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Effect of Over-seasoned Earthworm Products on Seed Germination: Implication for Early Rain Cropping

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Abstract: This study was to investigate if residual earthworm products in a soil left to dry up for five months would still be able to stimulate seed germination. Soil pots were treated with different levels of earthworms and planted with *Amaranthus* seed which grew for 36 days before they were harvested by uprooting. The pots were left to dry for five months simulating the dry season. The levels of germination correlated with the level of earthworm treatments. This suggests that earthworm products survive in the soil during the five months dry season experienced in this part of Nigeria. Leftover earthworm products must therefore be important to seed germination during the early cropping with the first rains before the earthworms populations build up. That the earthworm products improve total germination suggests that they may contain some enzymatic/catalytic component that affects the efficient utilization of the endosperm such that the embryo survives before the depletion of the endosperm. This may be related to the fact that the earthworm produce plant growth hormones that stimulate cell proliferation and elongation in the radicle. Fast development of the radicle ensures stabilization before depletion of the endosperm.

Key words:

INTRODUCTION

Many functions of earthworm in the soil are known[1,5,7,8,9,10,13]. A few less well known functions are being studied. For example, it has been demonstrated that rice stands with earthworms associated with their bases grow and yield better than those lacking earthworms at their bases[11]. It was demonstrated that residual products of earthworms in their casts break the dormancy in jute which otherwise needs to be steeped before it can germinate[3]. It has also been shown that the level of earthworms in the soil affects the rate of germination of the vegetable *Celosia*.

In its geographic setting, southern Nigeria, where this experiment was carried out experiences raining season from about March, April-October. This is followed by a dry season from about November through March. During the dry season, there is no rain and earthworm activities are virtually stopped. Adapting to this natural cycle, many peasant farmers prepare their seeds ready for planting, carry out land preparation in the month of March and April. If it rains, many take the risk of planting, even though the rain is yet unsteady and may withdraw for another 3-4 weeks before becoming steady. A motivating factor for taking the risk with early rain is the gain of early cropping which makes possible as much as 300% gain per unit mass of crop sold, compared to later cropping. A second reason is that the precocious cropping allows for multiple cropping of some crops (eg, maize) per raining season.

In the experiment here reported we sought to ask if residues of earthworm products and secretions left over after a raining season would make any impact on the rate and percentage germination after the soil has gone through a five-month dry season. In other words, would the left over earthworm products be any advantage to early cropping?

MATERIALS AND METHODS

Soil from the temporary site of the Rice Development Programme of Olabisi Onabanjo University, Ago-Iwoye was heat sterilized at about 104 ^{0}C. Plastic bowls (dimensions 22.5cm diameter, 10 cm height) were used as plant pot. Polyester cloth bags were made with vertical septa to divide each bag into two equal halves. A bag was placed in each pot and 820g of the sterilized soil was loaded into each half-side of a plant pot. Earthworms were introduced into

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Table 1a: Mean germination of *Amaranthus* seeds in soil left to dry up for five months after earthworm treatment.

	N	Mean	S.D.	S.E.	Minimum	Maximum
0-worm	8	2.72	0.67	0.24	2	4
5-worm	8	3.41	0.79	0.28	3	5
10-worm	8	3.94	0.44	0.15	3	5
15-worm	8	3.38	1.03	0.36	2	5
25-worm	8	4.44	0.66	0.24	4	6
Total	40	3.58	0.92	0.14	2	6

Table 1b: Anova Test of Significance of the Differences

	Sum of Squares	df	Mean Square	F	Sig
Between Groups	13.416	4	3.354	6.064	0.001
Within Groups	19.359	35	0.553		
Total	32.775	39			

Germination is least in the control (o-worm) pots, and highest in the 25-worm pots

Table 2: Multiple Paired comparisons to determine which treatment levels are effectively equivalent (ie, produce equivalent germination rate).

(I) Treatment level	(J) Treatment level	Mean Difference in germination (I-J)	Std Error	Sig
0-Worm	5-worm	-0.69	0.37	0.073
	10-worm	-1.22	0.37	0.002
	15-worm	-0.66	0.37	0.086
	25-worm	-1.72	0.37	0.000
5-worm	0-Worm	0.69	0.37	0.073
	10-worm	-0.53	0.37	0.162
	15-worm	0.03	0.37	0.934
	25-worm	-1.03	0.37	0.009
10-worm	0-Worm	1.22	0.37	0.002
	5-worm	0.53	0.37	0.162
	15-worm	0.56	0.37	0.139
	25-worm	-0.50	0.37	0.187
15-worm	0-Worm	0.66	0.37	0.086
	5-worm	-0.03	0.37	0.934
	10-worm	-0.56	0.37	0.139
	25-worm	-1.06	0.37	0.007
25-worm	0-Worm	1.72	0.37	0.000
	5-worm	1.03	0.37	0.009
	10-worm	0.50	0.37	0.187
	15-worm	1.06	0.37	0.007

Note: The mean difference is significant when sig. is <0.05

only one side of the pots at the levels of 5, 10, 15 and 25 respectively. The 0-worm per pot represented the control. Ten seeds of *Amaranthus* were planted on each side of a pot. All these were set up in five replicates. They were watered with 200 ml every other day. The water was obtained from a surface well. No fertilizer or leaf litter was applied to the soil. After 36 days the crop was harvested by complete uprooting and the pots were left to dry up for about five months during which the earthworms died off as would largely

Table 3: Homogenous subset

Treatment level	N	Subset for alpha =.05 1	2	3
0-worm	8	2.72		
15-worm	8	3.38	3.38	
5-worm	8	3.41	3.41	
10-worm	8		3.94	3.94
25-worm	8			4.44
Sig.		.088	.162	.187

Means for groups in homogeneous subsets are displayed. (Uses Harmonic Mean Sample Size = 8). This indicates that no treatment level is homogeneously different from others

Table 4: Comparison of germination on worm and wormless sides of pots after the five-month dryness Germination on worm and wormless sides

	Worm vs Wormless	N	Mean	S.D.	S.E. of Mean
Germination	Wormless	20	3.35	0.86	0.19
	Worm	20	3.80	0.94	0.21

Independent Samples T-test on the difference

		t	df	Sig (2-tailed)	Mean Difference	S.E. of Difference
Germination	Equal variances assumed	-1.582	38	0.122	-0.45	0.28
	Equal variances not assumed	-1.582	37.665	0.122	-0.45	0.28

Table 5: Correlation between levels of earthworm treatment and germination

		Treatment level	Germination
Treatment level	Pearson Correlation	1.000	0.548
	Sig. (2-tailed)	.	0.000
	N	40	40
Germination	Pearson Correlation	0.548	1.000
	Sig (2-tailed)	0.000	.
	N	40	40

There is strong positive correlation between the level of earthworm treatment and the level of germination

Table 6: Regression analysis between the level of earthworm treatment and the level of germination

	Unstandardazed Coefficients		Standardized Coefficients	t	Sig
	B	Std. Error	Beta		
(Constant)	2.940	0.199		14.750	0.000
Treatment level (worms/ha)	2.293E-07	0.000	0.548	4.041	0.000

Dependent variable: Germination

The regression coefficient is 2.293×10^{-7}. And the regression constant =2.940

Therefore level of germination = (2.940) + (2.293×10^{-7} x (number of earthworms per hectare)

happen in the natural setting. After this the pots were watered and left to stand for 24 hours. Then they were again planted with 20 seeds on the worm and wormless sides of each pot. The germinations from the two sides of a pot were observed and recorded over a period of 16 days (*Amaranthus* germinates in about 5 days). The rate and percentage germination were calculated. The experiment was terminated. All seedlings were uprooted.

RESULTS AND DISCUSSION

Discussion: Apart from the very few locations which have all-year-round rain, most Nigerian locations have sharply demarcated rainy and dry seasons[2]. The seasons last for three to nine months depending on the locality. For example, in Ago-Iwoye, the location of the present study, it lasts about 5 months. The present results suggest that a five-month dry season does not completely destroy effective products of earthworms from the soil.

The pattern of germination here recorded is the same as initially recorded in the pre-drying experiment. This suggests that the earthworm products leave enough residues in the soil to affect post-drying germination. It also suggests that the effective earthworm products are stable in the soil over the five-months dryness. This agrees with the findings that earthworm products left in over-seasoned casts can break dormancy of jute seeds[3]. Ayanlaja *et al*[3] had extracted the active earthworm products which was then used to incubate jute seeds. In the present study, the earthworm products were left in the soil in which the seeds were planted. This study therefore further indicates that earthworm may be playing a regular and important role in the germination of seeds planted in the field.

The survival of the earthworm products for five months in the soil also suggests that a good percentage of the earthworm products escape the usual microbial breakdown for a long time. The products must also be thermostable, since under field conditions they survive the usual high dry season temperature of the tropical soil.

It is usually assumed that seed germination requires oxygen, moisture, warmth, and viability of seed. Earthworms were not re-introduced into the soil in the present study, rather, their left over products in soil was wholly responsible for the results. It could not be asserted then that the gain in germination in the 25-worm pot over the control or 5-worm pots was due to heat produced by the earthworms in the soil, although earthworms are known to increase soil temperature[6,12]. Neither could the differences be due to moisture as an equal amount of water was added to the pots. The pots were all planted from the same seed stock and are initially of equal viability. Earthworm products must therefore be introducing an additional factor which may have been of chemical nature. That factor may in part cause breakdown of seed coat to facilitate germination. If that were all, the effects should show in the different rates of germination, but not in the total germination.

Could it also involve an embryo invigorating factor? This is possible, seeing that total germination is improved by earthworm products. Here is a suggested mechanism by which earthworm products improve total germination. Measurements by Owa *et al* (unpublished data)attests that some earthworm products affect cell proliferation and elongation regions of a plant. Ayanlaja *et al*[3] suggested that earthworm products make seed testa more permeable to water and ions. Subsequently, they gain access into the seed contents, especially, into the embryo. The embryo is activated and the endosperm is mobilized. Earthworm products are probably involved in nutrient utilization of the catabolic products of the endosperm such that the cell proliferation and elongation in the embryo are facilitated. Ayanlaja *et al.,*[3] had found that earthworm products in facilitating germination preferably affect radicle growth and elongation. Thus, before depletion of the small endosperm (of *Amaranthus*) the embryo has successfully germinated, the root has begun to draw from extra-endospermic resources of the soil, and the seedling is ready for autuotrophic photosynthesis activities.

A simple implication of this hypothesis is that some of the earthworm products are catalytic (enzymatic) in function, facilitating effective utilization of endosperm.

The present study also suggests that apart from the effects of earthworms on soil physics, their chemical effects are also significant. If earthworms were physically present in the soil, soil aeration via channels, burrows and galleries, would have been held responsible for the improvement in germination via improved oxygen contents of the soil, and thereby seed metabolism. In their physical absence, the improvement in germination with the different levels of (initial) exposure to earthworms must be due largely to the chemical products of the earthworms.

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