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Effects of Composted and Powdered Bones Meal on the Growth and Yield of *Amaranthus cruentus*

Dilruba Yasmin[1], Md. Zulfikar Khan[1*] and Shaikh Motasim Billah[1]

[1]Soil, Water and Environment Discipline, Khulna University, P.O.Box: 9208, Khulna, Bangladesh.

Authors' contributions

This work was carried out in collaboration between all authors. Author DY designed the study, wrote the protocol and wrote the first draft of the manuscript. Authors MZK and SMB reviewed the study design and all drafts of the manuscript. Authors MZK and DY undertook the statistical analysis of the data collected and managed the literature searches and reference-citations. Finally, all the authors read and approved the final manuscript.

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ABSTRACT

A pot experiment was conducted to investigate the effect of composted and powdered bones meal on the growth and yield of *Amaranthus cruentus* on Pirojpur soil series during the period of 25th March to 15th May, 2017. The experiment was laid to fit a completely randomized design (CRD) with seven treatments [control (T_0), 2 g chicken bone powder/pot (T_1), 2 g mutton bone powder/pot (T_2), 2 g beef bone powder/pot (T_3), 2 g chicken bone compost/pot (T_4), 2 g mutton bone compost/pot (T_5), and 2 g beef bone compost/pot (T_6)] each having three replications for this experiment. After plants were harvested, the laboratory investigation was carried out. Yield contributing characters like number of leaves, root length, shoot length, fresh weight, dry weight and moisture content were significantly (P <0.05) influenced by different treatments. Among the seven treatments applied, T_6 treatment (2 g beef bone compost/pot) has shown the highest response to plant growth due to the nutrient availability of the soil. The sequence of response was in the order $T_6>T_5>T_4>T_2>T_3>T_1$ and significantly (P <0.05) difference in plant growth from the control (T_0).

Keywords: Effects; chicken bone; mutton bone; compost; growth and yield response; moisture content; Amaranthus cruentus.

**Corresponding author: E-mail: zulfikar.ku11@gmail.com;*

1. INTRODUCTION

Bangladesh, a country that covers an area of 147,570 square kilometers, is one of the predominantly agro-based developing countries in the world. Since her independence in 1971, agriculture has been the core sector of Bangladesh economy, which is still contributing around 17 percent of the GDP and also providing employment to 45 percent labour force [1]. Around 84 percent of the rural people of the country depends on agriculture for their livelihood directly or indirectly. Moreover, it is the primary source of employment, livelihood and food security for the majority of rural people and also provides raw materials to industry and contributes to the country's exports. Although the modern economy is largely dependent on industrialisation, agriculture remains the lifeblood for many agrarian economies like Bangladesh.

Vegetable is one of the most important and popular products in the agriculture sector of Bangladesh. It is an important source of vitamins, minerals and plant proteins in human diets [2]. Vegetable cultivation and its marketing in rural and urban areas are also a source of income for the upland rural community. Side by side, vegetable cultivation is becoming costlier due to the increased price of different inputs like pesticides and fertilisers. In Bangladesh, farmers are cultivating a large amount of vegetables like eggplant, cucurbits, carrot, country bean, bottle gourd, red amaranth, cabbage, cauliflower, radish, tomato, etc. in 989 thousand acres of land and produce 3729 thousand metric tons' vegetables in the year 2015-2016 [1].

In general, red amaranth (*Amaranthus cruentus*) belonging to the family *Amaranthaceae* is a delicious vegetable with its considerable nutritional value around the globe and in particular, in parts of tropical and subtropical Asia, Africa and Central America. However, chiefly grown during summer and rainy season, amaranth is an important and popular vegetable in Bangladesh because of its cheapest price, quick growing character and higher yield potential [3]. Therefore, in Bangladesh context, it is considered as a potential upcoming subsidiary food crop [4].

Additionally, it contains 43 foods caloric which is higher than any other vegetables except potato and tomato [5] and [6]. Apart from this, it is processed into table products like soup. Even its seeds are used in making sweet rolls, crepes cookies crackers, etc. [7]. However, in Bangladesh, its cultivation is increasing day by day [8] although its production is lower than other amaranth producing countries [9]. Meanwhile, in Bangladesh, nitrogen fertiliser is the most crucial input for crop production and had been recognised as the central element for agricultural production as it imparts a major role on the increase in quality, colour and taste of vegetables [10].

Organic matter in soils plays a vital role by improving soil physical condition viz., soil structure, water holding capacity, aeration and protects soil erosion. It is a storehouse of plant nutrients, chiefly N, P, and S. It serves as a food and energy for beneficial organism e.g. N_2-fixing bacteria and earthworms. A good soil should have at least 2.5% organic matter but in Bangladesh, most soils have less than 1.5%, and some soils have even less than 1% organic matter [11].

Meat and bone meal (MBM) is a by-product of the rendering industry. It contains about 8% Nitrogen (N), 5% Phosphorus (P), 1% Potassium (K) and 10% Calcium (Ca) [12] and [13] which makes it a valuable source of nutrients for plant production. Meat bone is also an excellent source of calcium (Ca). Plants can get phosphorus (P) from bone if the soil pH is below 7.0 (acidic soil), according to recent Colorado State University research. Therefore, this experiment was conducted to investigate the effect of composted and powdered bones meal on the growth and yield of *Amaranthus cruentus*.

2. MATERIALS AND METHODS

A pot experiment was conducted to investigate the growth and yield of *Amaranthus cruentus* to the effect of composted and powdered bones meal. The purpose of this section is to summarise the description of the study area, materials used for the experiment and the methods of analysis.

2.1 Collection and Preparation of Soil Samples

The soil used in the experiment belongs to the "Pirojpur" series. Soil samples were collected from the agriculture field behind the Khulna University. The location of the sampling area is 22°48.302N and 89°31.962E, Bangladesh. The soil sample was collected from the surface (0-15 cm) on the basis of composite sampling method as suggested by the soil survey staff of the

USDA [14]. The collected soil samples were air dried ground and screened to pass through a 2.0 mm sieve and then mixed thoroughly to make it a composite sample. After that soil samples were collected into a plastic container for pot experiment.

2.2 Preparation of Powder and Composted Meat Bones

After eating meat (chicken, mutton, beef), the waste of bones were collected and dried. The dried bones were crushed into powdered form. For preparing meat bones compost, bones (chicken, mutton and beef) were crushed and transferred it into a plastic bag. An adequate amount of water was added into it to degrade the meat bones and kept it by digging soil into 30 cm depth. After 60 days (25th January to 25th March, 2017) the composted (chicken, mutton and beef) bones were ready to apply for this experiment.

2.3 Pot Experiment

A pot experiment was conducted in the greenhouse at Soil, Water and Environment Discipline, Khulna University, during the period of 25th March to 15th May 2017 investigate the growth, yield response of *Amaranthus cruentus* to the effect of composted and powdered meat bones. Three kg of air-dried soil was taken in 30 cm high and 18.2 cm diameter earthen pot. Pots had few micro pores in the bottom to protect the leaching of meat bone from the soil.

2.4 Experimental Design and Treatments

The experiment was laid to fit a completely randomized design (CRD) [15] with seven treatments, each having three replications for this experiment. The treatments are shown in Table 1.

Table 1. Treatments of the experiment

Treatment	Description
T_0	Control
T_1	2 g chicken bone powder/pot
T_2	2 g mutton bone powder/pot
T_3	2 g beef bone powder/pot
T_4	2 g chicken bone compost/pot
T_5	2 g mutton bone compost/pot
T_6	2 g beef bone compost/pot

2.5 Sowing of Seeds

The seeds were collected from the local seed market. Seeds were sown on 17th March, 2018. The seeds were sown thoroughly as it was possible to keep uniformity and then seeds were covered by soil. 0.01 gm seeds (5 kg ha^{-1} as recommended by [16]) were sown in each pot and maximum seeds germination within 7 days. After germination, only five plants were kept in each pot.

2.6 Harvesting and Preparation of Plant Samples

After 50 days, plant was harvested manually by uprooting the plant from the pot. Then the sampling plants were kept separately. Collected plant samples were washed thoroughly with distilled water to remove soil particles and soaked by tissue paper to remove excessive water. After taking fresh weight the plant samples were dried in the oven at 65°C temperature for 48 hours until the moisture content reached to a minimum level. The dried material of plants per pot from each treatment was recorded.

2.7 Data Collection of Different Attributes of the Test Crops

Different growth and yield parameters were recorded and their mean values were calculated from the sample plants during the experiment. The number of leaves of five plants of each pot was counted and average value was considered. Shoot length was measured using a measuring scale from the root level to the tip of the plant. From each pot, five plants were measured and averaged. Root length was measured using a measuring scale from root level to the tip of the longest root at harvest and their average was taken as the root length in cm. Harvest of five plants from each pot, fresh weight of whole plant was taken by an electrical balance and their mean value was calculated as fresh weight expressed in g plant^{-1}.

2.7.1 Moisture content

Percent moisture was calculated by using the formula:

$$\text{Moisture content (\%)} = \frac{Wf - Wo}{Wf} \times 100$$

Where,

W_f = Fresh weight of the plant sample
W_o = Oven dry weight of the plant sample

2.8 Statistical Analysis

Analysis of variance (ANOVA) was performed to investigate the changes in the growth and yield

response of *Amaranthus cruentus* for the comparative use of composted and powdered meat bones. The ANOVA and Duncan Multiple Test were done in completely randomised design by using the SAS 6.12 software package [17].

3. RESULTS AND DISCUSSION

Effect of composted and powdered bones meal on the growth and yield of *Amaranthus cruentus* was studied following pots experiment. The results are presented in Appendix 1.

3.1 Number of Leaves

Number of leaves per plant ranged from 5.25 to 10.5. The highest number of leaves was found in T_6 (10.5) (Fig. 1). Number of leaves varied significantly in T_2, T_4, T_5 and T_6 compared with control treatment T_0. There was an insignificant difference between T_0 and T_1 as well as T_4 and T_5 but significant (P <0.05) difference was found between T_3 and T_6. So, application of compost of beef bone showed significant (P <0.05) increment of the number of leaves in *Amaranthus cruentus* whereas application of powdered chicken bone and beef bone did not show any positive effect on the number of leaves on *Amaranthus cruentus*. On the basis of plant leave number, application of composted beef bone is the best for uses and it is recommended for *Amaranthus cruentus*. Changes in the number of leaves are bound to affect the overall performance of *Amaranthus* as the leaves serve as photosynthetic organ of the plant [18].

3.2 Root Length

Length of root per plant ranged from 1.14 cm to 4.30 cm. The longest root was found in T_6 (4.30 cm) (Fig. 2). Root length varied significantly in T_4, T_5 and T_6 compared with control treatment T_0. There was an insignificant difference between T_0, T_1, T_2, T_3 as well as T_4 and T_5 but significant (P <0.05) difference was found in T6. So, application of compost of beef bone showed significant (P <0.05) increment of root length in *Amaranthus cruentus* whereas application of powdered chicken bone, mutton bone and beef bone did not show any positive effect on the root length of *Amaranthus cruentus*. On the basis of the plant root length, application of composted beef bone is the best for uses and it is recommended for *Amaranthus cruentus*. Ehigiator [19] reported that the highest root length exhibited by plants treated with CPM at the 12 t ha^{-1} might have been due to the presence of the primary nutrients (NPK) plus calcium and magnesium found in organic manure, confirmed by Opara [20] and chemical analysis of the poultry manure.

3.3 Shoot Length

Shoot length per plant ranged from 5.19 cm to 11.79 cm. Tallest shoot was found in T_6 (11.79 cm) (Fig. 3). Length of shoot varied significantly in T_2, T_4 T_5 and T_6 compared with control treatment T_0. There was an insignificant difference between T_0, T_1, T_3 but significant (P <0.05) difference was found in T_6. So, application of compost of beef bone showed significant (P <0.05) increment of length of shoot in *Amaranthus cruentus* whereas application of powdered chicken bone and beef bone did not show any positive effect on the shoot length of *Amaranthus cruentus*. On the basis of plant shoot length, application of composted beef bone is the best for uses and it is recommended for *Amaranthus cruentus*. An optimum shoot length is claimed to be positively correlated with productivity of plants [21].

3.4 Fresh Weight

Fresh weight per plant ranged from 0.27 gm to 3.53 gm. The highest fresh weight of plant was found in T_6 (3.53 gm) (Fig. 4). Fresh weight varied significantly (P <0.05) in T_1, T_2, T_4, T_5 and T_6 compared with control treatment T_0. There was an insignificant difference between T_0 and T_3 but significant difference was found in T_6. So, application of compost of beef bone showed significant (P <0.05) increment of fresh weight in *Amaranthus cruentus* whereas application of powdered chicken bone, mutton bone and beef bone did not show any positive effect on the fresh weight of *Amaranthus cruentus*. On the basis of the fresh weight of plants, application of composted beef bone is the best for uses and it is recommended for *Amaranthus cruentus*.

3.5 Dry Weight

Dry weight per plant ranged from 0.06 gm to 0.45 gm. The highest dry weight was found in T_6 (0.45 gm) (Fig. 5). Dry weight varied significantly (P <0.05) in T_4, T_5 and T_6 compared with control treatment T_0. There was an insignificant difference between T_0, T_1, T_2, T_3 as well as T_4 and T_5 but significant difference was found between T_3 and T_6. So, application of compost of beef bone showed significant (P <0.05) increment of the dry weight in *Amaranthus cruentus* whereas application of powdered

chicken bone and beef bone did not show any positive effect on the dry weight of *Amaranthus cruentus*. On the basis of dry weight of plants, application of composted beef bone is the best for uses and it is recommended for *Amaranthus cruentus*. Yield of *Amaranthus* was least without application of poultry manure. This confirmed the findings of Adediran and Banjoko [22], who reported that the application of manure for enhancement of yield of crop.

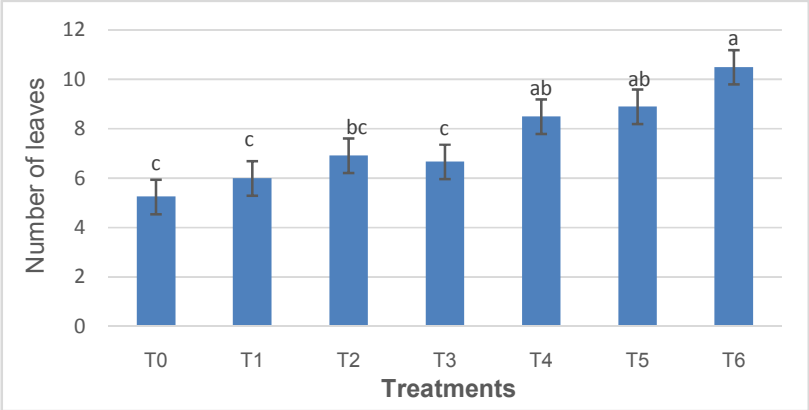

Fig. 1. Effect of powdered and composted meat bone on number of leaves of *Amaranthus cruentus*

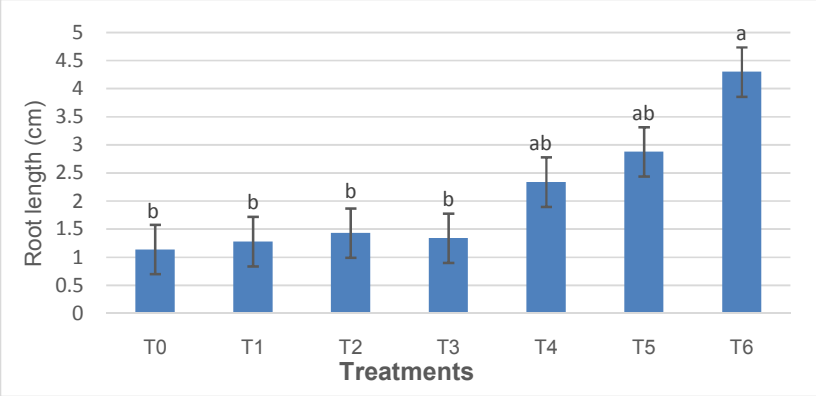

Fig. 2. Effect of powdered and composted meat bone on root length of *Amaranthus cruentus*

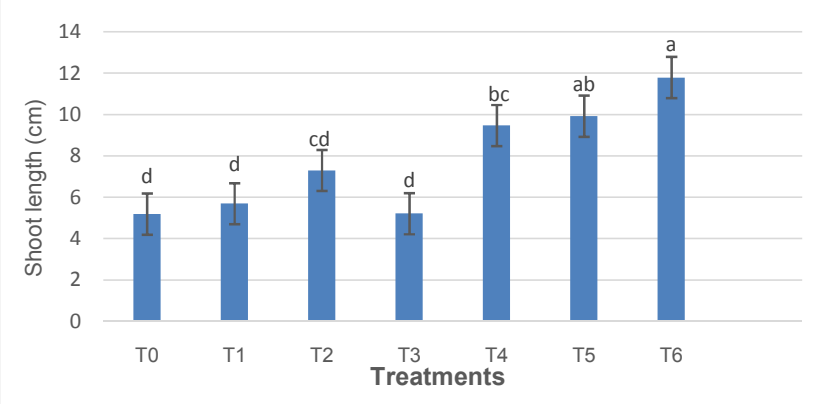

Fig. 3. Effect of powdered and composted meat bone on shoot length of *Amaranthus cruentus*

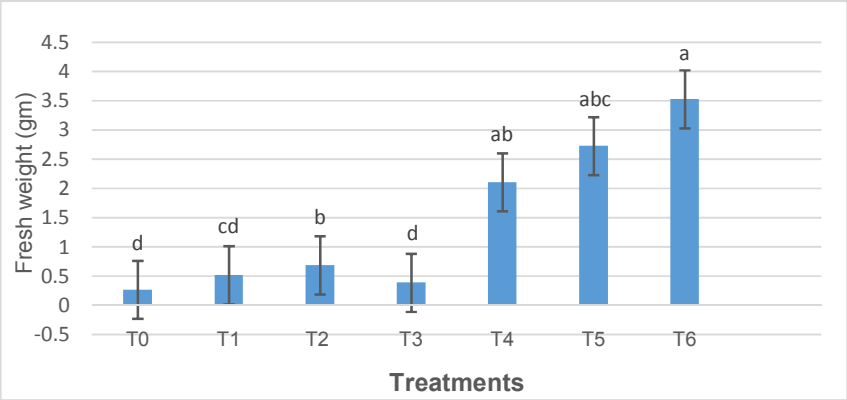

Fig. 4. Effect of powdered and composted meat bone on fresh weight of *Amaranthus cruentus*

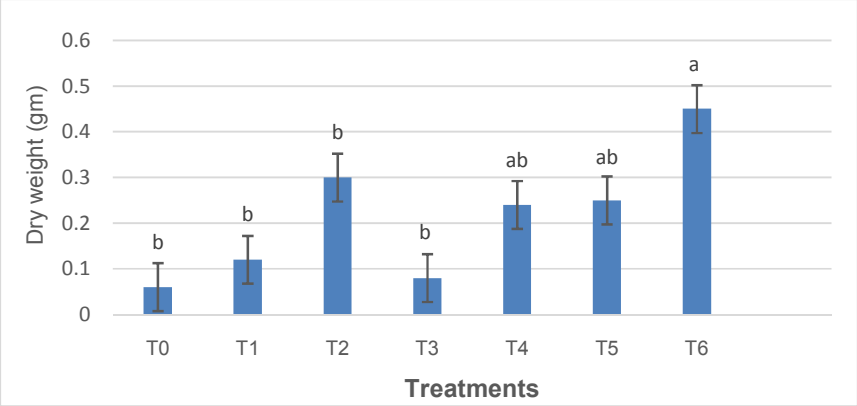

Fig. 5. Effect of powdered and composted meat bone on the dry weight of *Amaranthus cruentus*

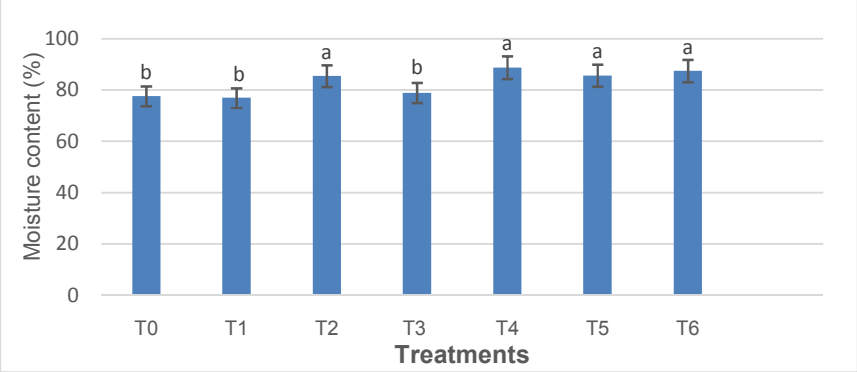

Fig. 6. Effect of powdered and composted meat bone on moisture content of *Amaranthus cruentus*

3.6 Moisture Content

Moisture content per plant ranged from 76.91% to 88.77%. The highest moisture content found in T_4 (88.77%) (Fig. 6). Moisture content varied significantly (P <0.05) in T_2, T_4, T_5 and T_6 compared with control treatment T_0. There was an insignificant difference among T_0, T_1 and T_3 but significant difference was found among T_2, T_4, T_5 and T_6. So, application of compost of chicken bone showed significant (P <0.05) increment of the moisture content in *Amaranthus*

cruentus whereas application of powdered chicken bone and beef bone did not show any positive effect on the moisture content of *Amaranthus cruentus*. On the basis of the moisture content of plants, application of composted chicken bone is the best for uses and it is recommended for *Amaranthus cruentus*.

4. CONCLUSION

A pot experiment was conducted to investigate the effects of composted and powdered bones meal on the growth and yield of *Amaranthus cruentus*. Yield contributing characters like number of leaves, root length, shoot length, fresh weight, dry weight and moisture content were significantly (P <0.05) influenced by different meat bones treatments. Among the treatment, T6 (composted beef bone) produced the highest number of leaves for *Amaranthus cruentus*. There was found a significant (P <0.05) change in treatment T_2, T_4 and T_6 compared with control T_0 but insignificant between T_1, T_2 and T_3 for *Amaranthus cruentus*. So, among the powdered and composted meat bones, composted beef bone (T_6) has shown the higher response than other treatments. Uses of composted meat bone can have a potential to increase the growth and yield of *Amaranthus cruentus*. From the experiments it has been observed that the effects of composted and powdered meat bones on the growth and yield of *Amaranthus cruentus* was $T_6>T_5>T_4>T_2>T_3>T_1>T_0$, respectively. The highest yield was found for the decomposed beef bone (T_6) due to the nutrient availability of the soil.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDIX

Appendix 1. Growth factors influenced by the application of meat bone powder and compost on *Amaranthus cruentus*

Treatments	No. of leaves per plant	Root length per plant (cm)	Shoot length per plant (cm)	Fresh weight per plant (gm)	Dry weight per plant (gm)	Moisture content (%)
T_0	5.25c	1.14b	5.19d	0.27d	0.06b	77.63b
T_1	6.00c	1.28b	5.69d	0.52cd	0.12b	76.91b
T_2	6.92bc	1.43b	7.30cd	0.69b	0.30b	85.50a
T_3	5.67c	1.34b	5.21d	0.27d	0.08b	78.90b
T_4	8.50ab	2.34ab	9.47bc	2.11ab	0.24ab	88.77a
T_5	8.90ab	2.88ab	9.92ab	1.73abc	2.73ab	85.68a
T_6	10.50a	4.30a	11.79a	3.53a	3.53a	87.43a

** Figures in a column having common letter(s) do not differ significantly at 5% levels of significance*

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