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# Foliar spray of Earthworm urine to improve *Amaranthus* growth performance and yield

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**ABSTRACT:**

The effects of foliar spray of earthworm urine on plant growth parameters and greengrocery values were studied on the leaf vegetable *Amaranthus.* The application caused 28% increase in plant height, 166% increase in plant girth taken at the ground level, 20% increase in the number of leaves per plant, 17% increase in length of leaves, 15% in leaf breadth and about 49% in leaf area. It was also observed that the stomatal diameters increased by about 19%. These results of foliar application indicate that earthworm urine contains some plant growth hormone that can be gainfully used to increase not only the yield of the vegetable crop, but also increase its market visual appeal with respect to the length of an *Amaranthus* stick, the leaf-density per stick and the length and area of a leaf. On a commercial scale earthworm urine application can be mechanized using a sprinkler.

**Keywords:**

Earthworm urine, horticulture, greengrocery, plant growth hormone, sprinkler application.

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## INTRODUCTION:

The importance of earthworms to the general health of crops and soil has been well documented. They affect the soil in many ways. Bayon and Binet 2001 reported that earthworm surface casts affect soil erosion by runoff water and phosphorus transfer in a temperate maize crop. Their casts improve the stabilization of organic matter in fine soil fractions (McInerney, Little and Bolger 2001). Their surface movement improves soil porosity and aeration (Mather and Christensen 1988). According to Sharpley, Syers and Springett (1979) their surface casting improves transport of phosphorus and nitrogen in surface runoff from pasture.

One mechanism of nitrogen efficiency in agricultural soils is due to release of nitrogen from herbage residues by earthworms (Ruz Jerez, Ball and Tillman 1988). According to Mackay and Kladivko (1985) earthworms improve the rate of breakdown of soybean and maize residues in the soil. By competitive feeding, earthworms depress soil nematode populations (Yeates 1981).

Earthworm burrowing activity reduces soil compaction (Bostrom 1986). Soil damage due to opencast mining is sometimes rehabilitated by earthworm transplant. (Stewart, Scullion, Salih and Al Bakri 1988).

Owa, Moreyibi and Dedeke (2002) demonstrated that wormcasting initiates thermal and nutrient convection current in the soil. By that earthworms raise soil temperature and thereby improve the physicochemical activities of crops (Owa *et al* 2004a).

When located at the base of a plant crop their effect could amount to creating an isolating environment (Owa *et al.* 2004b). Another positive effect on plant is that earthworms participate in dispersal of seeds (Decaens *et al.* 2003). According to Ayanlaja *et al. (*2001) leachate from earthworm cast can break seed dormancy and promote radicle growth.

Earthworm affect soil microbial population. Their casts and compost improve soil microbial activities and plant nutrient availability (Brown 1995; Chaoni *et al.* 2003). Microbial biomass and activities increase after the soil microbes have passed through the gut of earthworms (Daniel and Anderson 1992).

Studying earthworm populations and distribution in Nigerian soils Owa *et al.* (2003) showed that earthworms make significant contribution to the soil nitrogen, and that application of earthworms in a farm, or their protection from farming activity damages can lead to reduction of the quantities of inorganic fertilizers needed.

Studying lowland rice agroecosystems Owa *et al.* (2003b) showed that rice stands that have earthworm casts associated with their bases grew more tillers, grew taller, had more leaves, more grains and bigger grain size, than others stands lacking earthworm casts associated with their bases. Ojediran 1990 reported that increasing irrigation frequency induced an increase in the shoot length and root growth of wheat. Both root mass and length were reported to decrease significantly with water stress (Ojediran 1990, Snyman 2004).

Two major challenges confront expansion of earthworm urine irrigated farming: one is availability of water resource. Irrigation of vegetables requires significant quantities of water of suitable quality. The second is water lifting and distribution device. One traditional method is the rope and bucket. An alternative traditional method is the treadle pump which originated in Bangladesh or motorized pumps.

The present study is aimed at checking if foliar application of earthworm urine can produce enhancement in the growth parameters and market grocery values of the leaf vegetable crop *Amaranthus.* An argument is also provided that the foliar application can be mechanized by use of a sprinkler. Such a mechanization can significantly improve the production and availability of this very important leaf vegetable.

## MATERIALS AND METHODS

Earthworm urine was prepared by placing 1 kg live earthworms in 1 L earthworm saline for 1 hr. The decant was funnel filtered under suction. The filtrate was labeled as earthworm urine.

Ninety (90) plastic plant pots were loaded each with 1 kg top soil, set in an open space; and planted with viable seeds of *Amaranthus*. After germination, the plants were thinned down to one per pot. 30 pots randomly selected were reserved and properly labeled for earthworm urine treatment, another 30 for earthworm saline treatment and the last 30 for water treatment.

Each pot was watered with 500 ml water between 6.30 am and 7 pm daily. Using a handheld plastic sprayer, 30 $cm^3$ of earthworm urine, earthworm saline and distilled water were daily sprayed onto the leaves of each plant in the respective pots. The application was every morning.

On a regular weekly basis, the height of the plant in each pot was measured from the ground level to the apical bud, using a meter rule. The widest stem girth was measured at the ground level, using a thread and plastic ruler. The lengths and widest diameters of the lowest (and largest) three leaves on a plant were measured using a plastic ruler. The total number of leaves on each plant was recorded. At the end of the fifth week an additional factor, stomatal diameter, was measured and the experiment was terminated. To measure the stomatal diameter, nail vanish was applied to the lowest green leaf on a plant, in order to take an impression of the stomata pores. The vanish was allowed to dry, carefully peeled off, placed on a labeled microslide and taken to the laboratory. Using a stage micrometer and eyepiece graticule, the stomatal diameters were measured.

The resulting data were analyzed using the Statistical Package for Social Sciences (SPSS) Version 15. Analysis of variance, LSD and Duncan multiple range tests were performed on the data, in order to test the significance of the differences at $p = 0.05$.

## RESULTS

Compared to the controls, application of earthworm urine produces about 28% increase in plant height, 20% in number of leaves per plant, 166% in plant girth (**Table 1**), 17% in leaf length and about 40% in leaf area (**Table 2**). It also produces an increase of about 19% in stomatal pore diameter (**Table 3**).

## DISCUSSION

Hitherto, the effects of earthworms on plants have been viewed via their impacts on the soil. The present work shows that earthworm urine can affect plants more directly.

From agronomic considerations, the gain in height or length of a crop is a desirable effect similar to the effect of organic and inorganic fertilizers. For a leaf vegetable, it shortens the time taken for the crop to reach table size. It means savings in time and cost of operations before the crop is sold for a monetary gain. From the buyers' angle, the lengthening of the vegetable stick produces a visual advantage. In local greengroceries, buyers examine the length of the sticks of the vegetable, and prefer those that are long.

From research angle, this result is similar to the earlier results of Owa *et al.* (2002), Owa *et al.* (2003), Owa *et al.* (2004a, b) And it indicates that beyond just providing nitrogen and ammonia to plants through the soil, earthworm urine provides some growth hormone.

That plant girth is greatly increased by earthworm urine is beneficial in many ways. In the current drive to minimize artherogenesis and other diet-related diseases, there is a growing emphasis on vegetarianism, especially the use of intake fibers to reduce dietary cholesterol absorption at the villi level. Among the local community, not only the leaves of *Amaranthus* are shredded for cooking, but also the soft succulent stem. Thus, the application of earthworm urine could be indirectly contributing

**Table 1: Effects of foliar application of earthworm urine on the height, number of leaves and stem girth of *Amaranthus***

| | | N | Mean | Std. Dev | Minimum | Maximum | % Gain in parameter relative to control |
|---|---|---|---|---|---|---|---|
| Height of plant (cm) | Earthworm urine | 30 | 40.302a | 6.5102 | 28.4 | 56.2 | 28.0502 |
| | Saline water | 30 | 33.411b | 5.7132 | 23.4 | 48.6 | 6.157594 |
| | Water (control) | 30 | 31.473b | 4.9797 | 21.8 | 41.1 | |
| | Average | 90 | 35.062 | 6.8585 | 21.8 | 56.2 | |
| No of leaves | Earthworm urine | 30 | 12.10a | 2.845 | 7 | 16 | 20.19868 |
| | Saline water | 30 | 10.70b | 2.054 | 1 | 13 | 6.291391 |
| | Water (control) | 30 | 10.07b | 1.780 | 4 | 12 | |
| | Average | 90 | 10.96 | 2.403 | 1 | 16 | |
| Plant girth at ground level (cm) | Earthworm urine | 30 | 3.627a | .5836 | 2.5 | 5.1 | 166.4055 |
| | Saline water | 30 | 1.660b | .3001 | 1.3 | 2.2 | 21.93928 |
| | Water (control) | 30 | 1.361c | .0687 | 1.3 | 1.5 | |
| | Average | 90 | 2.216 | 1.0785 | 1.3 | 5.1 | |

**Note: Values labeled with same letter are not significant different, others with different letters are significantly different.**

**Table 2: Effects of foliar application of earthworm urine on leaf length, leaf width and leaf area of *Amaranthus***

| | | N | Mean | Std. Deviation | Std. Error | Minimum | Maximum | % Gain relative to control |
|---|---|---|---|---|---|---|---|---|
| Leaf length (cm) | Earthworm urine | 30 | 10.1150a | 1.47177 | .26871 | 7.08 | 14.08 | 17.11694 |
| | Saline | 30 | 9.5917a | 1.53517 | .28028 | 6.38 | 13.28 | 11.05751 |
| | Water | 30 | 8.6367b | 1.27177 | .23219 | 6.20 | 11.98 | |
| | Average | 90 | 9.4478 | 1.54258 | .16260 | 6.20 | 14.08 | |
| Leaf breath (cm) | Earthworm urine | 30 | 5.9350a | 3.04315 | .55560 | 2.95 | 21.35 | 15.09373 |
| | Saline | 30 | 5.0192a | .85872 | .15678 | 3.30 | 6.78 | -2.66645 |
| | Water | 30 | 5.1567a | 2.21831 | .40501 | 3.50 | 16.33 | |
| | Average | 90 | 5.3703 | 2.24181 | .23631 | 2.95 | 21.35 | |
| Leaf Area (cm**2) | Earthworm urine | 30 | 20.4851a | 12.08548 | 2.20650 | 6.95 | 78.03 | 39.83027 |
| | Saline | 30 | 16.3841a | 5.24115 | .95690 | 8.09 | 29.95 | 11.83741 |
| | Water | 30 | 14.6499b | 5.23739 | .95621 | 8.25 | 37.37 | |
| | Average | 90 | 17.1730 | 8.45779 | .89153 | 6.95 | 78.03 | |

**Note: Values labeled with same letter are not significant different, others with different letters are significantly different.**

significantly to higher fiber intake and thus contributing to the battle against artherogenic disease. Similarly amaranth oil is used in the treatment of ischemic and other artherogenic diseases (Czerwinski *et al.,* 2004; Gonor *et al.* 2006; Martirosyan *et al.* 2007).

Earthworm urine increases the number of leaves on a plant. To the local consumers the density of leaves on an *Amaranthus* stick is a major buyer's consideration. From dietary point of view many of the nutrients that humans benefit from *Amaranthus* are derived from the leaves. These include, among others, vegetable oils, protein, carbohydrates, macronutrients and micronutrients. Vegetable leaf is one of the most important sources of dietary fiber. Thus, application of earthworm urine can improve the nutritional value of *Amaranthus* for human consumption.

But in addition, there is an esthetic premium attached to the length of a vegetable leaf. There is a social and psychological preference for *Amaranthus* sticks with longer leaves than for those with shorter leaves, even when there is no known data that the one is richer in nutrients than the other. Thus, application of earthworm urine could significantly improve the premium value placed on *Amaranthus* in a greengrocery.

The widening of stomatal diameter by earthworm urine may be a factor to the higher growth performance and productivity of the plants. It increases the rate of in- and out-diffusion processes, thus increasing the rate of foliar and photosynthetic metabolism.

Beyond *Amaranthus,* the implication of the effect of earthworm urine on plant growth and yield performances is that the food basket can be

**Table 3. Effects of foliar application of earthworm urine on leaf stomatal diameter of *Amaranthus***

| Diameter of stomata (um) | | | | | | | |
|---|---|---|---|---|---|---|---|
| | N | Mean | Std. Deviation | Std. Error | Minimum | Maximum | % Gain relative to control |
| Earthworm urine | 100 | .006500a | 0.00188 | 0.000188 | 0.0025 | 0.01 | 19.26606 |
| Saline water | 104 | .005962b | 0.001608 | 0.000158 | 0.0025 | 0.01 | 9.386027 |
| Ordinary water | 100 | .005450c | 0.00125 | 0.000125 | 0.0025 | 0.01 | |
| Average | 304 | 0.00597 | 0.001651 | 9.47E-05 | 0.0025 | 0.01 | |

**Note: Values labeled with same letter are not significant different, others with different letters are significantly different.**

significantly improved by appropriate mechanization.

A major constraint to increased irrigated crop production is low water lifting and distribution capacity. Any pump supplying significantly greater flow rates relative to traditional rope and bucket system will increase irrigated surface areas and reduce irrigation labour time, resulting in increased production (Hyman *et al*. 1995). Generally, a proper irrigation interval increases the plant water stress tolerance and gives the vegetable leaves a very appealing green colour look.

Given the availability of land during the dry season and improved water lifting and distribution technology, the use of earthworm urine will lead to larger irrigated surface areas and consequently, larger vegetable yield.

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