



## EFFECT OF FAECAL SLUDGE COMPOST ON GROWTH, YIELD AND QUALITY OF RED AMARANTH (*AMARANTHUS CRUENTUS*)

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### Abstract

Worldwide, 2.7 billion people rely on onsite sanitation, which is a big problem in developing countries where the use of human excreta as organic fertilizer can give a solution in waste management as well as improve soil quality and sources of plant nutrition. Thus, a pot experiment was conducted at Soil, Water and Environment Discipline, University of Khulna, from November 2019 to March 2020 to investigate the best dose of faecal sludge application in soil for growth, yield, and nutrient uptake by *Amaranthus cruentus*. The experiment consisted of four treatments (1%, 2%, 3%, and 4% faecal sludge with soil) and a control (no faecal sludge) with three replications, which were laid out in a Completely Randomized Design (CRD). The present study revealed that the highest significant variation of germination (98.60%), plant height (36.99 cm), leaf number (14), root length (7.53 cm) fresh weight (8.65 g), yield per pot (8.63 g) was obtained for 4% faecal sludge mixture soil. Moreover, uptake by the plant N (2.90%), P (2.00%), K (5.51%), Ca (0.056%), Mg (0.29%) and Fe (0.036%) was also significantly higher for 4% rather than 1, 2 and 3% sludge treated soil. Therefore, for growth, yield and nutrient uptake of red amaranth, application of 4% faecal sludge compost to soil (faecal sludge compost: soil = 4:96) was the best for uses and it is recommended for the plants.

**Keywords:** Faecal sludge, Waste management, Red amaranth, Germination, Nutrient content

### Introduction

Faecal sludge (FS) is considered as a waste mixture of human excreta, soil, and water and other components. The significant amounts of nutrients from human excrement can be used as fertilizer for farms. With fertilizer and soil conditioner among the most popular reuse alternatives, research is currently transitioning from FS disposal to reuse. About 130 g of feces and 1.4 L of urine are produced daily by adults (Harada et al., 2016). Sustainable Development Goal (SDG) 12 (Schroeder et al., 2019) is concerned with responsible production and consumption that reduces waste; while, SDG 6 promotes clean water and sanitation. Approximately 13.25 million tons of vegetables are consumed annually in Bangladesh, but only 3.73 million tones are produced (Rahman et al., 2021), indicating a severe lack of supply to meet the demand for per capita vegetation. Red amaranth is one of the most significant crops that Bangladeshi farmers raise since it grows quickly, produces a lot, and is well-liked and eaten throughout the year in Bangladesh. These days, this crop is gaining attention from all over the world, and doctors advise anemic patients to consume red amaranth (Olumakaiye, 2011). According to BBS, red amaranth farming expanded in Bangladesh and in 2019-20 country produced 61,096 metric tons (Zaman et al., 2021). As a result, it is playing a principal role in ensuring both nutrition and food security for the people. It is one of Bangladesh's most popular vegetables due to its excellent nutritional content and comparatively inexpensive cultivation cost compared to other vegetables. Protein, fat, calcium, phosphorus, riboflavin, niacin, salt, iron, and ascorbic acid are all abundant in the leaves and stems of amaranth (Miah et al., 2013). Present studies have shown that while organic manure application significantly improved soil nutrient status and reduced disease occurrence, the application of NPK amendment

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significantly decreased the organic carbon content in post-harvest soils (Mondal et al., 2019). Studies on the impact of applying organic manures, such as chicken manure, cow dung, mustard oil cake, vermicompost, and other composts, have shown improved quality of leafy vegetables as well as increased growth and yield of vegetables like red amaranth (Mondal et al., 2019) and okra (Haque et al., 2020), burmese grapes (Munna et al., 2021), and mint (Shushupti et al., 2021). Nartey et al., (2017) investigated that co-composting DFS (Dewatered faecal sludge) with EFB (empty fruit bunches) and CPH (cocoa pod husks) can be used as an alternative option for managing these wastes and to produce a suitable soil amendment. Additionally, compost made from FS was an appropriate growing medium for tomato plants. On the other hand, Nasrin et al., (2021) discovered that a 2% faecal sludge mixture with soil produced the best red amaranth morphology and yield. There haven't, however, been enough investigations conducted on faecal sludge organic manure. Faecal sludge treatment during red amaranth production may increase yield, nutrient content, and soil health, which also deals with waste management techniques. Based on the discussion above, the goal of the current study is to investigate the effect of faecal sludge compost on morphological and yield properties of red amaranth, to find out the appropriate doses of faecal sludge compost for growing red amaranth and to evaluate the nutrient uptake from sludge treated soil by red amaranth.

### **Materials and Method**

The experiment was conducted from November 2019 to March 2020 at the field laboratory of Soil, Water and Environmental Discipline (SWED), Khulna University, Bangladesh (22°48'08.1"N 89°32'01.8"E) and chemical analysis conducted in SWED's laboratory. Soil samples of Pirojpur soil series at 0-15 cm depth were collected from agricultural field behind Khulna University.

#### ***Pot preparation***

Soil samples were air-dried at room temperature for at least 15 days and all plant debris was removed manually. The soil is then sieved through a 2 mm sieve and used for analyzing the physicochemical properties of the soil. Earthen pots were used to conduct the experiment. The containers were first cleaned and labeled and then 4 kg of 2 mm sieved soil was taken in each container and mix the soil with faecal sludge according to the rate.

#### ***Treatment combination***

In the experiment, faecal sludge compost was applied at four different rates ( $T_0$  = control,  $T_1$  = faecal sludge compost: soil = 1:99,  $T_2$  = faecal sludge compost: soil = 2:98,  $T_3$  = faecal sludge compost: soil = 3:97, and  $T_4$  = faecal sludge compost: soil=4:96). Three replicas of the pot were set up in a completely randomized pattern. The pot was left for 30 days to allow for the incubation period once the treatment combination was finished.

#### ***Seeds collection and sowing***

Red Amaranth seeds were procured from Modhumoti Seed Company Limited, Maona, Chourasta, Gazipur. The seeds were sown as thoroughly as it was possible to maintain uniformity and then the seeds were covered with soil. Fifteen seeds were sown in each pot and maximum seed germination was observed in 11 days. Only five red amaranth plants were placed in each pot after germination. Proper care and maintenance are done right from seed sowing to harvesting. To prevent root rot, each pot was irrigated very carefully with an equal amount of water as needed by the plants.

#### ***Harvesting***

The tested plants were harvested at an edible stage 45 days after sowing. Plants are carefully collected and washed with fresh water. The plants are then air-dried at room temperature. Fresh weight of each potted plant was collected. The cut plants were tagged separately, dried in an oven at 70°C for 72 h until the moisture content reached the minimum level. Plant dry matter weight was recorded per pot from each treatment.

#### ***Analysis of the soil sample***

Table 1 lists the physical and chemical characteristics of the soil and faecal sludge utilized in this experiment. Jackson (1962) suggested using a glass electrode pH meter (HANNA pH211; Italy) to electrochemically determine

the pH of soil samples. With a soil to water ratio of 1:5, the EC of soil samples was measured electrochemically with an EC meter (HANNA EC214; Italy) and converted to a 1:1 ratio in accordance with the instructions provided by the US Salinity Laboratory Staff (1954). According to Bremner and Mulvaney (1982), concentrated sulfuric acid (H<sub>2</sub>SO<sub>4</sub>) digestion was followed to estimate the total nitrogen of the soil samples. The wet oxidation method of Walkley and Black (1934) was used to calculate the amount of organic carbon in the soil sample. Marshall's triangular coordinate method was used to categories textures (USDA, 1987). The Olsen extract (0.5 N NaHCO<sub>3</sub> buffered at pH 8.5) was used to extract the soil's accessible phosphorus, and Murphy and Riley's (1962) molybdophosphoric blue color technique was used to quantify the amount colorimetrically. A spectrophotometer (APEL, PD-303 UV; Japan) operating at 882 nm was used to examine the extract. The flame photometer was used to assess the potassium content of the extract samples (JENWAY, PFP7; Scotland).

### ***Analysis of the FS sample***

Using the Walkey and Black (1935) wet oxidation method; the amount of organic matter in FS was calculated. After concentrated sulphuric acid digestion and distillation with 40% NaOH, total nitrogen was measured using the micro-Kjeldahl method. A titration against 0.02 N H<sub>2</sub>SO<sub>4</sub> was performed after the ammonia developed was collected in a boric acid mixed indicator solution (Jackson, 1973). Following the procedure outlined by Olsen (1954), accessible phosphorus was extracted from the FS sample using 0.5 M NaHCO<sub>3</sub> solution at an almost constant pH of 8.5. The intensity of the color created by ascorbic acid was measured using a spectrophotometer (John, 1970). According to Jackson, (1973) description, exchangeable potassium was extracted using neutral 1N HN<sub>4</sub>OAC, and its concentration was determined using an atomic absorption spectrophotometer (Hitachi Model 200-20).

Table 1. Properties of soil and faecal sludge

Properties	Soil	Faecal sludge
Field capacity (%)	50	50
Textural class	Silty clay loam	----
pH	8.04	7.41
EC (dS m <sup>-1</sup> )	0.01	7.0
Available K (%)	2.32	1.5
Organic carbon (%)	0.598	15.3
Total N (%)	0.28	2.1
Available P (%)	1.98	0.40

### ***Agronomical data collection and recording***

Red amaranth morphology and yield data were recorded 45 days after emergence. A metre scale was used to measure plant height from the soil's surface to the plant's tip, as well as root and branch length. The number of leaves on each plant was counted for each pot, and the mean value was then recorded. The plant tissue was cleaned with distilled water after harvesting. Plant shoots were washed, dried by air, and their fresh weight was measured with an electrical balance. Plant samples were dried in an oven for 48 hours at 65 °C, and dry weight was calculated using an electric balance.

### ***Plant sample analysis***

Samples of harvested plants were dried in an oven for 48 hours at 65 °C. Following that, the dried materials were weighed, crushed, and stored for later analysis in the lab. Jackson (1973) used an HNO<sub>3</sub> + HClO<sub>4</sub> (2:1) mixture to dissolve plant samples before calculating the total K, P, and S. The samples were digested with H<sub>2</sub>SO<sub>4</sub>, as directed by Nelson and Sommers (1980), to determine the total N content. By utilising a spectrophotometer with a wavelength of 655 nm and the colorimetric approach, the total N content of the digest samples was measured (Bremner & Mulvaney, 1982). By utilising a spectrophotometer (APEL, PD-303 UV; Japan) at a wavelength of 470 nm and the colorimetric method described in Jackson (1973), the total P content of the digest samples was ascertained. The Flame Emission Spectroscopic technique was used to determine the digest sample's total K content. Atomic Adsorption Spectrophotometer (Hitachi Model 200-20) was used to measure the Ca, Mg, and Fe contents.

### Statistical analysis

Microsoft Office Excel was used to analyses the collected data presented in a bar diagram and statistical analysis of variance (ANOVA) was carried out by using SPSS 16.

### Results

Germination percentage of plants was observed in this experiment (Table 2). The highest seed germination (98.60%) was observed in T<sub>4</sub> treatment, which was significantly higher as compared to T<sub>1</sub> (94.60%), T<sub>2</sub> (92.93%), T<sub>3</sub> (89.06%) and T<sub>0</sub> treatment which was 95.60% (Table 2). This germination percentage was due to the soil moisture availability, which causes a variety of biochemical changes in the seed necessary for starting the germination process. These changes include the hydrolysis or metabolism of inhibitors, imbibition, and enzyme activation, which increases the germination percentage. The best air and water infiltration for seed emergence may have been offered by the application of faecal sludge treated soil.

Table 2. Percent germination of red amaranth at different faecal sludge treatment

Treatment	Germination %
T <sub>0</sub>	95.60 ± 5.44 ab
T <sub>1</sub>	94.60 ± 6.43 b
T <sub>2</sub>	92.93 ± 8.66 b
T <sub>3</sub>	89.06 ± 8.93 c
T <sub>4</sub>	98.60 ± 6.73 a

In this experiment, plant height, leaf number, root length, shoot length, fresh weight and yield of T<sub>4</sub> treatment was significantly higher as compared to other treatments studied (Figure 1). The highest plant height (36.99 cm) was recorded in the T<sub>4</sub> treatment, whereas the lowest plant height (11.16 cm) was found in the T<sub>0</sub> treatment. On the other hand, plant height in the treatments T<sub>1</sub>, T<sub>2</sub> and T<sub>3</sub> was recorded as 22.89 cm, 20.27 cm and 18.61 cm, respectively. Researchers investigated that higher chlorophyll content found in the leaves may be due to the application of faecal sludge which is potential to provide better plant anchorage and nutrient uptake. A role for the extracted micro biota in better mineralization of soil organic matter and mineral solubilisation, ion chelation and microbial production of plant growth promoting hormones, such as auxins or cytokinin-like substances increases the plant height in 4% sludge treated soil. This result was also revealed with the findings of Shrestha et al., (2012) and Bernal-Vicente et al., (2008). Number of leaf per plant was found to be the highest (14) for T<sub>4</sub> treatment and the lowest number of leaf (6) was observed for T<sub>1</sub> and T<sub>3</sub> treatment where T<sub>0</sub> and T<sub>2</sub> treatment produced 8.33 and 9.67, respectively. Number of leaf production was due to the nutrient availability from the sludge treated soil which leads to the photosynthetic activity of a unit of leaf and in the production in the new leaf surface.

The highest plant fresh weight was found 8.63 g for T<sub>4</sub> treatment and the lowest weight was recorded 2.84 g for T<sub>0</sub> treatment. The experiment suggested that plant fresh weight increased with the increasing of treated swede sludge. Here, T<sub>1</sub>, T<sub>2</sub> and T<sub>3</sub> treatment produced 3.54, 3.68 and 6.19 g plant fresh weight respectively. Fresh weight of plant depends on the nutrient uptake and carbohydrate accumulation in plant body as well as the uptake of sufficient water. Yield per pot depends on the fresh weight and higher morphological character. T<sub>4</sub> treatment produced the highest yield per pot (8.63 g) where lowest yield was noticed for T<sub>0</sub> treatment which was 2.84 g. Yield of red amaranth increases with higher rate of faecal sludge treated soil due to the higher mineralization of nutrient from sludge which can available for the plant uptake. According to Barriuelo et al., (2003), using sewage sludge boosted the productivity of maize. Similarly, Szymanska et al., (2013) discovered that adding sewage sludge to mineral fertilizer increased yield growth for wheat, maize, and vetch by 62.6, 95, and 16.4%, respectively, compared to control, while applying only sludge increased yield growth by 89.7, 177.0, and 32.3%, respectively, compared to control. Islam and Hasan, (2017) discovered a significant difference in the yield of cabbage heads in contrast to this. Root length was ranged within 7.53 cm (T<sub>4</sub> treatment) to 6.76 cm (T<sub>0</sub> treatment) where T<sub>1</sub>, T<sub>2</sub> and T<sub>3</sub> treatment produced 6.88, 7.16 and 7.36 cm root length respectively. The root length of the control was generally short compared with the soil treated with higher faecal sludge due to the availability of nutrient in the soil for the elongation of root as well as microbial activity near the root area which was in conformity with the findings of Kang and van Iersel, (2004). Selivanovskaya and Latypova, (2006) discovered that in plots with the highest rates of

composted sludge, the beneficial effects on the height of the shoots as well as the length of the roots of pine seedlings were greater.

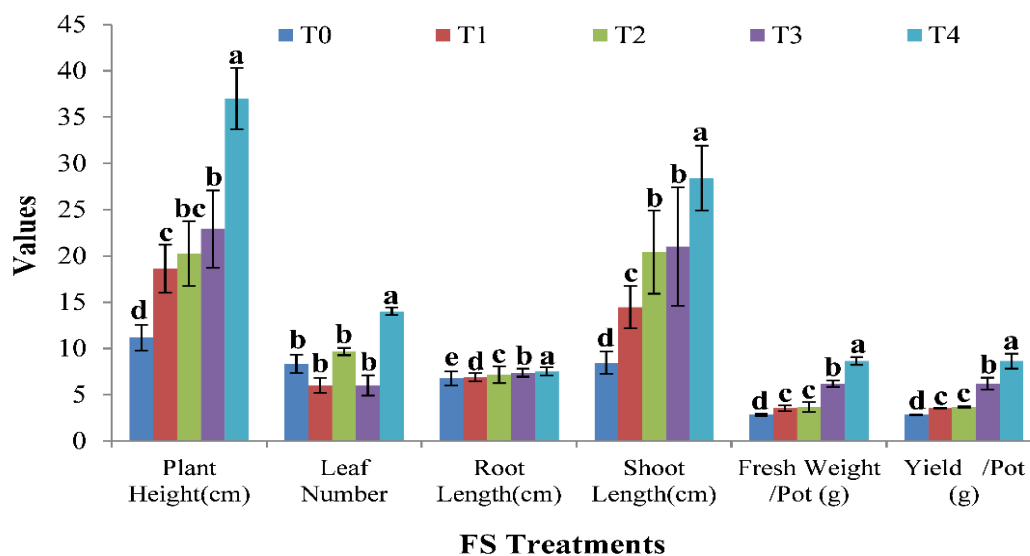


Figure 1. Morphological and yield properties of red amaranth at different faecal sludge treatment

Note: The black vertical bar represents the standard deviation of the mean. The means with dissimilar letters above the bars differed [ $p \leq 0.05$ ] considerably and the means with at least one common letter(s) in each column did not differ significantly. Here, T<sub>0</sub>= 0% faecal sludge (soil: sludge= 100:0); T<sub>1</sub>= 1% faecal sludge (soil: sludge= 99:1); T<sub>2</sub>= 2% faecal sludge (soil: sludge= 98:2); T<sub>3</sub>= 3% faecal sludge (soil: sludge= 97:3); T<sub>4</sub>= 4% faecal sludge (soil: sludge= 96:4).

Present study indicated that, the amount of nutrient content per plant was higher in higher dose of faecal sludge application (Table 3). The highest N content (2.90%) was investigated in T<sub>4</sub> treatment which was significantly higher as compared to T<sub>0</sub> treatment (1.13%) but non-significant with T<sub>1</sub> (2.89%), T<sub>2</sub> (2.36%) and T<sub>3</sub> (2.66%) treatment. T<sub>4</sub> treatment was also produced the highest percentage of P (2.00%) per plant, which was significantly higher as compared to the other treatments observed where lowest value was obtained 0.58% from T<sub>1</sub> treatment. In this study, significantly the highest value of K was recorded 5.51% in T<sub>4</sub> treatment compared with T<sub>0</sub> (0.59%), T<sub>1</sub> (2.76%) and T<sub>2</sub> (2.76%) which showed non-significant variation with T<sub>3</sub> treatment (5.18%) observed. Percent Ca per plant ranged from 0.056% (T<sub>4</sub> treatment) to 0.36% (T<sub>1</sub>, T<sub>2</sub> and T<sub>3</sub> treatment). There, Ca percentage per plant was statistically non-significant as compared with the other treatment studied. Mg and Fe content was found the highest in T<sub>4</sub> treatment that was 0.29 and 0.036%, respectively which showed statistically significant relationship then the other treatment studied in this experiment. Over all Nutrient content was the highest in 4% treated faecal sludge treated soil rather than control or other treatments. Besides, there are factors in the environment, such as microbes, temperature, and light intensity, which also influence the growth of the plants as well as nutrient uptake (Akon et al., 2018). This phenomenon was due to the availability of soil nutrients after the mineralization of a sludge mixture with soil. Plant can get more available nutrient (N, P and K) in 4% sludge treatment for plant growth which leads to uptake the other minor nutrients by the plant.

Table 3. Nutrient content of red amaranth at different faecal sludge treatment

Treatment	Element content plant <sup>-1</sup>					
	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Fe (%)
T <sub>0</sub>	1.13±0.02b	0.59±0.03b	0.59±0.06c	0.043±0.03a	0.04±0.002b	0.013±0.000b
T <sub>1</sub>	2.89±0.13a	0.58±0.05b	2.76±0.07b	0.036±0.06a	0.04±0.003b	0.013±0.000b
T <sub>2</sub>	2.36±0.33a	1.01±0.06b	2.76±0.03b	0.036±0.08a	0.04±0.001b	0.013±0.003b
T <sub>3</sub>	2.66±0.36a	0.62±0.16b	5.18±1.33a	0.036±0.001a	0.04±0.003b	0.023±0.006b
T <sub>4</sub>	2.90±0.53a	2.00±0.56a	5.51±1.73a	0.056±0.01a	0.29±0.006a	0.036±0.009a

Note: Means with dissimilar letters differed [ $p \leq 0.05$ ] considerably and the means with at least one common letter(s) in each column did not differ significantly. Here  $\pm e$  represents the standard deviation. Moreover, T<sub>0</sub>= 0% faecal sludge (soil: sludge= 100:0); T<sub>1</sub>= 1% faecal sludge (soil: sludge= 99:1); T<sub>2</sub>= 2% faecal sludge (soil: sludge= 98:2); T<sub>3</sub>= 3% faecal sludge (soil: sludge= 97:3); T<sub>4</sub>= 4% faecal sludge (soil: sludge= 96:4).

### Conclusion

In underdeveloped nations like Bangladesh, improper management of faecal sludge leads to several issues with the environment and public health. However, these can be utilized as a valuable source of nutrients for plants rather than being dumped or discharged into the environment. In order to replace part of the fertilizers used in agriculture, their use should be encouraged. This study showed that if faecal sludge compost is mixed properly with the soil, it can be a useful source of fertilizer. The results of this study demonstrated that, when compared to control (T<sub>0</sub>) and other treatments, a 4% faecal sludge mixture with soil performed much better, improving red amaranth's morphology, yield, and uptake of nutrients. According to the research, a 4% faecal sludge mixed with soil is optimum for the red amaranth plant's yield and nutrient uptake.

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### Conflict of Interests

The authors declare no conflict of interest.

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