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Plant nutrient release composition in vermicompost as influenced by Eudrilus eugenae using different organic diets

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Sub-adult earthworms, Eudrilus, Eugenae were cultured for 100 days in rubber containers made from old tyres to determine the plant nutrient release composition in vermicompost using different organic diets. The diets are Andropogon grass + Pig manure (AGPM) Andropogon grass (AG), Bracharia grass + pig manure (BGPM) and Bracharia grass (BG). Result of the study show that the produced vermicompost in each diet consisted mostly of high quality humus with favorable pH level and high cat ion exchange capacity (CEC) which varied with the diets. Pig manure enhanced the CEC of the vermicompost by 114.82%. Available P, exchangeable Ca and Mg were significantly (p = 0.05) increased in the vermicompost and varied among the various diet treatments. Available P was greatest with Andropogon vermicompost relative to the Bracharia vermicompost. Pig manure enhanced the release of available P of Andropogon vermicompost by over 185% and over 1000% in Bracharia vermicompost relative to the grass vermicompost alone. Exchangeable Ca and Mg of Bracharia vermicompost was enhanced 32 and 74% respectively by Pig manure. Results of the study also show increase in earthworm biomass production and cocoon size in the vermicompost which varied among the diet treatments and non-significant difference among the vermicompost in water holding capacity. Weight loss from composition and decomposition rate was highest in BG relative to BGPM, AG and AGPM. Average decomposition rate of the grass diet was 75.25%. Earthworm (Eudrilus eugenae) through its activities increased the rate of decomposition and degradation of organic wastes and is effective in plant nutrient release if subjected to proper culturing with suitable feed materials.

Key words: Eudrilus eugenae, vermicompost, Brancharia grass, Andropogon grass.

INTRODUCTION

The activities of earthworms in the decomposition, degradation, nutrient recycling and nutrient release of organic matter cannot be over emphasized. Numerous experiments by researchers and scientists using artificial cultures highlighted the tremendous effect of earthworm on plant litter degradation. The amount of soluble mineral matter in compost is increased by the activity of these organisms following their feeding on plant litters and compositing activities, digestion and decomposition proceeded nutrients were released to the benefit of crops. Worms accelerated nutrient release (Allison 1973). Mba (1984) showed that high earthworm activity resulted in considerable enzymatic activity, microbial biomass as well as high availability of nutrients and decreased cyanide contents in cassava peels. Also Mba (1989), using Eudrilus eugenae on fermented paspalum digitatum reported high activity of the worms and nutrient availability. Edwards et al. (1990) observed that some species of

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earthworm facilitate the break down and mineralization of surface litter while others incorporate soil organic matter deeper into the soil profile and enhance aeration and water infiltration through burrow formation, hence they reduce and prevent the accumulation of raw organic matter (fallen leaves) remains on the soil surface.

Similarly, Satchell (1967) reported that earthworm not only metabolize carbon but also increase organic matter decomposition by stimulating microbial activity. In another study Satchell (1955) observed three times higher earthworm activities and population in a plot receiving 0.75 ton/ha every four years than that of unmanured. The conjunction work between the earthworm and soil micro-organism in decomposition and degradation of organic matter especially resistant plant material is commendable, as earthworms not only decompose material themselves but stimulate other decomposers. The production of cellulases, chitinases and other degrading enzymes from the interaction activities of earthworm and micro-organisms help in the breakdown of cellulose of plant tissue, chitin of fungi and perhaps insect cuticle (Griffin, 1972).

The processes of using species of earthworm to compost organic materials are referred to as vermin composting. It is a biotechnological process of waste conversion to produce a better product which is vermicompost. Vermicomposting differs from composting in several ways (Gandhi et al., 1997). It is a mesophilic process, faster than compositing, because the material passes through the earthworm gut where significant transformation takes place and resulting earthworm castings (worm manure) are rich in microbial activity and for strong retention of nutrients, plant growth regulator and other plant growth influencing materials produced by micro-organisms including humates and fortified with pest and root knot nematode repellence attributes as well (Nagavallemma et al., 2004; Asha Aalok et al., 2008; Grappelli et al., 1987; Shi-wei and Fu-Zhen, 1991; Arancon et al., 2005b, 2006, 2003; Atiyeh et al., 2002). Containing water soluble nutrient and bacteria, vermicompost is an excellent nutrient rich organic fertilizer and soil conditioner (Appelhof, 1997). Vermicompost contains most nutrients in plant available form such as nitrates, phosphates and exchangeable calcium and soluble potassium (Edwards, 1998; Orozco et al., 1996).

Besides many methods of waste disposal such as burning, incineration, land filling or compost, the most competent and ideal method for the disposal of solid waste that pose a threat to environmental harmony can be achieved through vermiculture (earthworm farming). It is a biotechnological process of converting the organic waste into compost. This biotechnological process could provide an alternative solution to tackle the problem of safe disposal of waste as well as the most needed plant nutrients for sustainable crop production and soil productivity. In fact, earthworms, through a type of biological chemistry, are capable of converting refuse into a useful product in vermicompost. Thus this study was setup with the aim and objectives to evaluate plant nutrient release composition in vermicompost as influence by Eudrilus eugenae using different organic diets.

MATERIALS AND METHODS

Two species of grass, Bracharia SPP and Andropogon gayanus and Pig manure were used as a source of diet in this study to produce vermicompost using Eudrilus eugenae earthworm. The four different diet treatments were prepared as follows:

Bracharia grass B
Bracharia grass + Pig manure BG
Andropogon A
Andropogon grass + Pig manure AG

1.5 kg of air-dried Bracharia and Andropogon grass were each pre-composted for 2 weeks with or without 0.5 kg of air-dried Pig manure and the mixture (diets) was subsequently air-dried for 2 days. Each treatment was place in rubber containers made from old vehicle tyre. Treatments were replicated 4 times. The worms used in this study were isolated from soil-paspalum grass culture. Eight (8) sub-adult earthworms of Eudrilus eugenae were collectively weighed and inoculated to each of the 16 rubber containers of four treatments. One side of each of the tyre container was covered with fiber sack so that it can have bottom. Each of the treatments was staged together in one frame, while the foot of the frames stood in side a cup containing condemned oil and the entire treatment were covered with a polythene sheet. The oil protect the earthworm from predators and parasites like ants, beetles, centipedes, slugs, leeches and flatworms, that attack earthworms in green house as was reported by Lofty and Edwards (1972).

Treatment types were placed under shade and watered at rate of 130 ml per rubber container. Daily routine involved uncovering (that is, polythene sheet removed) of the entire treatments every morning to monitor earthworms activities and to ensure fresh air circulation in the culture and as well as to minimize carbon di oxide build up. The culture is later covered at mid-day. The cultures were watered on every other day to maintain moisture at the rate of 130ml per rubber container. After 100 days inoculation, the worms were harvested by hand sorting and the adult worms were weighed collectively per rubber container. The resulting vermicompost made up mostly of earthworm casts; and very little grass residues were collected and aliquot was taken for the chemical analysis of the vermicompost and oven dry matter content determination.

Decomposition rate

Another experiment was setup to determine the decomposition rate of Bracharia and Andropogon grass with or without Pig manure using 250 g of grass to 80 g of Pig manure. The grass was stipped in water for 2 days while the Pig manure was moistened overnight. The mixtures were prepared as follows: Andropogon grass + Pig manure (AGPM) Adropogon grass (AG), Bracharia grass + Pig manure (BGPM) and Bracharia grass (BG). Each mixture (treatment) was replicated three times. The mixture were properly mixed and bagged with polythene and tied up properly to prevent air-entry (air tight). The experiment was allowed a period of two (2) weeks after which the rate of decomposition was determined.

Laboratory methods

The resulting vermicomposts were analyzed for pH using a Digital pH meter. The values were determined both in H_20 and 0.1 NKCL

Table 1. Compost production by Eudrilus eugenae and water holding capacity of Vermicompost.

Treatment	Composts Initial dry matter	Vermicompost dry matter g/kg	Vermicompost water holding capacity %
AGPM	41.15	2.73	283.30
(AG)	32.85	2.06	322.47
BGPM	46.47	4.01	335.28
BG	53.66	2.59	243.70
LSD 0.05	0.94	0.11	NS

AGPM = Andropogon gayanus + Pig manure, AG= Andropogon grass, BGPM= Bracharia grass + Pig manure, BG= Bracharia grass, LSD=Least significant difference.

Table 2. Chemical properties of the Vermicompost of different Organic diets

Treatment	% Carbon	CEC $Cmolkg^{-1}$	pHH_2O	Avail. $Mgkg^{-1}P$	Ca $Cmolkg^{-1}$	Mg $Cmolkg^{-1}$	pHn 0.1N kCl
AGPM	28.90	304	6.27	1074.5	83.71	29.28	6.05
AG	31.21	265	6.03	376.52	92.91	30.37	5.84
BGPM	31.86	308	6.39	760.73	107.77	53.64	6.05
BG	35.39	268	6.52	68.32	81.66	30.85	6.12
LSD0.05	0.71	5.07	NS	0.73	0.50	0.15	NS

AGPM= Andropogon gayanus + Pig manure, AG= Andropogon grass, BGPM= Bracharia grass + Pig manure, BG= Bracharia grass. LSD=least significant difference.

with solid to liquid ratio of 1:2.5. Exchangeable cat ions (Ca^{2+} and Mg^{2+}) were extracted with ammonium acetate by Perkin Elmer atomic absorption spectrophotometer (Tel and Rao, 1982) while cat ion exchange capacity (CEC) was obtained by the method of Jackson (1958). Organic carbon (OC) was analyzed by the method of Nelson and Sommers (1982). Available P was determined by Bray II method, Bray and Kurtz (1945).

Data generated from the study was analyzed using analysis of variance (ANOVA) tested on randomized complete block designs (RCBD) according to steel and Torrie (1980).

RESULTS

Daily examination of earthworm activities

Daily examination of the worm culture revealed that worm's activities were prominent at the middle and bottom of the cultures. Castings were noticed in all the cultures at exactly 4 days after inoculation. Degradation of culture materials was most intensive with Andropogon grass + Pig manure culture, followed by Andropogon grass culture in contrast to the Bracharia grass + Pig manure and Bracharia grass treatments were distinct decomposition was observed about 13 days later. This was reflected in the kind of result obtained from the investigation summarized in Tables 1 to 4.

Compost production/Water holding capacity (WHC)

The percentage compost production of the two grass diet differed significantly (P = 0.05). Table 1 showed that the order of compost production among the organic materials were BG > GBPM > AGPM > AG. The average compost production of the grass was 43.53 g/kg diet. Pig manure enhanced compost production with both grass diets particularly with Bracharia even though the contribution of the manure was negligible.

The vermicompost dry matter content of the treatments in Table 1 were significant (P=0.05), the highest value of 2.06 g/kg was recorded in AG. Average dry matter content of the vermicomposts of the grass was 2.85 g/kg. The water holding capacities of the vermicomposts were similar (Table 1). Pig manure enhanced water holding capacity with both grass diets, particularly with Bracharia (BGPM). Average percentage water holding capacity of the grass was 296.19%.

Chemical composition of vermicompost

The result of chemical analysis of vermicompost of different organic diet summarized in Table 2, showed that the vermicompost differed significantly (P=0.05) in all the chemical parameters assessed except pH. The vermicomposting activities of Eudrilus eugenae increased the nutrient composition of the vermicompost. The two grass diet differed significantly (P=0.05) in their effect on the carbon content of the vermicompost (Table 2). The highest carbon level was observed in unmanured Bracharia grass relative to the manured ones. This indicated that the effect of manure was however not

Table 3: Effect of Vermicompost of different organic diets on Eudrilus Eugenae biomas production, Survival rate and Cocoon size

Treatment	Initial dry weight of worm g/kg diet	Dry earthworm biomass at harvest g/kg diet	Survival rate of worm %	Cocoon size mg/kg diet
AGPM	7.4	20.9	104.2	18.1
AG	7.9	13.8	66.7	17.6
BGPM	7.7	13.0	79.2	14.1
BG	6.9	15.4	95.8	11.9
LSD0.05	0.5	4.0	0.51	0.50

AGPM = Andropogon grass + Pig manure, AG = Andropogon grass. BGPM = Bracharia grass + Pig manure, BG = Bracharia grass. LSD = Least significant difference

significant. With Andropogon and Bracharia grass manured, C level was slightly reduced by vermicomposting.

The CEC values of the vermicompost in Table 2 was significant (P=0.05). The CEC values of AGPM and BGPM vermicomposts were higher than that of the AG and BG vermicomposts. The order of increase in CEC of the vermicompost were BGPM>AGPM>BG>AG. Pig manure enhanced the vermicompost CEC of both grass species by 114.82% relative to the unmanured grass diet. The net charge of vermicompost judged from the pH in water and in 0.1NKCL was negative. The pH was similar among treatments it varies from 6.03 to 6.52 among vermicompost in water and 5.84 to 6.12 in 0.1 NKCL.

The grass species significantly (P=0.05) vary in their influence on the P level of the vermicompost. Available P was greatest with Andropogon relative to the Bracharia. Pig manure contributed significantly to the available P particularly with the Bracharia grass. While Pig manure contribution enhanced the available P of Andropogon vermicompost by over 185%, its contribution to the available P with Bracharia was over 1000% relative to the grass vermicompost.

Exchangeable Ca of the vermicompost vary significantly (P=0.05) among the various treatments. The order of increase in the Exchangeable Ca were BGPM > AG > AGPM > BG. Pig manure enhanced the exchangeable Ca of Bracharia vermicompost by 32%, while the manure contribution to the Exchangeable Ca with Andropogon vermicompost was negligible.

Similar to the Ca level of the vermicompost, the exchangeable Mg vary significantly (P=0.05) among the treatments. Pig manure enhanced the Mg level of Bracharia vermicompost by 74%. The trend of increase of Mg level in the vermicompost, however, were BGPM > BG > AG > AGPM.

Earthworm biomass production

The result of the experiment (Table 3) show that the vermicompost significantly (P=0.05) increased the earthworm (Eudrilus eugenae) weight, survival rate of worm and cocoon size. These parameters differed among the treatments. The highest weight of 20.9 g/kg diet earthworm biomass was obtained in the AGPM diet.

The percentage increase in weight observed in the treatments relative to initial weight was 182.4% (AGPM), 74.7% (AG), 68.8% (BGPM), and 123.2% (BG). The average production of earthworm biomass was 15.78 g biomass/kg diet. Pig manure enhanced biomass production with both grass diets particularly with Andropogon grass. The survival rate of the worms was influenced by the different diets the highest percentage survival rate of the worms was recorded in AGPM. With regard to the cocoon size, the order of increase were AGPM > AG > BGPM > BG. Cocoon size was significantly (P = 0.05) influenced by the diets (Table 3). With Andropogon diet cocoon size was 28.4% greater than the Bracharia treatment. Pig manure slightly enhanced the cocoon size of the grass species.

Decomposition rate

The result of the study (Table 4) showed that the weight loss from composting and decomposition rate differed significantly (p=0.05) among the treatments.

The weight loss was highest in BG relative to BGPM, AG and AGPM diets. The result of decomposition rate (%) was similar to the weight loss, the highest rate was observed in BG diet. The order of increase in percentage decomposition rate were BG > BGPM > AG > AGPM. Average decomposition rate of the grass diet was 75.25%, Pig manure enhanced decomposition in both grass diets particularly with Bracharia grass.

DISCUSSION

The result of this study indicated that Eudrilus eugenae can be cultured successfully using rubber containers made from old tyre, and that it could produce vermicompost from Andropogon grass, Bracharia grass and Pig manure. Also that Eudrilus eugenae can make use of plant materials as a source of feed. The significant difference in compost production of the two grass diet could be attributed to preference in grass diet by the

Table 4 Decomposition rate of Andropogon grass and Bracharia grass with or without Pig manure.

Treatment	Weight loss from composting g/kg	Percentage (%) rate of decomposition
AGPM	303	69.7
AG	268	73.2
BGPM	217	78.3
BG	203	79.7
LSD0.05	4.10	1.1

AGPM = Andropogon grass + Pig manure, AG = Andropogon grass BGPM = Bracharia grass + Pig manure, BG = Bracharia grass. LSD = Least significant difference

earthworm species in Eudrilus Eugenae. Toutain et al. (1982) noted that earthworm show a preference for particular parts of a plant. The non-significant value observed in the water holding capacity among the grass vermicompost with or without Pig manure cultures might be due to soilless nature of the compost. If the vermicompost where produced in the presence of soil, formation of burrows may have produced macro pores that will increase water infiltration and aeration. Fallani (1978) showed that earthworm activities correlated with higher infiltration rate, while Urbanek and Do lezal (1992) reported that earthworm channels contribute to the water movement and relation under natural condition. The organic carbon content reduction observed among the diets could be due to utilization of carbon by the earthworm as carbon and energy sources during the biosynthesis associated with growth and productivity. The result of the CEC value could be a reflection of high humification activities of compost materials, which involved the breakdown of plant residue by earthworm into smaller particles giving rise to large specific surface area and the formation of good quality colloids. It can also be attributed to increased maturity of the bio product as decomposition proceeded. The amount of available P was found to be increa-=sed in all the diets and the value of exchangeable Ca and Mg was also influenced by the compositing activities of Eudrilus eugenae. The result could be explained on the ability of earthworm to modify characters of organic materials and productivity of the resultant product in vermicompost. Oxygenation and biological activities are highly affected by earthworms through microbial interaction. This obviously must have contributed to the modification of the diets degradation rate, chemical properties and plant nutrient release of the vermicompost. Vermicompost contains most nutrients in plant available form such as nitrates, phosphates and exchangeable calcium and soluble potassium (Edwards, 1998; Orozco et al., 1996). The pH results show that the resultant vermicompost in each diet consisted mostly of high quality humus with favorable pH level. The increase in earthworm biomass production, survival rate of worm and cocoon size could be as a result of increased nutrients in the vermicompost and of nutrients thereof, by earthworm for growth and productivity, especially with regards to Andropogon Pig manure diet. Mba (1988) found out that hatchability and number of worms per hatch were negatively correlated to weight and cocoon size are varied with the stage (duration days) of vermicompositing at which the cocoons were laid. The result of the decomposition of the two grass species suggests that the addition of animal manure will bring about faster decompose-tion of organic materials probably as a result of rich in microbial population.

Results of this study showed that earthworm through the compositing activities increased decomposition, degradation rate and nutrient release of organic diets, Effective in bio waste conversion and if properly cultured can be an effective tool in waste management and bio fertilizer production. The result equally showed that Eudrilus eugenae is effective in plant nutrient release if subjected to proper culturing with suitable feed materials.

REFERENCES

Allison FE (1973). Soil organic matter and its role in crop production. Elsevier Scientific pub. Company Amsterdam, London, New York.

Appelhof M (1997). Worms eat my garbage. 2nd edition, Kalamazoo. MI flower press P3.

Arancon NQ, Yardin EN, Edwards CA, Lee S (2003). The trophic diversity of nematode communities in soils treated with vermicomposts. Pedobiologia, 47:731-735.

Arancon NQ, Edwards CA, Bierman P. Metzger JD, Lucht C (2005b). Effects of vermicomposts produced from cattle manure, food waste and paper waste on the growth and yields of peppers in the field. Pedobiologia 49, 297-306.

Arancon, NQ, Edwards CA, Yardin EN, Oliver T, Byrne RJ, Keeney G (2006). Suppression of two spotted spider mite (Tetranychus Urticae) mealy bugs (Pseudococus SPP) and aphid (Myzus persicae) populations and damage by vermicomposts. Crop production 26, 29-39.

Asha Aalok A, Tripathi K, Somi P (2008). Vermicompositing: A better option for organic solid waste management. J. Hum. Ecol. 24(1): 59-64.

Atiyeh RM, Lee SS, Edwards CA, Arancon NQ, Metzger JD (2002b). The influence of humic acid derived from earthworm-processed organic wastes on plant growth. Biores. Technol 84:7-14

Bray RH, Kurtz IT (1945). Determination of total organic and available forms of Phosphorous in soils. Soil Sci: 59.39-45.

Edwards CA (1998). The use of earthworm in the breakdown and management of organic wastes. In Earthworm Ecology C.A.Edwards (Ed) pp. 327-254, CRC Press Boco Roton, FL.

Edwards WM, Shipitalo MJ, Owens LB, Norton LD (1990). Effect of lumbricus terristaris L. burrows on hydrology of continuous no till corn fields. Geordema 46:73-84.

Fallani E (1978). Die Boden Fauna in Dquerkucturen mit unterschieducher Bodenbedeckung Ergebnisse eines Fellversuchs

Mit einer Erhebung in Nirdian. Ph. D thesis Univ. Giessen.

Gandhi M, Sangwan V, Kapoor KK, Dilbaghi N (1997). Composting of household wastes with and without earthworms. Environ. Ecol. 15(2):432-434.

Grappelli A, Galli E, Tomati U (1987). Earthworm casting effect on Agaricus bisporus fructification. Agrochemical 21:457-462.

Griffin DM (1972). Ecology of soil fungi Chapman and Hall Ltd. London.

Jackson, M.L. (1958). Soil chemical Analysis prentice Hall. Eaglewood cliffs NJ pp. 511-1519.

Mba CC (1984). Decomposition of cassava by Eudrilus eugenae (King Berg). Beitrege Trop. Land witch Verterinamed 22 H.L 41-46.

Mba CC (1988). The effect of diet and incubating media on the production and hatchability of the earthworm *Eudrilus eugenae* (King Berg) cocoons. Rev. Biol. Trop. 36(1):89-95.

Mba CC (1989). Biomass and vermicompost production by earthworm Eudrilus eugenae (King Berg) Rev. Biol. Trop. 37(1):11-14.

Nagavallemma KP, Wani SP, Stephane Lacroix, Padmaja VV, Vineela C, Babu Rao M, Sahrawat KL (2004). Vermicomposting: Recycling wastes into Valuable organic fertilizer. Global theme on Agro ecosystem Report no.8 Patancheru 502324, Andhra Pradesh, India ICRISAT. p. 20.

Nelson DW, Sommers LE (1982). Total organic carbon and organic matter. In Pege C.A. Miller, R.H.Keeny D.R. (Eds). Method of soil analysis part2, 2nd edn. Agronomy monograph No.9 ASA and SSSA. Madison 1:539-579.

Orozco FH, Cegarra J, Trujillo LM, Roig A (1996). Vermicomposting of coffee pulp using the earthworm Eisenia Foetida: effects on C and N contents and the availability of nutrients. Biology and fertility of Soil, 22: 162-166.

Satchell JE (1955). Earthworm In soil Zoology D.K.McE, Kavan (ed.) Butterworth, London. pp. 180-201.

Satchell JE (1967). Lumbricidae In soil Biology. Burges, A. and Raw, F. (Eds) Academic press, New York pp. 259-322.

Shi-wei Z, Fu-Zhen, H (1991). The Nitrogen uptake efficiency from ^{15}N labeled chemical fertilizer in the presence of earthworm manure (cast) pp 539-542. In Advances in management and conservation of soil fauna. GKVeeresh, D Rajgopal, CA Viraktamath (Eds). Oxford and IBH Publishing Co. New Delhi, Bombay.

Steel GD, Torrie JH (1980). Procedures of Statistics. A biometrical Approach 2nd edn McGraw Hall Book Co Inc. New York p. 633.

Tel DA, Rao R (1982). Automated and Semi-automated method for soil plant analysis. Manual series No711 TA Ibadan.

Toutain F, Villemin G, Albrecht A, (1982). Ultra structural study of biodegradation processes. II Enchytraeids-Leaf litter models. Pedobiologia, 23:145-156.

Urbanek J, Dolezal F (1992). Review of some case studies on the abundance and on the hydraulic efficiency of earthworm channels in Czechoslovak soil, with reference to the subsurface pipe drainage. Soil Biol. Biochem. 24:1563-1572.