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NUTRIENT ANALYSIS OF THREE EARTHWORM CAST-TYPES COLLECTED FROM IKENNE, OGUN STATE, NIGERIA

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ABSTRACT

Three types of earthworm cast, i.e. pellet cast, turret cast and mass cast, were analysed for physico-chemical characteristics, nutrient composition and compared with impact on soil fertility. The standard methods of AOAC was used to analyse the pH, moisture content, cast profile, cations (Ca, Mg, Na, K, Mn, Cu and Zn), anions (P, PO_4, NO_4, NO_3, N), Organic Carbon and Organic Matter. Pellet cast recorded a significantly higher pH of 8.60±0.01 while the mean pH of 8.09±0.01 and 7.81±0.01 were obtained for turret and mass cast respectively ($p<0.05$). On the other hand, pellet cast recorded the lowest moisture content (29.42%) compared with 45.60% and 47.19% obtained for mass cast and turret cast respectively. The % organic matter (1.05±0.02), % organic carbon (0.61±0.01), % Nitrite (0.008±0.001), % Nitrate (0.018±0.001), % Nitrogen (0.063±0.001) and % Phosphorus (0.39 ± 0.001) obtained for Pellet Cast were significantly higher ($p<0.05$) than those obtained for mass and turret casts. Pellet cast had higher Ca (11.04±2.80 mg/dL), Mn (113.08±38.45 mg/dL) and Zn (8.54±2.62 mg/dL) than turret (9.64±0.77, 77.0±17.02, 6.68±1.65 mg/dL) and mass cast types (4.54±0.25, 19.12±6.82, 2.04±0.70) mg/dL). This study indicated that pellet cast has poor water holding capacity whereas it has higher nutrient concentration compared with mass and turret casts. On the overall, pellet cast, mass cast and turret cast all played synergistic role in soil fertility.

Keywords: Earthworm casts, moisture content, nutrient composition, organic matter, soil fertility

INTRODUCTION

A worm casting is a biologically active earthen mound containing thousands of bacteria, enzymes, and remnants of plant materials and animal manure, that were not digested by the earthworm (Appelhof, 1982). An important component of casting is humic acid, which provides binding sites for plant nutrients such as calcium, iron, potassium, sulphur and phosphorus and releases them on demand to the plants (Holcombe and Longfellow, 1995). This indicates as suggested by Delahaut and Koval (2002), that nutrients from both particles of organic and inorganic matter that would otherwise remain unavailable to plants are liberated in castings.

The humus-rich earthworm casting has been shown to play important role in soil fertility and productivity. According to Faniran and Areola (1980) earthworm casting stores and supplies about 90-95% of soil nitrogen, 50% of phosphorus and 80% of sulphur. Earthworm casting shares the ability of clay to hold and exchange cation nutrients on negative exchange surface sites (Faniran and Areola, 1980). Comparatively, the analyses of castings and their surrounding soils have shown that castings contain seven times more phosphorus, five times more nitrogen, eleven times more potassium and three times more exchangeable magnesium and one and one-half times more calcium (de Vleeschauwer and Lal, 1981; Brady and Weil, 1999; Delahaut and Koval, 2002). In addition, studies have shown that cast production by earthworms is an important activity that contribute greatly to soil fertility by stimulating natural activity of beneficial microorganisms, promoting the activity of enzymes and natural growth regulators and as such are beneficial to plants (Feller *et al.,* 2003). The study of Vinotha *et al.* (200) and Sabrina *et al*. (2009) showed that earthworm cast contains population of beneficial microorganisms, microbial enzymes, micro- and macro-nutrients. Card *et al*. (2004) reported that earthworm casts had 10-20 times microbial activities than the parent organic material ingested by the earthworms.

Three major earthworm cast types are recognized in the Nigerian ecological zones, each of which is produced by different groups of earthworms. The granular (pellet) casts are produced by *Eudrilus spp, Agrotoreutus spp, Eutoreutus spp*. Turret (funnel shaped) casts are produced by *Hyperiodrilus africanus, Ephyriodrilus afroccidentalis* and the mass (mouldy) cast is produced by *Libyodrilus violaceus* and *Alma millsoni* (Madge,1966; Madge and Sharma, 1969; Sims, 1971; Segun, 1976). Since the various earthworms differ in their ducts and digestive activities, their characteristic cast types are expected to differ in organic and nutrient composition as well as their relative contribution to soil fertility.

The objective of this study therefore is to determine the organic and nutrient composition of Pellet, Turret and Mass Casts, and ascertain their relative contribution to soil fertility.

MATERIALS AND METHODS

Cast collection

Cast samples were collected in three replicates of 50 g each, at the Ikenne Campus of Olabisi Onabanjo University, Ogun State, Nigeria. Turret casts (Plate 1) were collected from under hedgerows within the University Campus, while the Mass (Plate 2) and Pellet (Plate 3) Casts were collected 300 cm away from the hedgerows. The different Cast samples were collected into various pre-labelled polythene bags and taken immediately to the laboratory for air drying. The soil samplings were analysed for organic and nutrient composition at the ROTAS Soil Laboratory, Ibadan, Oyo State for analysis.

Physicochemical analysis of casts

The pH of the casts was measured using top loading O'Hauz Digital pH meter. Moisture content was determined by conventional means of oven drying to a constant weight. Particle size grades was mechanically analysed by hydrometer method (Boyoucos, 1951; Anderson and Ingram, 1993). Percentage organic carbon and organic matter were determined by the Walkey-Black method (Walkey and Black, 1934). Available Phosphorus was determined by the Bray (1) method (Bray and Kurtz, 1945). The phenol-disulphonic acid colorimetric method was used to determine the percentage nitrate of the Cast while the total nitrogen was determined using the Kjeldahl method. Atomic absorption spectrophotometer was used to determine the Ca, Mg, Na, K, Mn, Cu and Zn in mg/dL (AOAC, 1995).

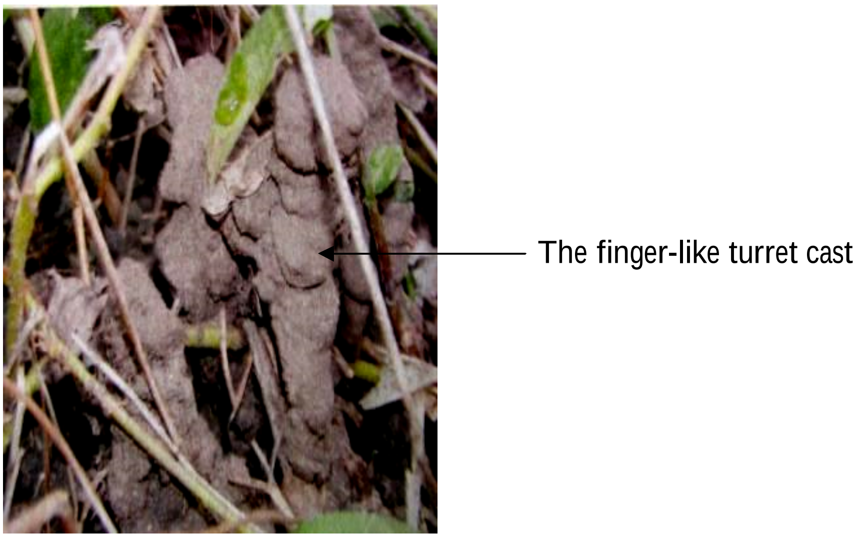

Plate 1: Finger-like turret casts in the under-growths

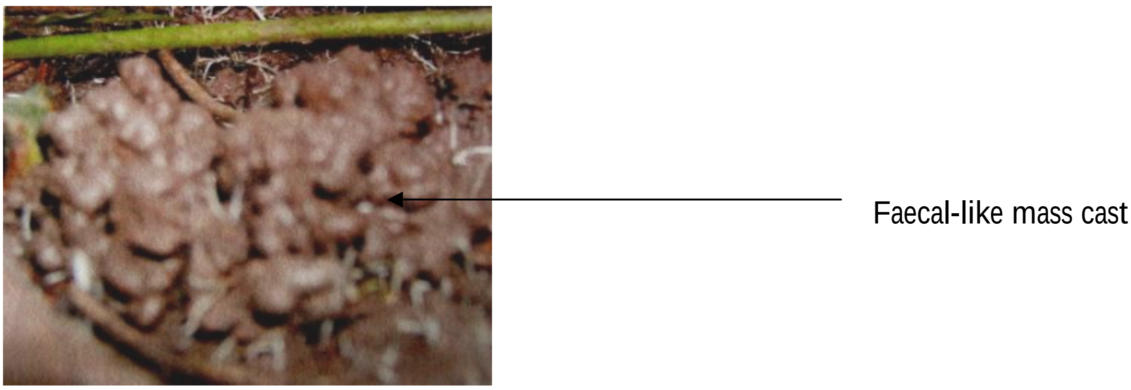

Plate 2: Faecal-like mass cast in more open marshy habitat

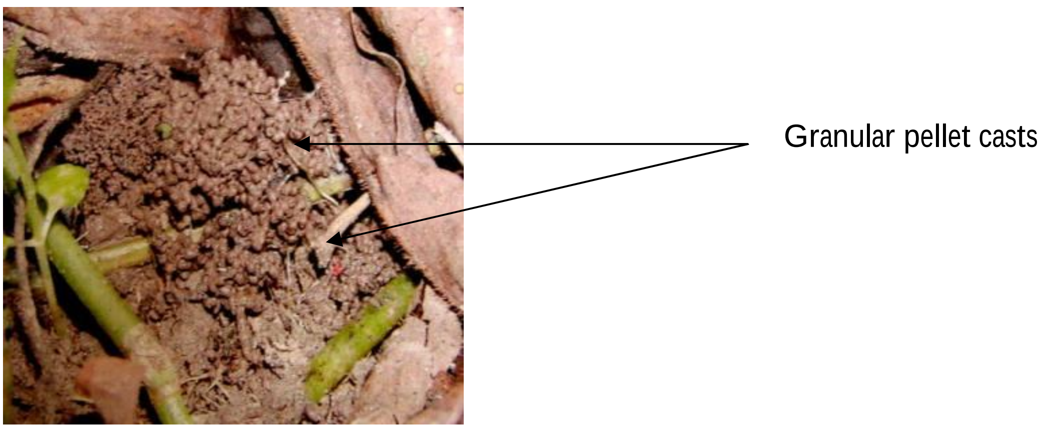

Fig. 3: Granular pellet cast under leaf litters

Statistical Analysis

Using the Statistical Package for the Social Science (SPSS) version 17.0, the results obtained in the study was subjected to statistical analysis; these included descriptive statistics, analysis of variance (ANOVA), and Duncan Multiple Range test.

RESULTS

The Descriptive statistics of the physical and organic properties of the casts are shown in Table 1. The pellet casts had the highest mean pH (8.60±0.01), while the mass cast had the lowest pH (7.81±0.01). However, all three cast types had basic pH values. The turret cast had significantly higher moisture content (47.10±0.14%) than both mass cast (45.60±1.09%) and the pellet cast (29.43±0.08%).

Sand content was highest in the pellet cast (79.47±3.06%), but lowest in the turret cast (76.47±3.06%). There was however no significant difference in the % sand contents of the three cast types. Silt content on the other hand was higher in the mass cast than the other two cast types. There was no significant difference between the silt composition of the turret and mass casts, but both were significantly higher than in the pellet cast. Though the % clay content was not established by experiment, the sum of the % silt and sand content showed that the pellet cast has the highest clay content.

The pellet cast had the highest % organic carbon and organic matter (0.62% and 1.05% respectively). There was a significant difference in the % organic matter of the pellet cast and the other two cast type. Turret cast, however, also had significantly higher % organic carbon (0.42%) and organic matter (0.72%) than mass cast (table 1).

Table 1: The Descriptive Statistics of the Physical and Organic properties of the Casts

Physical & organic properties	Earthworm cast types			
	Pellet Cast (Mean±SD)	Turret Cast (Mean±SD)	Mass Cast (Mean±SD)	P-value
pH (n=5)	8.60±0.01a	8.09±0.01b	7.81±0.01c	0.000
% Moisture (n=10)	29.43±0.08c	47.10±0.14a	45.60±1.09b	0.000
% Sand (n=3)	79.47±3.06a	76.47±3.06a	77.13±5.77a	0.975
% Silt (n=3)	14.07±2.31b	20.07±1.16a	21.40±0.00a	0.002
% Organic Carbon (n=3)	0.62±0.01a	0.42±0.01b	0.36±0.01c	0.000
% Organic Matter (n=3)	1.05±0.02a	0.72±0.02b	0.63±0.09c	0.000

Means with the same superscript in a row are not significantly different

The calcium (11.04±2.80mg/dL), manganese (113.08±38.45mg/dL) and Zinc (8.54±2.62mg/dL) composition of the pellet cast were significantly higher than that of the mass cast (4.54±0.25mg/dL, 19.12±6.82mg/dL and 2.04±0.70mg/dL). However, though it was higher than that of the turret cast (9.64±0.77mg/dL, 77.0±17.02mg/dL and 6.68±1.65mg/dL), the difference is not statistically significant (table 2).

Mass cast had the highest mean composition of magnesium (1.75±0.49 mg/dL), sodium (1.26±0.32mg/dL) and copper (0.63±0.10mg/dL). These were significantly higher than in the other two cast types in the case of copper and potassium ($P<0.05$) but not significantly different than that of magnesium and sodium composition in pellet and turret cast types (table 2).

Percentage phosphorus, nitrate, nitrite and nitrogen were significantly higher ($P<0.05$) in the pellet casts (11.27, 0.018, 0.008, and 0.063%, respectively) than in the turret and mass casts. However, phosphate was significantly higher in both the pellet (0.039%) and turret casts (0.030%) than in the mass cast (0.023%).

Table 2: The Descriptive Statistics of some cationic and anionic components of the Casts

Cast components	Earthworm cast types			
	Pellet Cast (Mean±SD)	**Turret Cast (Mean±SD)**	**Mass Cast (Mean±SD)**	**P-value**
Cations				
Ca (n=3) (mg/dL)	11.04±2.80a	9.64±0.77a	4.54±0.25b	0.007
Mg (n=3) (mg/dL)	1.71±0.25a	1.70±0.19a	1.75±0.49a	0.981
Na (n=3) (mg/dL)	1.02±0.09a	1.02±0.12a	1.26±0.32a	0.311
K (n=3) (mg/dL)	0.62±0.07b	0.93±0.19a	0.07±0.07c	0.001
Mn (n=3) (mg/dL)	113.08±38.45a	77.00±17.02a	19.12±6.82b	0.010
Cu (n=3) (mg/dL)	0.45±0.05b	0.50±0.05bc	0.63±0.10a	0.051
Zn (n=3) (mg/dL)	8.54±2.62a	6.68±1.65a	2.04±0.70b	0.012
Anions				
% Av. Phosphorus (n=3)	11.27±2.02a	9.50±1.40b	6.33±0.70c	0.017
% Phosphate (n=3)	0.039±0.001a	0.030±0.001a	0.023±0.001b	0.000
% Nitrate (n=3)	0.018±0.001a	0.013±0.001c	0.015±0.001b	0.000
% Nitrite (n=3)	0.008±0.001a	0.003±0.001c	0.005±0.001b	0.000
% Nitrogen (n=3)	0.063±0.001a	0.048±0.001c	0.054±0.000b	0.000

Means with the same superscript in a row are not significantly different.

DISCUSSION

Physical Properties and Implication on Soil fertility:

Comparatively, the significantly higher pH and lower moisture content recorded for pellet cast suggests that pellet cast is significantly more alkaline and have lower water holding capacity than turret and mass casts. This lower water holding capacity of pellet casts is in conformity with its physical structure.

Physically, pellet cast is made up of tiny aggregates or granules that were loosely held together, easily crumbled at the touch of a finger and highly porous, whereas the other two cast-types have larger aggregates whose granules were more tightly cemented together to form either a finger-like erect structure (turret cast) or a mass much like faecal deposit on top of the soil (mass cast). These two cast-types do not crumble easily to touch and were not as porous as pellet cast thereby reducing their tendency to lose water quickly. In addition, the higher silt content in turret and mass casts gives greater allowance for these cast types to retain a higher amount of moisture in them than pellet cast.

Although the pH value (8.60) obtained for pellet cast was significantly higher than that of turret and mass casts ($p<0.05$), on the overall, values obtained for the different cast types confirms that earthworm casts are generally alkaline. However, English and Costello (2005) and Owa *et al.* (2008) identified a pH range of 5.0-7.4 for earthworm distribution and abundance in soils. According to these authors soils within this pH range support earthworm survival and in those outside these range earthworms were rarely found. The implications of this to the present result would be that as the soil passes through the earthworm gut the pH is altered by enzymatic activity or and microbial activity in the earthworm gut.

By implication therefore, turret and mass casts having much higher water holding capacity would enhance the soil to retain a higher amount of its moisture for a longer period than pellet cast. Furthermore, the alkaline nature of these casts would make them useful in ameliorating acidity in the soil and the pellet cast with a significantly higher pH could contribute more in this respect.

Nutrient & Organic Properties and Implication on soil fertility:

The significantly higher mean calcium, zinc, available phosphorus, phosphate, nitrate, nitrite and nitrogen in pellet cast than turret and mass casts indicate that pellet cast contains a significantly higher nutrient content than the other two cast-types, hence would likely contribute significantly more nutrient to enhance soil fertility.

Also we infer that the higher nutrient content of pellet cast indicated a higher energy and electron source. Atlas (1997) reported that a higher energy and electron source will stimulate higher microbial proliferation which in turn will facilitate faster degradation of organic matter hence production of more organic carbon and release of other nutrients, thereby helping in building soil fertility or in the amelioration of less fertile soils for horticultural purposes.

From the foregoing, though pellet cast contained a comparatively higher nutrient content than turret and mass casts, the nutrient contents of the other two types of earthworm cast-types were still higher than the surrounding soil. This therefore suggests a synergy between these cast-types in enhancing soil fertility. Stewart *et al.* (1988) had earlier reported that earthworm casts act as time-release nutrient capsules (releasing over a longer period of time).

Our study hereby clarified that turret and mass cast by their physical structure will fit the report of Stewart *et al.* (1988), acting as time-release nutrient capsules while pellet cast on the other hand acts as quick-release nutrient capsule (releasing quickly in a shorter period of time) with a larger dose of nutrient released to the soil. This suggests that while turret and mass casts released their nutrients gradually to the soil and enhance the latter growth periods of plants, the pellet cast acting as a quick release nutrient capsule would make its nutrients available to germinating seedlings, at a time when the seedlings need such nutrient boost, thereby helping them to proliferate faster.

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