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Influence of Cassava Effluent on Phytotoxicity, Nutrient Quality and Stability of Compost

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ABSTRACT

The reckless release of cassava effluent into the environment has posed diverse environmental challenges. Its effects on phytotoxicity, nutrient quality and stability on compost were assessed under windrow composting method. There were two carbon (Rice bran and Sawdust) and nitrogen (Poultry manure and Cow dung) sources. Each of the carbon and nitrogenous feedstock were combined in ratio 1:3 with or without cassava effluent applied at 15 litres per pile. There were two replications. Ambient temperature and those of the composting piles were taken daily. Turning and moisture content were monitored. At compost maturity, composite compost samples were subjected to proximate analysis and phytotoxicity assessment by raising cowpea seedling in the compost extracts in the dark for 72 hours. There were four compost types and two compost extract concentration levels including 50 and 100 %. Two checks including distilled water and raw cassava effluent were considered for comparison. There were two replications laid out in completely randomized design. Data assessed showed that cassava effluent significantly reduced Mn and Fe concentrations in the compost. It further reduced number of days to attain stability by 9 and 19 days in rice bran and sawdust based compost respectively. It also increased the nitrogen content and alkalinity in the compost. Feedstock decomposition rate was increased by 54% in sawdust based compost. Its ability to greatly improve germination index of cowpea with values above the 100 % from distilled water growing medium at both concentrations levels showed the possibility of cassava effluent under aerobic composting condition to release growth stimulating substances into the growing medium.

Introduction

Agro industrial effluents are waste waters from the processing of raw food products from farms. Treatment of agro industrial effluent has become a global issue of concern for actualization of environmental safety. Cassava (*Manihot esculenta*) is a major staple and industrial crop in the tropics. Annual cassava production in Africa is about 84 million tonnes of which Nigeria is the largest producer (FAO, 2001). The processing of this major staple food is associated with generation of lot of waste ranging from solid to liquid wastes (Osakwe, 2012). Cassava effluent is characterized by high organic matter content (soluble carbohydrate and proteins), suspended solids (lipids and non-soluble carbohydrates) and cyanide. (FAO, 2001). The effluents from cassava processing are directly and recklessly released into the environment without adequate treatments. This of course is a source of pollution to both surface and underground water (Nwoko et al., 2010). This is as a result of its high linamarine (cyanogenic glucosides) and phenolic compounds (Onyia et al., 1998; Nwoko et al., 2010). Its high molasses content conferred on it very high biological and chemical oxygen demand from the receiving soils and water. Untreated cassava effluent also have great potential of acidifying soils. Several methods for the treatment of cassava effluent have been suggested including aerobic and anaerobic biological treatments which helps in breakdown of the organic compounds, pH adjustment using caustic materials and composting (Ubalua, 2007).

Composting is the decomposition of raw organic materials under a controlled environmental condition for the formation of biologically stable humic substances suitable for use as soil amendments. This process helps to eliminate odour and phytotoxic substances in the cured product. Composting has received increasing interest as a method of handling various types of wastes (Ogazi and Omueti 2000; Ogunwande *et al.*, 2008). Compost stability is a measure of the intensity of organic matter decomposition in compost. It is expressed as a function of microbial activity in the composting set up. It is generally assessed by microbial oxygen uptakeuptake rate, carbon dioxide production rate and most especially heat release rate in the composting set up.

Phytotoxicity assessment of compost is a measure of compost maturity which shows the suitability of the compost for use on farm lands in terms of absence or reduction of ammonia, lower molecular weight organic acids, dissolved salt and heavy metals contents below critical values (Brewer and Sullivan, 2003). This helps to avoid environmental risks and adverse effects on seed germination, plant growth and development. Concentration of volatile organic acids in compost water extract, determination of heavy metal concentrations and germination test are methods for assessing phytotoxicity in compost. Zucconi et al ., 1981; Tiquia et al., 1996 and Gariglio et al., 2002 had earlier submitted that

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germination test procedure is the best method for assessing phytotoxicity in compost. A germination rate of above 85 % and seedling biomass weight of above 90 % from compost germination phytotoxicity test procedure had been reported for compost with non- toxic substances (Zucconi et al., 1981a; Selim et al., 2012).

Germination index (GI) which is a measure that combines relative seed germination and relative root elongation had been used extensively in the assessment of presence of phytotoxic substances such as ammonia and low molecular weight organic acids in the compost (Tiquia et al., 1996, Wong et al., 2001 and Selim et al., 2012). It is a useful tool in assessing whether a compost is matured and if such compost could have any toxic effect on crop. GI increases with decreasing phytotoxicity (Tiquia and Tam, 1998 and Selim et al., 2012). A compost with GI higher than 60 % is considered matured (Zucconi and De Bertoldi, 1987) while Tiquia et al., 1996 was of the opinion that compost having GI higher than 80 % is free of phytotoxic substances. Compost with GI value higer than 100 % had been reported (Ancuta et al., 2013).

This work aimed at assessing effects of cassava effluent on nutrient quality of rice bran and sawdust based composts. Also to evaluate the safety of cassava effluent treated composts on germination of cowpea.

Materials and Methods

Organic waste collection

The organic materials used for the composting included: rice bran (RB), sawdust (SD), poultry manure (PM), cow dung (CD) and cassava effluent (CE). The carbon sources: sawdust and rice bran were sourced from the local saw and rice mill centres in Ogbomoso, Oyo State. The nitrogen sources including poultry manure and cowdung were sourced from NABEST farms, Aje Ikose and Kraal at Sabo Ogbomoso respectively. The cassava effluent was collected from the local garri processing centre located at Randa area in Ogbomoso.

Proximate analysis of the composting feedstock

Composite samples of the carbon and nitrogen feedstock were subjected to proximate analysis prior to composting largely following methods for plant samples. Moisture content was by oven method (105 °C for 24 hours). Total nitrogen was determined by Micro-Kjeldahl method as described by IITA, 1978. The procedure for ash free organic carbon described by Anderson and Ingram (1996) was utilized for the determination of the carbon content. The pH was determined on 1:4 (feedstock: water) ratio after 15 minutes of equilibration using a calibrated glass electrode. Oven dried and ground feedstock were subjected to wet digestion using perchloric acid, HNO_3 and H_2SO_4 acid mixture and the digest analysed by atomic absorption spectrophotometer to determine the Ca, Mg, Fe, Mn and Zn concentrations and the K and Na read on flame photometer (IITA, 1978). The phosphorus in the digest was determined by the Vanado-Molybdate yellow method (IITA, 1978).

Compost preparation

The composting was carried out at the composting garden of the teaching and research farm of Ladoke Akintola University of Technology, Ogbomoso Oyo State Nigeria. Windrow aeration composting method was used with roof protection from rain and sun. Each of the carbon sources (SD and RB) were combined differently with each of the nitrogen source (PM and CD) in ratio 1:3 (Oyeyiola et al., 2014) on wet weight basis respectively (30 kg: 90 kg) with or without cassava effluent applied at 15 litres per pile in the 5m by 1m windrow. Compost mixtures that received no cassava effluent were moistened with water from the bore hole. There were eight feedstock combinations altogether including:

RB+PM (C1) , SD+PM (C2), RB+CD (C3), SD+CD (C4), RB+PM+CE (C1+CE), SD+PM+CE (C2+CE), RB+CD+CE (C3+CE) and SD+CD+CE (C4+CE). Each of the homogenized composting feedstock was piled up in each windrow and initial temperature taken with a mercury thermometer. The decomposing organic materials were turned every three days for the first 2 weeks. Thereafter, they were piled turned every five days till compost stability.

At compost stability when the temperature of each pile dropped to that of the ambient and remained relatively constant over a period of two weeks, composted samples were randomly taken from each pile, homogenized and labeled. The composite samples were subjected to proximate analysis for the determination of total N, P, K, Ca Mn and Fe contents following procedures earlier described. Data were also taken on the weights of cured compost from each pile for the estimation of

$$\text{Decomposition rate} = \frac{\text{Initial weight of feedstock mix} - \text{final weight of stabilized compost}}{\text{Initial weight of feedstock mix}} \times 100$$

Initial weight of feedstock mix

Phytotoxicity assessment of the cured compost

Experimental design and treatments combination

There were eight compost extracts tagged C1, C2, C3, C4, C1+CE, C2+CE, C3+CE and C4+CE applied at two concentration levels (100 and 50 %). Two control treatments including 10 ml each of distilled water and raw cassava effluent were also compared. The experimental set up was replicated two times to bring about 36 experimental units Procedure for the germination test in compost extract described by Zucconi at al., 1981 and Tiquia et al., 1996 was adopted for use with little modification. Oven sterilized cotton wool at 70° C and cowpea seeds (*Vigna unguiculata*) were utilized. 5 g of each of the eight stabilized compost types were shaken in 50 ml distilled water in 120 ml plastic bottles placed on mechanical shaker for 1 hour. This was followed by filtering through the whatmann filter paper to get the compost extract. 10 ml of each compost extract represented 100 % concentration while 5 ml compost extract mixed with 5 ml distilled water represented 50 % concentration. Compost extract concentrations, raw cassava effluent and distilled water were applied unto appropriate sterilized cotton wool. Ten equal sized selected cowpea seeds were surface sterilized by immersion in 75 % ethanol for two minutes followed by rinsing in distilled water. The treated seeds were then evenly placed on the soaked cotton wool, taped with foil paper to prevent water loss while encouraging in flow of oxygen. The whole set up was placed in the dark at room temperature for 72 hours.

Data collection

Data were collected on number of germinated seeds which was used for the estimation of seed germination percentage using

$$\text{Seed germination percentage} = \frac{\text{Number of seeds germinated in compost extract}}{\text{Number of seeds germinated in distilled water}} \times 100$$

The mean root length of the germinated seedlings from each petri dish was utilized for the estimation of root elongation percentage using

$$\text{Root elongation percentage} = \frac{\text{Mean root length in compost extract}}{\text{Mean root length in distilled water}} \times 100$$

The seed germination and root elongation percentages per treatment as reported by Selim et al., (2012) were utilized in estimating the germination index using

Germination index = Seed germination percentage X Root elongation percentage / 100

Results and Discussion

The nutrient composition of the feedstock used for composting is presented in Table 1. All the feedstock had alkaline pH range of 7.4 – 9.5 except rice bran that was slightly acidic (5.9). The nitrogenous feedstock were higher in nitrogen content while the carbon sources were higher in organic carbon content. Poultry manure was highest in phosphorus, bases and micronutrients. Sawdust was however least in phosphorus and micronutrients.

Table 1. Nutrient composition of the feedstock composted

	pH	N	OrgC	C/N		a	g	
Feedstok		g/kg			g/kg			
Sawdust	7.4	1.3	983.5	756.5	.5	6.7	.8	.8
Rice bran	5.9	6.2	803.5	129.6	.1	.6	.5	.7
Poultry manure	7.6	26.0	627.7	24.1	9.4	7.1	.2	0.6
Cow dung	9.5	19.3	841.1	43.5	.6	.6	.8	.0

The temperature changes during the composting process is shown in Fig. 1. The temperature in all the composting pile rose beyond the ambient temperature a day after the composting set up. All the compost types except SD + CD reached temperature of 50°C and above with RB +CD attaining 56°C at day 6 of composting. This high temperature had been reported to be important for the destruction of weed seeds and pathogens in the composting piles (Ogazi and Omueti 2000; Adewumi *et al.*, 2005). The temperature however began to drop as the weeks rolled by.

Rice bran based compost entered stability stage earlier than sawdust based compost (Fig. 2). Addition of cassava effluent however further reduced the number of days to stability. Cassava effluent saved 9, 1, 19 and 15 days in RB + PM, RB + CD, SD + PM and SD + CD composts treated with it compared with similar compost types without it. The implication of this is that the cassava effluent treated composts get cured faster and assures faster release to the end users. The increased decomposition rate observed from cassava effluent treated compost supports this assertion as shown in Fig. 3. Cassava effluent treatment increased decomposition rate of sawdust based compost by 54 and 6 % in SD + PM and SD + CD compost respectively. The high molasses content including dissolved organic matter in cassava effluent (FAO, 2001) could have served as source of energy to the microbes working on the more lignified sawdust based compost.

Figure 4 shows pH changes during the composting process. Inclusion of cassava effluent in composting feedstock improved pH of the resultant product. Sawdust based compost had higher pH values compared to rice bran based compost. The initial moderately acid reaction (5.7) of the rice bran used for the composting explains this lower pH value compared to sawdust. Cassava effluent treated sawdust based compost gave a range of 8.4 – 9.4 while similar compost without cassava effluent had a range of 8.1 – 8.7. In rice bran based compost, pH range of 7.1 – 8.7 and 6.7 – 7.5 were observed from cassava effluent and no cassava effluent treated compost across day 42.

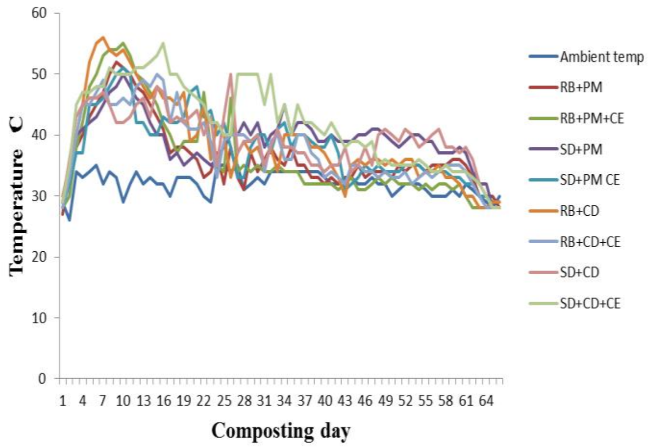


Fig 1. Temperature changes during the composting process in each pile

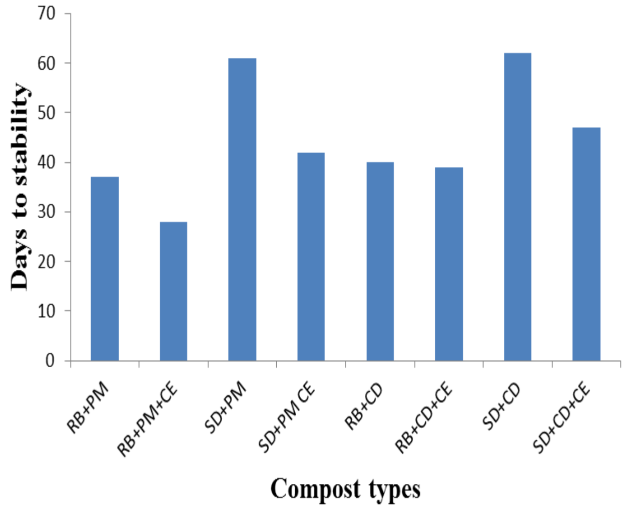


Fig 2. Effects of cassava effluent on number of days to compost stability

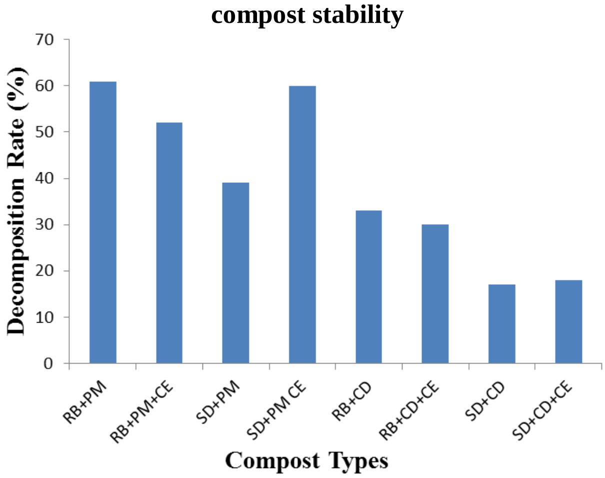


Fig 3. Effects of cassava effluent on the decomposition rate of different compost types

56 and 63 of composting respectively. The alkaline pH range of cassava effluent treated compost as observed from this work suggests this compost type to be a useful amendment on acid soils of the tropics.

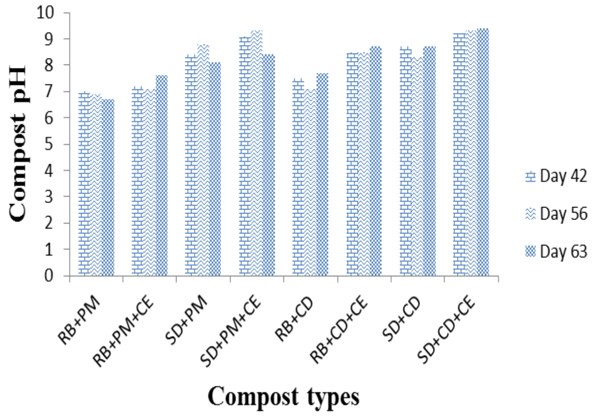


Fig 4. Changes in pH during the composting process

The nutrient content of the stabilized compost is presented in Table 2. The N: P: K values across the carbon feedstock (RB and SD) which received poultry manure were within the range of compost quality considered suitable for use as soil conditioner for farming (Adewumi et al., 2005). Cassava effluent treatment however improved soil pH, organic carbon, nitrogen and calcium contents in all the compost that received it. It however reduced phosphorus and potassium in all the compost except RB + CD.

Table 2. Effects of cassava effluent treatments on compost nutrient composition

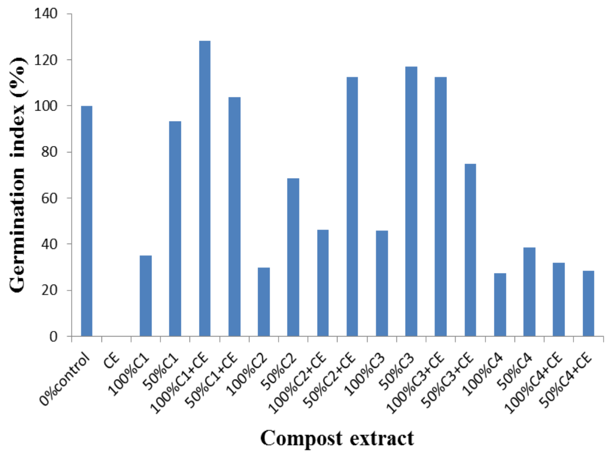
		Org. C	N	P	Ca	K
Compost Types	pH	g/kg				
RB+PM	6.7	609	15.2	23.2	16.3	12.0
SD+PM	8.1	618	17.3	25.2	35.9	14.8
RB+CD	7.7	642	12.5	7.8	11.8	6.8
SD+CD	8.7	595	14.2	21.5	16.9	12.3
RB+PM+CE	7.6	602	16.5	10.3	27.3	8.5
SD+PM+CE	8.4	649	17.9	22.2	37.4	9.6
RB+CD+CE	8.7	630	15.3	8.1	11.3	6.6
SD+CD+CE	9.4	701	16.0	7.2	26.9	9.8

Micronutrient concentrations including Mn, Fe, Cu and Zn were generally higher in compost not treated with cassava effluent (Table 3). Cassava effluent reduced micronutrient concentrations in compost. It was responsible for 11, 20, 36 and 47 % reduction in Mn, Fe, Cu and Zn respectively. The ability of cassava effluent to reduce micronutrients in compost especially Mn and Fe will go a long way to foreclose these micronutrients reaching toxicity levels in soils they will be applied to. This of course is against the report of increasing micronutrient contents in soils treated with raw cassava effluent (Okunade and Adekalu 2014).

Table 3. Effects of cassava effluent on the concentrations of micronutrient in compost

	Mn	Fe	Cu	Zn
Compost Types	mg/kg			
RB+PM	397.6	381.1	27.8	35.5
SD+PM	350	315.7	25.4	42.5
RB+CD	435.5	376.6	19.6	15.3
SD+CD	362.9	338.2	7.2	32.6
Mean	386.5	352.9	20.0	31.475
RB+PM+CE	389.1	276.7	19.8	18.9
SD+PM+CE	293.4	277.3	7.2	15.6
RB+CD+CE	424.9	268.3	10.1	17.4
SD+CD+CE	272.32	309	14.3	14.7
Mean	344.93	282.825	12.85	16.65

The effects of cassava effluent on germination index (GI) of cowpea seedling under two concentration levels across the different compost types is shown in Fig.5. Sole cassava effluent treatment had toxic effect on the cowpea by not been able to support cowpea germination. Its toxicity on crops has been widely reported (Onyia et al., 1998; Nwoko et al., 2010; Osakwe 2012). Conversely, its addition into compost generally increased GI compared to similar compost without it except in C3 and C4 at 50 % concentration level. A GI range of 27.4 – 116.8 % and mean of 56.9 % was observed from compost without cassava effluent. Compost treated with cassava effluent however gave a range of 28.4 – 128.2 % and a mean of 79.4 %. The GI values of 100 % concentration level were consistently below 60 % considered critical for matured compost (Zucconi and De Bertoldi, 1987). The implication of this is that such application rate at 100 % (which mimics seed sowing immediately after compost application on the field) could have toxic effects. Thus, the reasons for delaying seed sowing for at least 2 weeks after compost application. This time lag allows the reduction of the initial high concentrations of organic acids released at the commencement of mineralization reaction which could be toxic to plant. The higher GI values (> 60 %) in 50 % concentration level in all the compost types even without cassava effluent except in compost C4 support this assertion. The 50 % concentration level mimics delaying seed sowing after compost application and it assures better conditions for the growth of cowpea seedling. It was however interesting to observe increased GI in 100 % concentration level when cassava effluent was added across all the compost. The GI increased by 73, 35, 59 and 14 % in compost C1, C2, C3 and C4 applied at 100 % concentration level respectively. This suggests ability of cassava effluent to improve growth condition of crops in compost treated with it. The high molasses content and other components such as proteins and minerals in cassava effluent might have served as source of extra energy and tissue building for the microbes to effectively work during composting such that state of compost stability and maturity was reached. Cassava effluent treated 100 % C1, 50 % C1, 50 % C2 and 100 % C3 gave GI values of above 100 % compared to the standard control treatment (Distilled water). These composts treatments were practically free of phytotoxic substances and possibly containing growth stimulating substances that could support better plant performance.



Where: CE = cassava effluent, C1 = RB + PM compost, C2 = SD +PM compost, C3 = RB + CD compost, C4 = SD + CD compost.

Conclusions

Cassava effluent inclusion in compost encouraged faster decomposition rate and reduced number of days to compost stability especially in sawdust based compost. It also improved pH, nitrogen and basic cations contents of the resultant cured composts. Germination index of cowpea was increased by cassava effluent treatment with values higher than the standard 100 % in C1, C2 and C3. Treating compost with cassava effluent help alleviate the fear of compost scotch on seedling when seed sowing immediately followed compost application. The present results infers that inclusion of cassava effluent in composting feedstock will not only result in timely production of highly stabilized phytotoxic free compost, but also help circumvent the environmental challenges associated with its reckless release into the environment.

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