Influence of earthworm cast on manure from cattle, sheep and goats and its effects on maize growth

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Abstract

An experiment was conducted to evaluate the effect of earthworm activities on manure from indigenous breeds of cattle, sheep and goats of Nigeria. Three treatment groups of manure from cattle, sheep and goat were inoculated with earthworms in prepared worm beds and worm casts derived were evaluated after 8 weeks. The results showed that earthworms had a great impact on the chemical constituents' transformations in the manure. The percentage of nitrogen, phosphorous and potassium in worm cast was found to increase. Nitrogen totals from worm casts were 1.65, 1.72 and 1.96% for cattle, sheep and goats, respectively compared to 0.95, 1.21 and 1.31%, obtained from manure. Within the species, the manure and worm casts derived from goats were superior to that from sheep and cattle. Weights of maize plant grown with worm cast were almost twice that of the fresh manure across the treatments. It was concluded that earthworm casts from cattle, sheep and goat manure were nutritionally superior to manure from which they were derived. Such improved manure can serve as a ready source of high quality fertilizer for the resource poor farmers in Nigeria.

Keywords: Ruminant, manure, earthworm, maize, chemical composition.

Introduction

Livestock production worldwide generates millions of tonnes of faecal excretion, which are used as fertilizer, soil replenishment, medicant, feed for ruminants and fuel in place of firewood for cooking and domestic heating (**Muller, 1980; Murwira *et al.* 1993;** Parkolwa and Shihemi, 2003; Fasae *et al.*, 2008). In Nigeria, many small scale farmers have ruminants especially sheep and goats in their homestead which produce animal droppings and these droppings have been observed to form a direct linkage between livestock and crop production. However, improving the quality of this manure through different processing methods has not been fully explored due to lack of technical know-how by these farmers.

The role of earthworms in improving soil fertility has long been appreciated by farmers but attempts to employ them as a component in an organic recycling system has not been given adequate attention. The ability of some earthworms to consume a wide range of organic residues such as sewage sludge, animal wastes, crop residues, and industrial refuse has been fully established (Edwards *et al.* 1988; **Atiyeh** *et al.*, 2000; Sogbesan, *et al.*, 2005). In the process of feeding, earthworms fragment the waste substrate, enhance microbial activity and the rates of decomposition of the material, leading to a composting or humification effect by which the unstable organic matter is oxidized and stabilized. The end product, worm cast, obtained as organic wastes which pass through the earthworm gut, is quite different from the parent waste material

(Subler *et al.* 1998).

The physical and resultant chemical effects of earthworms on manure promotes short and rapid recycling of nutrients (Lavelle and Martin, 1992) thereby improving the efficacy of manure as an efficient source of fertilizer for crop production. This study therefore evaluates the potential of earthworms to compost cattle, sheep and goat manure into high quality organic fertilizer.

Materials and methods

The chemical properties of earthworm cast manure from cattle, sheep and goats and its effect on seed germination and seedling growth of maize was evaluated at the Ruminant Unit of the Teaching and Research Farm, College of Animal Science and Livestock Production, University of Agriculture, Abeokuta, Nigeria, situated in the forest transition zone of south western Nigeria.

Three worm beds were prepared by digging three holes each of length 120cm to a depth of 30cm and replicated four times in a completely randomized design. Wooden frames of the same length and depth were constructed and fixed into the holes as described by Savala (2003). 50kg of fresh manure deposited within the research site from mixed local breeds of Nigerian cattle managed extensively and that of the West African Dwarf breed of sheep and goats managed semi intensively in different units were collected and deposited into the worm beds and allowed to ferment aerobically for 20days with water added to avoid loss of moisture.

Earthworms (*Eisenia foetida*) sourced within the experimental site were inoculated into each of the worm beds at 0.5 kg of earthworm to $1m^2$. Wooden covers with nets were used to cover the beds to avoid scavenging birds from feeding on the earthworms and also allow adequate ventilation within the beds. The worms were allowed to stay in the beds for 8 weeks during which water was sprinkled daily to protect worms' dehydration and hardening of manures.

Bioassay of the fertilizer value of both fresh manure and worm cast were evaluated by using maize. Three seeds of maize variety SUWAN 1-Y were sown in polythene bags. 0.25kg of either fresh manure or worm cast from excreta of each ruminant species was added to each bag to give a total of six treatments replicated four times. The nitrogen content of fresh manure and worm cast was determined (AOAC, 1995), phosphorus and potassium contents using atomic absorption spectrophotometer.

After 30 days of planting, the maize plants were separated from the soil by washing and allowed to drain in the shade for one hour, after which the root and green biomass portions were weighed and the plant height determined.

Data collected were subjected to analysis of variance using the statistical package (SAS, 1999). Significant means were separated using Duncan Multiple Range Test (Duncan, 1955).

Results and discussion

The chemical constituents of manure from cattle, sheep and goats used in this study before inoculating with earthworms are shown in Table 1. The results showed variation among species which supports earlier reports that the physical and chemical properties of animal wastes could be affected by the physiology of the animal, digestibility of the feed ration and environment (Garg *et al.*, 2005). The faecal nitrogen tends to decrease with increase in body size of the animal. This corroborate the reports Hermanson and Kalitha, (1994) that size of the animal, as measured by its

Table 1: Chemical constituents (%) DM of fresh manure from cattle, sheep and goats

Constituents (%)	Manure			
	Cattle	Sheep	Goat	SEM
Nitrogen	0.95	1.20	1.31	0.53
Phosphorus	1.50	1.17	1.22	0.67
Potassium	0.41	0.40	0.53	0.34
Calcium	1.24	1.09	1.31	0.56
Magnesium	0.45	0.67	0.77	0.39

live weight, is perhaps the most important physiological factor. Sex, breed, and activity of the animal also affect the manure properties to the extent that they partially determine the feed conversion efficiency under a given environment.

Table 2 shows the chemical constituents of worm casts derived from cattle, sheep and goats. There was a significant ($P > 0.05$) increase observed in the constituents of worm cast manure compared to fresh manure. The results suggests earthworms play a significant role in processing ruminant manure by accelerating the mineralization rate and conversion of manures into castings with a higher nutritional value and degrees of humification. This corroborates the findings of Albanell *et al.* (1988) in castings of *Eisenia foetida* from sheep manure.

The concentration of nitrogen in the three manures increased tremendously suggesting that the nitrogen fixing bacteria found in the guts of earthworms tend to increase the nitrogen content of substrates so that mineral nitrogen was retained in the nitrate form (Lee, 1985). This further suggests that *Eisenia foetida* produced conditions in the manure that favoured nitrification, resulting in the rapid conversion of ammonium-nitrogen into nitrates. Similar results were reported by Hand *et al.* (1988) who found that *Eisenia foetida* in cow slurry increased the nitrate-nitrogen content of the substrate. Sogbesan *et al.*, (2005) also observed an increase in the concentration of nutrients for some organic wastes as substrate to earthworms. The findings of Lazcano *et al.*, (2008) also showed that cattle manure as substrate for earthworms promoted the retention of nitrogen and gradual release of phosphorus thereby producing improved substrates for agricultural use. However, Loh *et al.*, (2004) found that cattle manure provided a more nutritious and friendly environment to the earthworms than goat manure. The

Table 2: Chemical constituents (%) DM of worm cast from cattle, sheep and goats

Constituents (%)	Worm Casts			
	Cattle	Sheep	Goat	SEM
Nitrogen	1.65[b]	1.72[b]	1.96[a]	0.75
Phosphorus	1.30[b]	1.47[b]	1.51[a]	0.69
Potassium	1.26[b]	1.34[b]	1.63[a]	0.54
Calcium	1.54	1.49	1.61	0.59
Magnesium	0.78	0.89	0.91	0.51

[a, b] *means followed by the same superscript in a row is not significantly different* ($P< 0.05$)

breed of animals used and management differences might be the source of variation.

The results of the present study further showed that the concentrations of nitrogen as well as phosphorus and potassium contents in worm casts derived from goat manure were higher ($P < 0.05$) than those from sheep and cattle. In contrary, Bansal and Kapoor, (2007) reported more total nitrogen content in the compost derived from cattle dung prepared by earthworm inoculation, while total phosphorus, potassium and copper contents did not differ in compost prepared with earthworm inoculation from the uninoculated treatments.

The fresh biomass (g) and plant height (cm) of maize plants as influenced by the various treatments is illustrated in Figure 1 and Figure 2, respectively. Maize biomass production and plant height were significantly ($P > 0.05$) affected by the imposed treatments.

The weight and plant height of maize plants grown with worm casts was almost twice that of the fresh manure. This corroborates earlier reports by Nguyen *et al.*, (**2000**) and Hidalgo *et al.*, (2006) that earthworm castings from ruminant manure had a greater nutrient content than other substrates used for planting maize and marigold flowers, respectively. The enhancement in maize plant growth with worm cast could be due to the more favorable physicochemical characteristics of the processed waste and the higher content of nitrate - a form of nitrogen that is readily available for plant uptake.

Maize plants fertilized with worm casts derived from goats manure grew better ($P < 0.05$) than maize fertilized with worm casts derived from sheep and cattle manure.

Also, the significant performance of maize plant grown in worm cast could be attributable to the finely divided peat-like materials with high porosity, aeration, drainage, and water-holding capacity of worm cast (Edwards and Burrows, 1988). Worm casts have been found to have a vast surface area, providing strong absorbability and retention of nutrients (Shiwei and Fuzhen, 1991). Several researchers have also studied the role of earthworms in soil fertility. From such studies, it has been established that earthworms are one of the most useful and active agents in introducing suitable chemical, physical, and microbiological changes in the soil and,

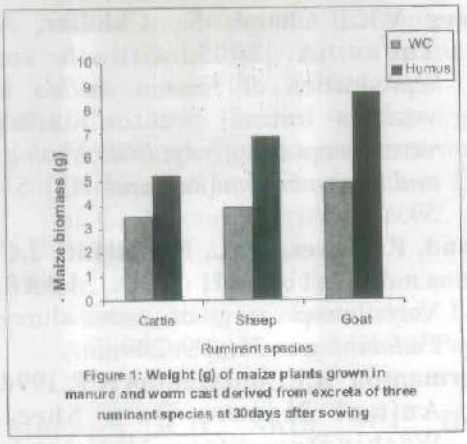

Figure 1: Weight (g) of maize plants grown in manure and worm cast derived from excreta of three ruminant species at 30days after sowing

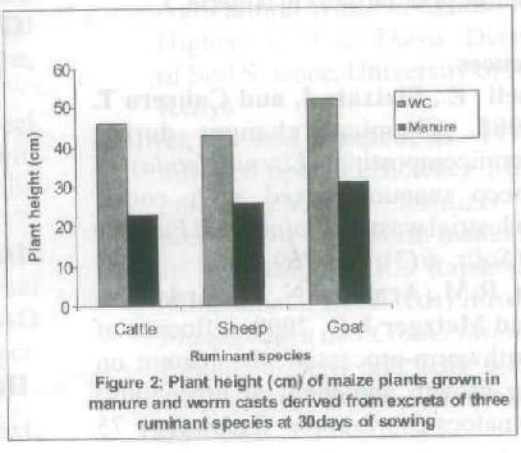

Figure 2: Plant height (cm) of maize plants grown in manure and worm casts derived from excreta of three ruminant species at 30days of sowing

thereby, directly increasing the fertility and crop-producing power of soils (Joshi and Kelkar, 1951). Edwards and Bates (1992) found that earthworms increased significantly the number, growth rate, and yield of plants growing on inoculated sites. Evidences from a number of plant growth studies conducted with worm casts indicates that microbial activity, and possibly the makeup of the microbial communities existing within earthworm castings, play an important role in the plant growth responses observed (Mba, 1996, Subler *et al.*, 1998, **Nguyen, 2010**).

Conclusion

In this experiment, worm casts derived from cattle, sheep and goat manure were found to be superior in plant nutrients relative from the manure from which they were derived. In addition, maize plants fertilized with goat worm casts had better growth compared to maize grown with casts from sheep and cattle manure. It can be therefore be concluded that processing of ruminant manure using earthworm offers a practical method of optimizing nutrient recycling. This in turn will reduce the reliance on scarce and expensive chemical fertilizers for high quality crop production by resource poor farmers in Nigeria.

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