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Can Earthworm Inoculated Cow Dung Enhance Nutrient Availability for Plant Growth in Degraded Sandy Soil?

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Abstract: A greenhouse experiment was conducted at Micheal Okpara University of Agriculture Umudike, to study the effect of using earthworm to degrade cattle manure on yield of amaranthus. The experiment was a 2×3×3 factorial in completely randomized design for analysis of selected crop yield parameter. The treatments were a combination of Earthworm and Cattle manure (EWC), Cattle Manure alone (CM) and a control applied to two soils of different textures. The treatments were replicated three times and plant data were taken at 4, 5 and 6 weeks after planting. Results show that inoculation of cowdung with earthworm improved the plant growth in both the nutrient rich soil and the degraded sand. However the level of improvement was higher in the nutrient rich clayloam soil than in the degraded sand. Generally at $p<0.001$ both treatments and soil type significantly affected amaranthus growth

Key words: Cattle manure, cowdung, earthworm, sandy soil

INTRODUCTION

Organic farmers, gardeners and researchers recognize earthworms as important organisms contributing to healthy soils (Romig *et al*., 1995). They mix the soil (Cook and Linden, 1996; Marinissen and Hillenaar, 1997), increase soil water infiltration (Bauche and Al-Addan, 1997; Lindan *et al*., 1991; Zachmann *et al*., 1987, Troyan and Lindan 1994; 1998) and improve soil structure (Kettering *et al*., 1997). Other research works has drawn attention to the importance of earthworms in maintaining soil fertility and favourable conditions for plant growth in minimum cultivation farming. Earthworms produce assimilable products of excretion such as ammonia, urea and body tissues that are rapidly mineralized. Thus earthworm casting represent a potentially significant source of readily available nutrients for plant growth (Curry and Byrne, 1992).

Researchers examining earthworms in agricultural soils has primarily focused on their response to single inputs such as tillage or pesticide application but few studies investigated populations under field conditions that closely resemble those found in a farmers field. Moreover, most research work on the effect of earth worm (cast) on soil fertility, physical properties and plant yield focused on the use of plant related residues and or inputs. Therefore, the objective of this study is to evaluate the effect of inoculating cattle manure with earthworm on a degraded sandy soil and a nutrient rich clay-loam on the yield of amaranthus a prominent vegetable in the tropics.

MATERIALS AND METHODS

Site characteristics: Soils for this study were collected from the research farm sites of the University of Agriculture Umudike, Abia State. The Location is within the low land rainforest and lies between latitude 05° 29N and longitude 07° 32E, with a mean annual maximum and minimum temperature of 32 and 23°C , respectively. Soils from this area are acidic and are classified as Ultisols (Keay, 1959).

Sample collection: The soils used for the study were collected from 0-30 cm depth from the experimental sites, with soil auger and were transferred to the green house where the inoculation was done. Before planting, the inoculated manure were allowed to decompose for three months and the physicochemical characterization of the soils were carried out (Table 1).

Crop yield assessment: The soils containing the different treatments (Cow Dung alone (CD), Earthworm Worked Cowdung (EWC) and untreated Control (C) were transferred into buckets of known capacity and drilled with amaranthus seeds in grooves. The bucket contents were watered daily until seedling emergence. The seedling were thinned down to a single stand and monitored for three weeks before samples were taken for analysis on crop yield. The yield parameters taken were; Plant height, stem diameter, number of roots, leaves and flowers and dry matter yield of amaranthus.

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Table 1: Physiochemical characteristics of soil samples used for the study

Characteristics	Sample A	Sample B
Sand (%)	38.72	86.88
Silt (%)	23.28	4.28
Clay (%)	38.0	9.04
Textural class	Clay-loam	Sand
Bulk density (g cm^{-3})	0.75	1.70
Porosity (%)	71.69	35.7
Aggregate stability (%)	53.3	20.0
pH (H2O)	4.65	4.38
pH (KCl)	4.06	4.00
Available P (mg kg^{-1})	4.0	11.3
Exchangeable acidity(cmol(+) kg^{-1})	2.0	1.60
Organic carbon (%)	4.60	2.05
Organic matter(%)	2.67	1.19

Statistics: The effect of the treatments on selected crop yield parameters were analysed using a 2×3×3 Complete Randomised Design (CRD), While factor A represent the soil type (that is sand or clay-loam soil, respectively), factor B represent the sampling time and factor C represent the treatments (that is earthworm plus cow dung, cow dung alone and control). Significant treatment means were separated using FLSD0.05. Spearman's Rank correlation was carried out between organic carbon some soil and plant parameters.

RESULTS AND DISCUSSION

The soils used for this study were of different textures, a clay-loam and sand texture; the clay-loam had better physical and chemical properties (Table 1).

These plant growth indices greatly increased with the application of earthworm worked cow dung (Table 2 and 3). For the untreated soils, the plant growth indices were on the decrease with increase in sampling time (Fig. 1a and 2a). While for the treated soils the plant growth parameters improved with increased length of time after inoculation, indicating that the soils were supplied with more nutrients by these treatments with time (Fig. 1 and 2b, c). The level of increase was higher in the earthworm inoculated soils (Fig. 1c and 2c) and in the nutrient rich clay loam compared to the sand (Fig. 3). The level of increase in plant growth parameters peaked for the sandy soil to a level equal to the peak obtained in the clay-loam soil six weeks after planting. (Fig. 3) Generally at $p<0.001$ both treatments and soil type significantly affected amaranthus growth (Table 4 and 5). This agrees with the observations of Abbot and Parker (1981) and Pablo *et al.* (1997) who reported similar increases in growth indices by earthworm casting compared to peat moss. Also Barley (1961), reported that plant growth stimulants such as auxins are produced in the castings, these hormones

Table 2: Effect of earthworm worked cow dung and cow dung alone on plant height

		Sampling time (Weeks)		
Soil texture	Treatment	4	5	6
Clay-loam	EWC	36.3	70.3	89.7
	CM	30.0	67.0	71.0
	Control	12.0	21.3	29.0
Sand	EWC	32.6	65.0	77.0
	CM	20.0	41.3	52.0
	Control	5.0	5.0	-
	FLSD0.01	16.16		

Table 3: Effect of earthworm worked cow dung and cow dung alone on number of leaves

		Sampling time (Weeks)		
Soil texture	Treatment	4	5	6
Clay-loam	EWC	55	93	145
	CM	40	79	124
	Control	18	44	90
Sand	EWC	48	76	127
	CM	27	67	113
	Control	8	3	-
	FLSD0.01	29.08		

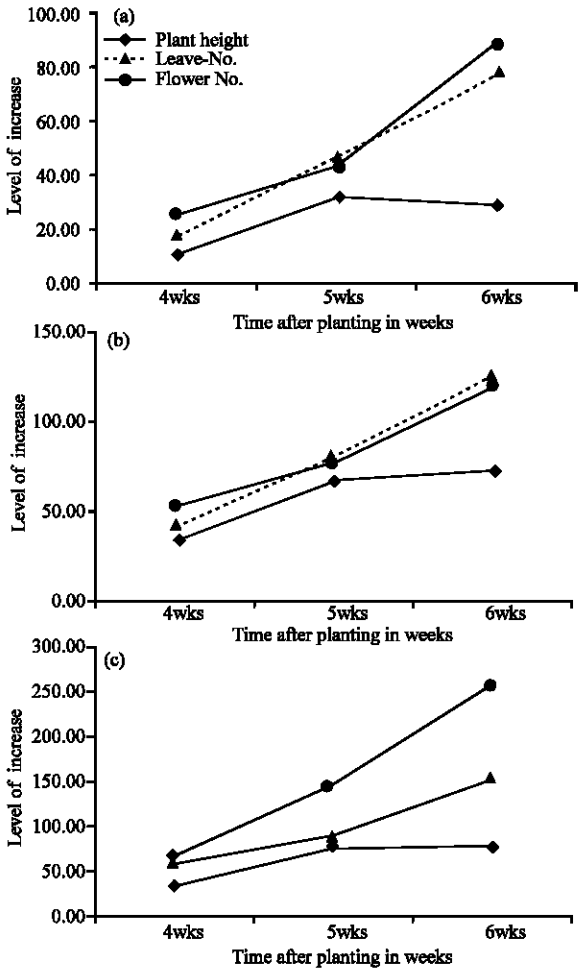

Fig. 1 (a-c): Plant growth indices on untreated, cow dung treated and earthworm worked cow dung-treated clay-loam soil

Table 4: Analysis of variance on the effect of EWC and CD on plant height

Source of variation	DF	SS	MS	F-value	F-probability
Treatment(T)	2	2816.67	2816.67	53.16	<.001***
Soil type(S)	1	8674.70	4337.35	81.87	<.001***
Samp. time(t)	5	20231.59	10115.80	190.93	<.001***
T×S	2	300.11	150.06	2.83	0.072^{ns}
T×t	10	706.33	353.17	6.67	0.003**
S×t	5	2320.74	580.19	10.95	<.001***
T×S×t	10	225.56	56.39	1.06	0.388^{ns}
Error	72	1907.33	52.98		

Table 5: Analysis of variance on the effect of EWC and CD on number of leaves

Source of variation	DF	SS	MS	F-value	F-probability
Treatment(T)	2	7537.9	7537.9	14.65	<.001***
Soil type(S)	1	40881.4	20440.7	39.73	<.001***
Samp. time(t)	5	43700.3	21850.1	43.47	<.001***
T×S	2	1918.3	959.1	18.86	0.170^{ns}
T×t	10	2965.1	1482.6	2.88	0.069^{ns}
S×t	5	7972.6	1993.2	3.87	0.010***
T×S×t	10	1999.7	479.9	0.97	0.435^{ns}
Error	72	18520.0	514.4		

stimulate roots to grow deeper and faster, While Nelson (1965), observed increase in pasture yield and attributed it to the presence of plant-promoting compounds elaborated by earthworms and secreted into their castings which then supplement the soil. Similarly, Ruz-jerez *et al.* (1992) observed that soils previously inhabited by earthworm promote significant increase in plant growth and N-uptake. In the same year an experiment conducted in Cute d' Ivoire, reported increased growth of maize in an infertile granite derived soil as a result of the addition of earthworm to the soil (Spain *et al.*, 1992). Edward and Bates (1992) also observed that earthworms increased significantly the number, growth rate and yield of plants growing on inoculated site, while grass production doubled in New Zealand, a region that historically did not have earthworm when European species were introduce, (Edward and Lofty, 1980).

These observations agree with the results of this study that the earthworms are useful and active agents in introducing suitable chemical, physical and micro-biological changes in the soil that can directly increase the fertility and crop producing power of soils. It is believed that earthworms' addition to soils either in pots or in the field, results in increases in yield, however, their influences varied according to crop growth stage and soil type. This increase in yield is attributed to the release of beneficial chemicals from the bodies of the earthworms as well as the ability of earthworms' to chelate nutrients, making mineral available to plants that would otherwise be in a form that would be chemically unavailable. It is

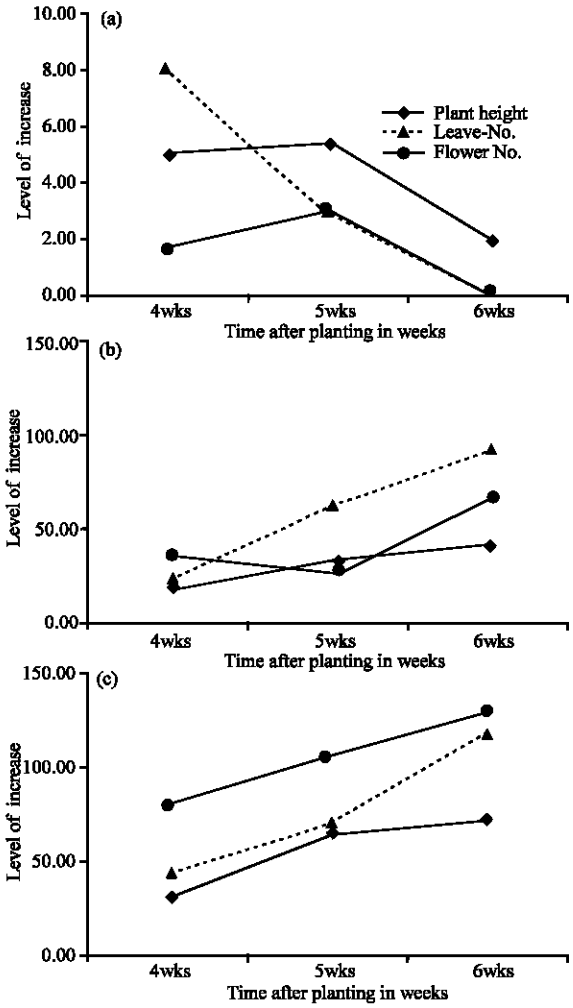

Fig. 2 (a-c): Plant growth indices on untreated, cow dung treated and earthworm worked cow dung-treated sandy soil

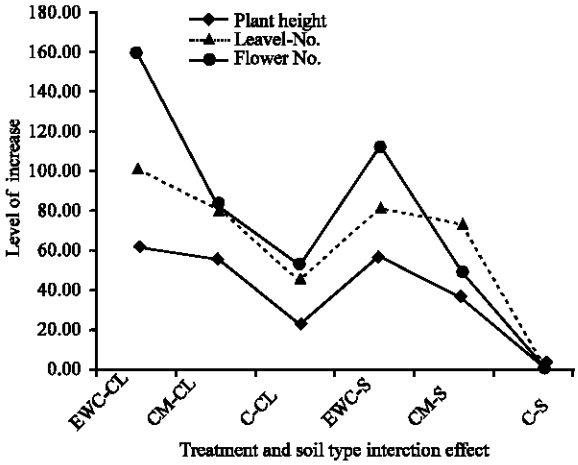

Fig. 3: Comparison between earthworm worked cattle manure and manure the plant growth

therefore important that organic and inorganic manure inputs into soils be accompanied by microbial activation to ensure maximum improvement in both soil and plant productivity.

CONCLUSION

Plant growth was greatly enhanced on introduction of earthworm worked cow dung into the soils probably as a result of enhanced availability of nutrients with application of the earthworm worked manure which acted as an ameliorator of poor physiochemical conditions of soils and a booster to plant growth and yield. This was achieved probably by the ability of the earthworms to destroy harmful chemical, breakdown organic wastes and create fertile root channel. Therefore, it is beneficial to apply this knowledge during application of soil amendments since the introduction of earthworms encouraged seedling emergence, establishment and growth. Also there is the need to carry out a study on the effect of the applied treatments on soil properties to arrive at target specific property moderation for agricultural soils

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