GLOBAL JOURNAL OF PURE AND APPLIED SCIENCES VOL. 11, NO. 4, SEPTEMBER 2005: 445 - 447
 ISSN 1118- 0579

GROWTH RESPONSE OF *AMARANTHUS CAUDATUS* TO EARTHWORM CASTS AND POULTRY MANURE APPLICATION

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(Received 17 September, 2004; Revision accepted 21 March, 2005)

ABSTRACT

The effect of earth worm cast on the physiomorphological differences of *Amaranthus caudatus* was studied in the green house of the Department of Agronomy, University of Ibadan for seven weeks in 1998. Earthworm casts were collected from soils cultivated with maize, cassava and oil palm fields and secondary forest. The result showed that performance of A. *caudatus* depended to some extent on earthworm casts rate (r=0.977) and casts produced from maize, oil palm crop fields and undisturbed forest, gave a yield advantage over control by 54.8, 19.4 and 64.5% respectively, while that from cassava fields gave yield disadvantage of 22.6%. In addition, growth performance was low on soils treated with cast, which also had a dry matter yield of 0.4 g pot^{-1} compared to 2.64 and 5.78 g pot^{-1} obtained from inorganic fertilizer and poultry manure respectively. It can therefore be concluded that application of earthworm casts from fields can play a good role in plant nutrient recycling and not at best solely in soil fertility amendment of degraded soils and as the only source of fertilizer for maximum A. *caudatus* production.

KEYWORDS: Earthworm casts, Poultry manure, ***Amaranthus caudatus***, Ibadan, Nigeria.

INTRODUCTION

The nutritional qualities of A. *caudatus* is attracting world wide attention especially when it is discovered that it is a cheap and rich source of carotene, ascorbic acid, minerals and proteins which are essential to the continual healthy existence of the people (Dowton 1973). However, Olufolaji (1985) reported that the amount of proteins, vitamins and minerals in an amaranth leaf is a function of plant age.

A. *caudatus* could be used as a leafy vegetable where by young leaves and stems are boiled as greens and added to soups. In view of the dietary importance of this crop, it is important to seriously encourage the production of the vegetable.

A. *caudatus* are known nitriphiles and often accumulates nitrates. With the substantial amount of biomass removed with the crop, the soil will become depleted without substantial fertilizer inputs (Martineau, 1985). Degraded soils should not be abandoned instead, instead ways should be sought to restore their productivity. In doing so, the restoration materials such as earthworm casts, which are in abundance, are investigated. If found effective, it will go a long way in nutrient recycling, while harnessing its potentials.

Nutrient are taken up by plants from various depths of soil and stored in the biomass. They are returned to the surface soil through litter fall, root decomposition and root exudates or residue decomposition (Webster and Wilson 1987). The decomposition rate is influenced by a number of factors including the nature and type of soil organisms involved in the process and the quality of the decomposing material. Earthworm plays a great role in organic matter decomposition. The activities and abundance of earthworm are affected by the proximity of trees shade and quality of the leaf litter (Hauser 1993) and food supply (Somani and Bhandari 1994). Lavelle et al (1994) reported an average earthworm density for the humid tropics as 19 individuals m^{-2} for crops, 77 for tropical rain forest and 310 for pastures. Cast of about 30 tons ha^{-1} $year^{-1}$ could be produced (Sharpley and Seyers 1976). The concentration of plant nutrient is higher in the casts than in the total soil (Kang *et al* 1994). Then, if the recycling of the nutrients can be achieved through casts production, the knowledge of its use for soil amendment and the extent to which it can influence growth of plants if not for long period then for short period of plant growth cycle such as *A. caudatus*.

This study assessed and compared the effects of earthworm casts with poultry manure and inorganic fertilizer on the growth and yield of *A. caudatus*. It is expected that the study will provide information on plant response to earthworm casts when applied to improve the fertility of degraded soils.

METHODS

In 1998, earthworm casts were collected from soils cultivated with maize, cassava and oil palm, which has been under cultivation for more than 15 years and a secondary foerest of more than 15 years in Ibadan. The experimental soil was a degraded soil (sandy) collected from a land of over 20 years of exhaustive cultivation. Samples were air dried, ground and screened through 2 mm mesh sieve. Poultry manure was air-dried, crushed using blender and then sieved through 2 mm sieve. Seed of *A. caudatus* was used. The experiment was carried out as a 5 x 4 factorial (comparative factors were earthworm casts from the four fields, poultry manure and inorganic fertilizer).

Experimental soil of 2 Kg weight was placed into plastic pots and 0, 5, 10, 15 and 20 tons ha^{-1} of the casts and poultry manure were added. Inorganic fertilizer (NPK 15-15-15) was added at the rate of 60 Kg ha^{-1} (Olufolaji 1985). A. *caudatus* seeds were broadcasted and slightly covered with the experimental soil and were adequately watered. The crop was irrigated daily to 75% field capacity to avoid leaching. The seedlings were thinned to 2 plants per pot one week after germination. Evaluation of the treatment effect was done at 2, 3, 4, 5, 6 and 7 weeks after sawing (WAS) when the plants were cut for dry matter assessment.

RESULTS

Treatment rate effects of earthworm casts, poultry manure and inorganic fertilizer is shown in Table 1.The effect of earthworm casts rate on plant height, stem girth, leave number and leave area of A. *caudatus* shows that there is no significant difference between the casts due to treatment effect. However there were significant difference ($P>0.05$) in the growth

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Table 1: Effect of treatment rate on height, stem girth, leaf number and leaf area of A. *caudatus*

Medium	Rate Tons/ha	Plant Height (cm)		Stem girth (mm)		Leaf number		Leaf area (cm^2)	
		4WAS	7WAS	4WAS	7WAS	4WAS	7WAS	4WAS	7WAS
Poultry manure	5	17.25^{c}	23.93^{c}	4.92^{d}	5.65^{c}	15.17^{bc}	20.83^{b}	136.26^{c}	169.93^{d}
	10	20.97^{b}	30.80^{b}	5.70^{c}	6.55^{b}	14.83^{c}	22.83^{b}	197.86^{b}	237.14^{cd}
	15	22.57^{ab}	31.20^{b}	6.43^{b}	6.98^{ab}	18.17^{b}	22.17^{b}	242.49^{b}	291.83^{b}
	20	24.33^{a}	37.37^{a}	7.00^{a}	7.82^{a}	22.50^{a}	28.30^{a}	348.60^{a}	413.93^{a}
Maize cast	5	2.57^{gh}	4.85^{gh}	1.42^{e-g}	2.17^{f-h}	6.17^{ef}	12.00^{c-g}	7.59^{d}	18.28^{e}
	10	3.25^{f-h}	5.77^{f-h}	1.67^{e-g}	2.80^{d-g}	7.00^{d-f}	13.17^{c-g}	12.62^{d}	25.42^{e}
	15	3.80^{e-h}	7.50^{e-g}	1.88^{ef}	3.05^{d-f}	8.83^{de}	13.67^{c-g}	20.64^{d}	34.06^{e}
	20	5.03^{ef}	8.80^{ef}	1.95^{e}	3.28^{de}	9.00^{de}	14.50^{cd}	22.57^{d}	42.37^{e}
Cassava cast	5	1.77^{h}	3.32^{h}	1.12^{g}	1.90^{gh}	5.33^{f}	9.00^{h}	3.97^{d}	12.71^{e}
	10	2.28^{h}	3.68^{h}	1.15^{g}	1.83^{gh}	5.00^{f}	9.50^{gh}	3.84^{d}	12.74^{e}
	15	1.97^{h}	3.83^{h}	1.25^{fg}	1.78^{gh}	5.00^{f}	10.50^{e-h}	4.33^{d}	12.30^{e}
	20	2.37^{gh}	3.65^{h}	1.13^{g}	1.72^{gh}	5.50^{f}	10.00^{f-h}	4.15^{d}	9.07^{e}
Oil palm cast	5	2.53^{gh}	5.43^{gh}	1.68^{e-g}	2.75^{d-h}	7.00^{d-f}	11.83^{c-h}	13.84^{d}	29.84^{e}
	10	2.27^{h}	3.72^{h}	1.25^{fg}	1.72^{h}	5.50^{f}	$9.33g^{h}$	3.36^{d}	9.43^{e}
	15	3.10^{f-h}	4.83^{gh}	1.45^{e-g}	2.30^{e-h}	6.50^{ef}	11.67^{c-h}	4.62^{d}	17.43^{e}
	20	2.40^{gh}	3.85^{h}	1.27^{fg}	2.10^{f-h}	5.50^{f}	10.00^{f-h}	4.21^{d}	12.67^{e}
Forest cast	5	2.80^{f-h}	5.23^{gh}	1.40^{e-g}	2.20^{f-h}	6.17^{ef}	11.50^{d-h}	8.07^{d}	19.45^{e}
	10	3.53^{e-h}	7.17^{e-g}	1.93^{e}	3.08^{d-f}	9.67^{d}	15.15^{c}	23.63^{d}	37.56^{e}
	15	4.70^{f-h}	8.73^{ef}	2.00^{e}	3.35^{d}	7.83^{d-f}	13.67^{c-f}	23.92^{d}	45.10^{e}
	20	5.65^{e}	9.12^{e}	1.98^{e}	3.12^{d-f}	8.67^{de}	14.00^{c-e}	17.96^{d}	33.17^{e}
NPK (Kg/ha)	60	17.25^{d}	26.07^{c}	4.60^{d}	5.48^{c}	14.50^{c}	26.50^{b}	133.20^{c}	190.47^{cd}
Control	0	2.90^{f-h}	5.22^{gh}	1.43^{e-g}	2.57^{d-h}	6.83^{d-f}	11.83^{c-h}	9.49^{d}	22.00^{e}

a, b, c, d, e, f, g, and h: Means having the same letter are not significantly different (P=0.05) using Duncan's Multiple Range Test.

Table 2: Treatment effect on growth and yield of *Amaranthus caudatus*.

Medium	Plant Height (cm)	Stem girth (mm)	Leaf number	Leaf area (cm^2)	Dry matter Yield ($g\ pot^{-1}$)
Poultry manure	30.83	6.75	23.67	278.21	5.78
Maize cast	6.73	2.83	13.33	30.03	0.48
Cassava cast	3.61	1.81	9.75	11.70	0.24
Oil palm cast	4.46	2.22	10.71	17.54	0.37
Forest cast	7.56	2.94	13.67	33.82	0.51
NPK ($Kg\ ha^{-1}$)	26.07	5.48	26.50	190.47	2.64
Control	4.22	12.17	11.33	12.20	0.31
SE	0.82	0.31	1.14	19.94	0.24
LSD (0.05)	1.17	0.45	1.63	28.50	0.35
Rate (tons ha^{-1})					
5	8.55	2.93	13.03	50.04	0.96
10	10.22	3.20	14.07	64.46	1.37
15	11.22	3.49	14.33	80.30	1.67
20	12.56	3.61	15.47	102.25	1.90
SE	0.82	0.31	1.14	19.94	0.24
LSD (0.05)	1.04	0.40	1.46	25.49	0.31

parameters of A. *caudatus* in which casts, poultry manure and inorganic fertilizer were added. The effect of treatment (Table 2) on the growth of A. *caudatus* shows that soils treated with casts collected from soils under secondary forest had higher values followed by soils treated with casts collected from soils cultivated with maize.

Treatment effect by rate of application shows that 20 tons ha^{-1} was superior to other treatments rates. Results recorded from the growth parameters (Table 1) indicates that nutrient content of the casts (Table 3) has effect on A. *caudatus* though no significant differences were recorded between the soils treated with casts. However, treatment effect on dry matter yield (Table 2) shows that poultry manure is superior to all other treatments in the following order; Poultry manure > inorganic fertilizer > secondary forest cast > maize cast > oil palm cast > control > cassava cast with the corresponding values of 5.78, 2.64, 0.51, 0.48, 0.37, 0.31 and 0.24 g pot^{-1} respectively.

DISCUSSION

Plant height and number of leaves were evaluated to determine the vegetative growth of A. *caudatus* as suggested by Pfeiffer and Harris (1990) who observed and reported that plant measurements are used as indicator of vegetative growth. Although cast have higher plant nutrient content than the total soil (Kang *et al* 1994), results shows that it may not be used as fertilizers when compared to the report of Olufolaji (1985) of applying 60 Kg ha^{-1} of inorganic fertilizer (N P K 15-15-15) to Amaranth. The higher values for the growth parameters of A. *caudatus* from soils treated with casts from secondary forest than other casts agrees with the findings of Fragoso et al, 1993 that low soil disturbance and leaf litter fall enhances organic matter build up, consequently it's higher nutrient status.

Plant height of *Amaranthus* increased with the rate of

Table 3: Some chemical properties of the earthworm casts and the experimental soil (control).

Earthworm Casts field	pH 1:2 Soil: Water	Org. C (%)	Org Matter (%)	Tot N (%)	Av P (mg kg^{-1})	K	Ca	Mg	Na	Ex Acidity	CEC
								(cmol kg^{-1})			
Maize	6.25	3.44	5.95	0.30	37.18	0.82	10.0	3.12	0.32	0.08	14.3
Cassava	6.52	2.46	4.25	0.21	4.19	0.36	6.50	2.60	0.30	0.16	9.90
Oil palm	5.87	3.03	5.24	0.26	9.46	0.31	6.00	4.49	0.32	0.08	11.2
Secondary Forest	6.54	3.08	6.57	0.33	29.74	0.49	8.50	2.30	0.24	0.08	11.61
Mean	6.36	3.00	5.50	0.27	20.14	0.50	7.75	3.13	0.30	0.10	11.75
Control	7.00	0.36	0.62	0.03	2.43	0.08	1.15	0.51	0.33	0.08	2.15

Table 4: Particle size distribution of the experimental soil (%)

	Sand	Silt	Clay
Experimental soil	93.8	2.0	4.2

application of the casts with the exception of cassava and oil palm casts. The increase could be attributed to increased amount of nutrients with the rates that could sustain or meet the demand of the crop. This is corroborated with a high correlation between rate of application and plant height (r=0.957). In all the treatments, cassava cast had the lowest value of plant height, probably due to the fact that earthworms burrow deep down into the soil profiles where cassava extract most of its nutrients. Also, micro-organism population differ from one earthworm cast to the other depending on the conditions prevailing, such as temperature, moisture and the amount and type of organic materials. Stem girth, leaf number and leaf area of *Amaranthus* increased with the rate of application for both the poultry manure and earthworm casts except for cassava and oil palm casts. This could also be attributed to the nutrient status of the earthworm casts as there were correlation between the rates of application and stem girth, leaf number and leaf area (r=0.944, 0.906 and 0.935). This agrees with the findings of Agboola and Omueti (1982) that organic materials used for soil fertility restoration increases plant yield as rate of application is increased. With this trend, it shows that air-dried poultry manure induced plant growth most at periods below 4 WAS while earthworm casts at periods above 4 WAS.

The dry matter yield indicated the dependency of *Amaranthus* on the nutrient available and the quantity. It can therefore be inferred that growth of *Amaranthus* like any other plant requires N, P, K, Ca and Mg. These are corroborated with high correlation between the dry matter yield and the nutrients (r=0.970, 0.960, 0.894, and 0.919 for N, P, K, Ca and Mg).

CONCLUSION

Application of earthworm casts produced in maize, cocoa crops and undisturbed forest had *A. caudatus* yield advantage by 54.8, 19.4 and 64.5% respectively, while soils treated with casts from cassava based cropping system had yield disadvantage by 22.6%. However, effects of earthworm casts gave a low yield of 0.4 g pot-1 compared to 2.64 and 5.78 g pot-1 obtained from inorganic fertilizer and poultry manure respectively.

It can therefore be concluded that application of earthworm casts from fields can play a good role in plant nutrient recycling and not at best solely in soil fertility amendment of degraded soils and as the only source of fertilizer for maximum *A. caudatus* production.

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