost tea and solid compost were significantly ($P \leq 0.05$) higher compared to the control (Table 2). This confirmed earlier work done by (Lopez-Bucio *et al.,* 2003). Optimum plant height is claimed to be positively correlated with the productivity of plants. The liquid content in tea tends to make nutrient more readily available to plant (Arancon *et al.,* 2007). Compost tea, increased the height of *A. cruentus,* than the solid compost but was not significantly different at the 4th to 7th week after planting.

The number of leaves of *A. cruentus* grown on the soil amended with compost tea, solid compost, and soil with no amendment (control) was not significantly (P≤0.05) different at the 4th week. At the 5th to 6th week after planting, *A. cruentus* grown on solid compost was significantly (P≤0.05) higher than the control. However, there was no significant difference between solid and liquid compost. At the 7th week after planting, compost tea and solid compost were significantly (P≤0.05) higher than the control (Table 3). This showed that compost improved/increased the number of leaves of *A. cruentus* and this agreed with earlier work of Marere *et al.* (2001). At the 5th to 7th week after planting, the stem girth of *A. cruentus* grown on soil amended with solid compost and compost tea was significantly higher (P≤0.05) compared to the control (Table 4).

Table 3: Effect of Compost Manure on Stem girth (mm) of *A. cruentus*

	Weeks After Planting							
	2015 First season				2015 Second season			
Treatments	**4**	**5**	**6**	**7**	**4**	**5**	**6**	**7**
Control	4.01b	7.41b	9.68b	11.52b	2.56b	6.26b	8.43b	10.23b
Compost tea	12.80ab	17.73a	21.27a	25.04a	2.67b	7.18ab	11.46a	15.29a
Solid compost	15.29a	17.15a	20.92a	24.74a	3.78a	8.01a	12.35a	17.18a
LSD	10.70	5.37	6.26	8.65	1.04	1.11	2.32	2.83

Means followed by the same letters (s) within a column are not significantly (P≤0.05) different using LSD

Table 4: Effect of Compost manure on the Number of Leaves of *A. cruentus*

	Weeks After Planting							
	2015 First season				2015 Second season			
Treatments	**4**	**5**	**6**	**7**	**4**	**5**	**6**	**7**
Control	17.06a	21.11b	28.39b	39.17b	13.66b	16.04b	19.08b	26.17b
Compost tea	25.33a	34.17ab	43.67ab	76.83a	14.40b	23.56a	30.21a	49.84a
Solid compost	26.11a	44.44a	56.55a	78.55a	17.55a	25.27a	32.22a	52.44a
LSD	15.23	22.94	23.38	28.00	2.39	1.84	3.09	3.84

Means followed by the same letters (s) within a column are not significantly (P≤0.05) different using LSD.

Table 5: Effect of Compost manure on Nutrient content (g/kg) and Nutrient uptake (ton/ha) of *A. cruentus*

	Nutrient content (gkg^{-1})			Nutrient uptake (tonnes ha^{-1})		
Treatments	**N**	**P**	**K**	**N**	**P**	**K**
control	12.89c	0.80b	15.10b	29.98b	1.91b	36.06b
Compost tea	17.30b	1.33b	16.20ab	258.01ab	19.62ab	237.42a
Solid compost	29.80a	2.00a	17.60a	483.44a	32.88a	280.45a
LSD	3.64	0.58	2.28	269.99	23.44	127.66

Means followed by the same letters (s) within a column are not significantly (P≤0.05) different using LSD.

Table 6: Effect of Compost manure on the Fresh and Dry matter Yield of Amaranthus (t ha^{-1})

	First season						Second season					
	Fresh wt			Dry wt			Fresh wt.			Dry Wt.		
	Leaves	**Stem**	**Root**	**Leaves**	**Stem**	**Root**	**Leaves**	**Stem**	**Root**	**Leaves**	**Stem**	**Root**
Control	3.56b	3.62b	0.74b	1.18b	1.21b	0.25b	2.70b	2.71b	0.50b	0.90b	1.21b	0.25b
Compost tea	16.11a	27.98a	4.35ab	5.37a	9.33a	1.45ab	10.17a	17.45a	2.51ab	3.39a	9.33a	1.45ab
Solid compost	18.12a	30.10a	7.25a	6.16a	10.03a	2.41a	10.69a	18.63a	5.03a	3.56a	10.03a	2.41a
LSD	7.90	15.57	5.12	2.95	5.20	1.72	2.20	2.86	2.85	0.97	5.20	1.72

Means followed by the same letters (s) within a column are not significantly (P≤0.05) different using LSD.

Compost increased the stem girth of *A. cruentus*. This confirms the earlier work of Okokoh and Bisong, (2011). The positive performance of the composted manure on the stem girth response of *A. cruentus* may be due to the balance nutrients the compost contained. However, Solid compost increased the stem girth of *A. cruentus* than the compost tea though not significantly different.

3.2 Nutrient Uptake and Plant Yield

The nitrogen and phosphorus content was significantly ($P \leq 0.05$) higher in solid compost compared to other treatments (Table 5). Potassium (K) content of *A. cruentus* grown on solid compost was significantly ($P \leq 0.05$) higher than the control. However, there was no significant difference between solid compost and compost tea. According to Lopez- Bucio *et al*. (2003); *Oworu et al.* (2010); Soumare *et al.,* (2003); Walker and Bernal, (2008). Compost addition can increase soil nutrient availability and hence nutrient uptake by the plant. The *A. cruentus* fresh and dry weight (leaf and stem) on soil amended with Compost tea and solid compost were significantly ($P \leq 0.05$) higher compared to the control (Table 6). The fresh root and the dry root of *A. cruentus* grown on soil amended with solid compost was significantly ($P \leq 0.05$) higher than the control. However, there was no significant difference between solid compost and compost tea. This result confirms the earlier work done by Marere *et al.* (2001). They reported an increase in dry matter yield of *A. cruentus* when compost was applied. Solid compost increased the fresh and the dry matter yield of *A. cruentus* but was not significantly different from compost tea. According to Alam *et al.,* (2007) and Ogedegbe *et al.* (2013), the application of organic manure significantly ($p \leq 0.05$) increased the growth of amaranthus.

3.3 Fungi isolates

A total of nine different fungi species were isolated from plots amended with liquid, solid compost and soil without compost grown with amaranthus; these include *Aspergillus fumagatus, Aspergillus niger*, *Aspergillus sydowili, Aspergillus ustus, Fusarium species, Penicillium aurantiogiseum, Penicillium brevicompactum, Penicillium camemberti* (Table 6). Dubey and Maheshwan (2005), reported that the cellulolytic fungi such as *Aspergillus* and *Penicillium* accelerate decomposition for efficient recycling of waste with high C/N ratio and reduce composting period. In soil amended with solid compost four species of *Aspergillus* were isolated and identified; *A. fumagatus A. niger, A. sydowili A. ustus; penicillium species; Penicillium brevicompactum, Penicillium camemberti*, and *Fusarium spp.* From the soil amended with compost tea; *A. niger, A. sydowili A. ustus, Penicillium camemberti* and *Fusarium spp* . were isolated. In soil without amendment; *A. niger, Penicillium camemberti*, *Penicillium aurantiogiseum* and *Fusarium spp* . were isolated. Only *fusarium species* was isolated from compost tea. *Penicillium* was another common fungal genus isolated. The isolates were *P. aurantiogiseum P. brevicompactum, P. camemberti.* Its abundance can be attributed to its universal presence as a saprophyte growing on dead leaves, woods, and other decaying vegetation. The spores are widespread and are often associated with organic materials and soil. *Fusarium species* were another fungi isolated from the decomposed waste. Lesile and Summerall (2006) identified *Fusarium spp* . As a common fungi species in the decomposition of organic matter .

4. CONCLUSION

This experiment was conducted to investigate the effect of compost on the growth of *A. cruentus* in degraded soil. The application of liquid and solid compost immensely improved the fertility of the soil, nutrient uptake and yield of amaranthus. In conclusion , solid compost had higher amaranthus yield , fungi isolates and residual effect which make it more suitable to ameliorate degraded soil. However, for quick nutrient absorption and growth of amaranthus, compost tea can be applied to soil.

Table 7: Isolates from Soil amended With and Without Compost

SA_mSC_M	SA_MC_mT	CONTROL	COMPOST TEA
Aspergillus fumagatus	*Aspergillus niger*	*Aspergillus niger*	*Fusarium species*
Aspergillus niger	*Aspergillus sydowili*	*Penicillium camemberti*	
Aspergillus sydowili	*Aspergillus ustus*	*Pencillium aurantiogiseum*	
Aspergillus ustus	*Penicillium camemberti*	*Fusarium species*	
Penicillium brevicompactum	*Fusarium species*		
Penicillium camemberti			
Fusarium species			

LEGEND
SA_m SC_m- Soil amended with solid compost
Sa_m C_mT- Soil amended with Compost Tea

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