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Effects of Vermicompost and Chemical Fertiliser on the Growth of Yield and Nutrient Content of *Ipomoea aquatica* and *Basella alba*

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

A pot experiment was conducted to investigate the effect of vermicompost and chemical fertiliser on the growth of yield and nutrient content of *Ipomoea aquatic* and *Basella alba* during the period of 14th May to 13th July, 2013. The experiment was laid to fit a completely randomized design (CRD) with three treatments [control (T_0), vermicompost (T_1) and chemical fertiliser (T_2)] each having three replications for each plant. After plant harvesting, the laboratory investigation was carried out in the Soil, Water and Environment Discipline, Khulna University, Khulna, Bangladesh. Yield contributing characters like plant height, stem length, rooting depth, number of leaves, fresh weight and dry weight were significantly *(*$P < 0.05$*)* influenced by different (vermicompost and chemical fertiliser) treatments. All yield character was decreased in order to $T_1>T_2>T_0$, except rooting depth for the both plants *Ipomoea aquatica* and *Basella alba*. The causes of variation may due to the nutrient availability in soil. In addition, the nutrient (P, K and S) content of both plants varied significantly *(*$P < 0.05$*)* with the treatments $T_1>T_0>T_2$. From the experiments it has been observed that the effect of vermicompost and chemical fertiliser on the growth of yield and nutrient content of *Ipomoea aquatic* and *Basella alba* were $T_1>T_2>T_0$ and $T_1>T_0>T_2$, respectively. The highest yield was found for the vermicompost treatment (T_1) due to the nutrient availability of the soil.

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1. INTRODUCTION

In today's era, heavy doses of chemical fertilisers and pesticides are being used by the farmers to get a better yield of various field crops. These chemical fertilisers and pesticides decreased soil fertility and caused health problems to the consumers. Due to adverse effects of chemical fertilisers, interest has been stimulated for the use of organic manures [1]. Porosity, drainage, water holding capacity and microbial activity are high in vermicompost. Vermicompost is produced by biodegradation of organic material through interactions between earthworms and micro-organisms [2]. There it the presence of nutrients such as nitrates, phosphates and exchangeable calcium and soluble potassium in vermicompost [3]. Vermicompost contains plant growth influencing materials produced by micro-organisms [4].

Environmental degradation is a major threat confronting the world, and the rampant use of chemical fertilisers contributes largely to the deterioration of the environment, loss of soil fertility, less agricultural productivity and soil degradation [5]. On one hand tropical soils are deficient in all necessary plant nutrients and on the other hand, large quantities of such nutrients contained in domestic wastes and agricultural byproducts are wasted. It is estimated that in cities and rural areas of India nearly 700 million organic wastes are generated annually which is either burned or land filled [6]. In natures laboratory, there are a number of organisms that have the ability to convert organic waste into valuable resources containing plant nutrients and organic matter which are essential for maintaining soil productivity [7]. Microorganism and earth worms are important biological organisms helping nature to maintain nutrient flow from one system to another and also minimise environmental degradation. The earthworm population is about 8-10 times higher in uncultivated area. This clearly indicates that earthworm population decreases with soil degradation and thus can be used as a sensitive indicator of soil degradation [7]. In this report a simple biotechnological process disposal of waste as well as the most needed plant nutrients for sustainable productivity is described, which could provide a 'win-win' solution to tackle the problem of safe disposal of waste as well as the most needed plant nutrients for sustainable productivity.

Vermicomposting is a simple biotechnological process of composting, in which certain species of earthworms are used to enhance the process of waste conversion and produce a better end product. Similar is the process of pit composting in which biological aerobic transformation of an organic by product takes place and results into different organic product that can be added to the soil without detrimental effects of crop growth [8]. Vermicompost is nutritionally rich natural organic fertiliser, which releases nutrients relatively slowly in the soil and improves quality of the plants along with physical and biological properties of soil. It has a more beneficial impact on plants than soil [7]. Vermicompost produces a natural fertiliser and improves the physical, chemical as well as biological properties of the soil. These composts provide all nutrients in readily available forms and also enhances uptake of nutrients by plants and plays a major role in improving growth and yield of different field crops [9]. Therefore, this experiment was conducted to investigate the effects of vermicompost and chemical fertiliser on the growth of yield and nutrient content of *Ipomoea aquatica* and *Basella alba*.

2. MATERIALS AND METHODS

A pot experiment was conducted to investigate the growth, yield response and nutrient content of *Basella alba* and *Ipomoea aquatica* to the effect of vermicompost and chemical fertiliser. 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 "Ganges tidal floodplain soil". Soil samples were collected from Batiaghta upazila (22^{o}74″N and 89^{o} 52″E) in Khulna district, Bangladesh. The soil sample was collected from surface (0-15cm) on the basis of composite sampling method as suggested by the soil survey staff of the USDA [10]. 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. A small portion of the soil sample was stored for laboratory analysis.

2.2 Pot Experiment

A pot experiment was conducted in the green house at Soil, Water and Environment Discipline, Khulna University, during the period of 14th May to 13th July 2013 investigate the growth, yield response and nutrient content of *Basella alba* and *Ipomoea aquatica* to the effect of vermicompost and chemical fertiliser. One kg of air-dried soil was taken in 16 cm high and 10.5 cm diameter earthen pot. The soil was fertilised according to the calculation by following the Fertilizer Recommendation Guide [11]. The amount of used fertiliser has been given at Table 1.

Table 1. The amount of fertiliser used

Serial no	Fertiliser used	Amount (g/kg)
1	Organic farming (Use of composts) (g/kg)	10
2	Urea (g/kg)	1.5
3	TSP (g/kg)	0.7
4	Potash (g/kg)	0.5

2.3 Experimental Design and Treatments

The experiment was laid to fit a completely randomized design (CRD) [12] with three treatments, each having three replications for each plant. The treatments are shown in the Table 2 and layout of the experiment in the Table 3.

Table 2. Treatment of the experiment

Treatment	Description
T_0	No fertiliser has been applied (Control)
T_1	Vermicompost has been applied
T_2	Chemical fertiliser has been applied

Table 3. Layout of the experimental plot

Treatment	*Basella alba*		
T_0	CR_1	CR_2	CR_3
T_1	VR_1	VR_2	VR_3
T_2	FR_1	FR_2	FR_3
Treatment	***Ipomoea aquatica***		
T_0	CR_1	CR_2	CR_3
T_1	VR_1	VR_2	VR_3
T_2	FR_1	FR_2	FR_3

2.4 Intercultural Activities

The pot was kept free from weeds up to harvesting. Weeding was done manually when weed were noted. Normal water is applied for the growth of the plants. Different cultural practice shown in Table 4.

Table 4. Date of cultural practices of the experimental plot

Cultural practices	Date
Pot preparation	14th May 2013
Seed sowing	20th May 2013
Seed germination	28th May 2013
Harvesting	13th July 2013

2.5 Plant Sample Preparation

After 45 days plant was harvested manually by uprooting the plant carefully from the pot. The parts of the plants were separated by using a scissor to cut larger parts of the plant in to smaller size. The samples were kept in paper bags and date, location of the sampling, treatment number was written on the paper bags. The Paper bags were put in an oven at 65 ^{0}C for 48 hours until a constant dry weight was obtained. After completion of the drying the dry weight was measured. The samples were cut in to smaller pieces and powdered in a grinding mill and passed through 0.2 mm sieve. The powder was mixed thoroughly. The powdered samples were preserved in plastic pots and tagged properly for chemical analysis.

2.6 Plant Sample Analysis

Total phosphorus of the plant sample was determined colorimetrically after digesting with nitric acid: perchloric acid (2:1) mixture by yellow color method [13]. Total potassium of plant sample was determined by flame emission spectroscopic method after digesting with nitric acid: perchloric acid (2:1) mixture [14]. Total sulfur of the plant sample was determined by turbidimetric method using spectrophotometer at 420 nm after digestion with nitric acid: perchloric acid (2:1) mixture as described by Jackson [13].

2.7 Statistical Analysis

Analysis of variance (ANOVA) was performed to study investigate the changes on the growth and yield response of *Basella alba* and *Ipomoea aquatica* for the comparative use of vermicompost and chemical fertiliser. The ANOVA and Duncan Multiple Test were done in completely randomized design by using the Using the SAS 6.12 software package [15].

3. RESULTS AND DISCUSSION

An experiment was conducted to investigate the effect of vermicompost and chemical fertiliser on the growth and yield response of *Ipomoea aquatica* and *Basella alba*.

3.1 The Effect of Vermicompost and Chemical Fertilisers on the Growth of Yield

3.1.1 Plant height

Plant height showed significant variations by the applications of different fertiliser treatments (Table 5). Plant height ranged from 19.83 to 22.17 cm for *Ipomoea aquatica*. The maximum plant height (22.17 cm) was observed in T_1 and the minimum (19.83 cm) was observed in T_0 (Table 5) and plant height per pot decreased in the order of $T_1>T_2>T_0$. There found a significant *($P < 0.05$)* change in treatment T_1 toT_2 and T_0 but insignificant between T_2 and T_0.

Plant height ranged from 15.17 to 17.06 cm for *Basella alba*. The maximum plant height (17.06 cm) was observed in T_1 and the minimum (15.17 cm) was observed in T_0 (Table 5) and plant height per pot decreased in the order of $T_1>T_2>T_0$. found a significant *($P < 0.05$)* change in treatment T_1, T_2 and T_0.

However, comparing with *Ipomoea aquatica* and *Basella alba* it was found that plant height was higher in T_1 than T_2 and T_0. The causes of variation may due to the nutrient availability in soil. Alam et al. [1] and Narkhede et al. [16] found similar findings. Hashemimajd, et al. [17] and Lazcano et al. [18] indicate that the vermicompost significantly stimulates the growth of a wide range of plant species including several horticultural crops such as tomato and sweet corn.

3.1.2 Stem length

Stem length showed significant variations by the applications of treatments (Table 5). Stem length ranged from 15.8 cm to 18.03 cm for *Ipomoea aquatica*. The maximum stem length per plant (18.03 cm) was observed in T_1 and the minimum (15.8 cm) was observed in T_0 (Table 5) and stem length per pot decreased in the order of $T_1>T_2>T_0$. There found a significant *($P <0.05$)* change in treatment T_1 toT_2 and T_0 but insignificant between T_2 and T_0.

Stem length ranged from 11.72 to 13.64 cm for *Basella alba*. The maximum stem length per plant (13.64 cm) was observed in T_1 and the minimum (11.72 cm) was observed in T_0 (Table 5) and stem length per pot decreased in the order of $T_1>T_2>T_0$. But there found a significant *($P <0.05$)* change in treatment T_0, T_1 and T_2.

However, comparing with *Ipomoea aquatica* and *Basella alba* it was found that the stem length showed significant variations by the applications of treatments (Table 5). The causes of variation may due to the nutrient availability in soil. Narkhede et al. [16] found similar findings. The effects of vermicompost alterations in seedling morphology such as increased stem area and root branching [19].

3.1.3 Rooting depth

Rooting depth showed significant variations by the applications of different fertiliser treatments (Table 5). Rooting depth ranged from 3.99 to 4.14 cm for *Ipomoea aquatica*. The maximum rooting depth (4.14 cm) was observed in T_1 and the minimum rooting depth (3.99cm) was observed in T_2 (Table 5) and rooting depth per pot decreased in the order of $T_1>T_0>T_2$. But there found an insignificant change in treatment T_0, T_1 and T_2.

Rooting depth ranged from 3.36 to 3.53 cm for *Basella alba*. The maximum rooting depth (3.53 cm) was observed in T_1 and the minimum (3.36 cm) was observed in T_2 (Table 5) and rooting depth per pot decreased in the order of $T_1>T_0>T_2$. But there found an insignificant change in treatment T_0, T_1 and T_2.

However, comparing with *Ipomoea aquatica* and *Basella alba* it was found that Rooting depth was higher in T_1 than T_0 and T_2. The causes of variation may due to the nutrient availability in soil. Alam et al. [1] found similar findings. Edwards et al. [20] found that the vermicompost also has a positive effect on vegetative growth, stimulating shoot and root development to compared with chemical fertiliser.

3.1.4 Number of leaves

The number of leaves per plant is an important parameter. The number of leaves per plant showed significant variations by the applications of different fertiliser treatments (Table 5). Leaves per plant ranged from 10.27 to 10.97 for *Ipomoea aquatica*. The maximum number of leaves per plant (10.27) was observed in T_1 and the minimum (10.97) was observed in T_0 (Table 5) and number of leaves per pot decreased in the order of $T_1>T_2>T_0$. But there found an insignificant change in treatment T_0, T_1 and T_2.

Leaves per plant ranged from 6.61 to 7.67 for *Basella alba*. The maximum number of leaves per plant (7.67) was observed in T_1 and the minimum (6.61) was observed in T_0 (Table 5) and number of leaves per pot decreased in the order of $T_1>T_2>T_0$. There found a significant *(P <0.05)* change in treatment T_1 toT_2 and T_0 but insignificant between T_2 and T_0.

However, comparing with *Ipomoea aquatica* and *Basella alba*it was found that leaves per plant was higher in T_1 than T_2 and T_0. The causes of variation may due to the nutrient availability in soil. Alam et al. [1] and Narkhede et al. [16] found similar findings.

3.1.5 Fresh weight

Fresh weight showed significant variations by the applications of different fertiliser treatments (Table 5). Fresh weight ranged from 14.47 to 16.65 gm for *Ipomoea aquatica*. The maximum fresh weight **(**16.65 gm) was observed in T_1 and the minimum (14.47 gm) was observed in T_0 (Table 5) and fresh weight per pot decreased in the order of $T_1>T_2>T_0$. But there found an insignificant change in treatment T_0, T_1 and T_2.

Fresh weight ranged from 34.72 to 30.03 gm for *Basella alba*). The maximum fresh weight (34.72 gm) was observed in T_1 and the minimum (30.03 gm) was observed in T_0 (Table 5) and fresh weight per pot decreased in the order of $T_1>T_2>T_0$. There found a significant *(P <0.05)* change in treatment T_0, T_1 and T_2 but there found an insignificant change in treatment T_0, T_1 and T_2.

However, comparing with *Ipomoea aquatica* and *Basella alba* it was found that fresh weight was higher in T_1 than T_2 and T_0. The causes of variation may due to the nutrient availability of the plants. Narkhede et al. [16] found similar findings. Wang et al. [21] and Pevvast et al. [22] reported that the vermicompost may also increase the plant growth and yield quality of some vegetable crops such as Chinese cabbage and spinach in compared with inorganic fertiliser.

3.1.6 Dry weight

Dry weight showed significant variations by the applications of different fertiliser treatments (Table 5). Dry weight ranged from 1.43 to 1.67 gm for *Ipomoea aquatica*. The maximum dry weight (1.67 gm) was observed in T_1 and the minimum dry weight (1.43 gm) was observed in T_0 (Table 5) and dry weight per pot decreased in the order of $T_1>T_2>T_0$. But there found an insignificant change in treatment T_0, T_1 and T_2.

Dry weight ranges from 1.75 to 2.0 gm for *Basella alba*. The maximum dry weight (2.0 gm) was observed in T_1 and the minimum dry weight (1.75 gm) was observed in T_0 (Table 5) and dry weight per pot decreased in the order of $T_1>T_2>T_0$. There found a significant *(P <0.05)* change in treatment T_0, T_1 and T_2 but there found an insignificant change in treatment T_0, T_1 and T_2.

However, comparing with *Ipomoea aquatica* and *Basella alba* it was found that dry weight was higher in T_1 than T_2 and T_0. The causes of variation may due to the nutrient availability in soil. Similar findings were found Narkhede et al. [16]. Vermicompost has also been shown to stimulate plant flowering, increasing the number and biomass of the flowers produced [23], as well as increasing dry matter yield [24].

3.2 Total Nutrients of Plant

3.2.1 Potassium

The mean value of potassium concentration in plant as affected by different fertiliser treatments in two plant species have been presented in the Table 6. Potassium concentration ranged from 33.44 to 37.38 mgg^{-1} for *Ipomoea aquatica*. The maximum potassium concentration (37.38 $mg\ g^{-1}$) was observed in T_1 and the minimum (33.44 mgg^{-1}) was observed in T_2 (Table 6) and potassium concentration per pot decreased in the order of $T_1>T_0>T_2$. There found a significant *(P <0.05)* change in treatment T_0, T_1 and T_2.

Potassium concentration ranged from 42.6 to 45.48 mgg^{-1} for *Basella alba*. The maximum potassium concentration (45.48 mgg^{-1}) was observed in T_1 and the minimum (42.6 mgg^{-1}) was observed in T_2 (Table 6) and potassium concentration per pot decreased in the order of $T_1>T_0>T_2$. There found a significant *(P <0.05)* change in treatment T_1 and T_0, T_2 but there found an insignificant change in treatment T_0 and T_2.

Table 5. Effect of Vermicompost and chemical Fertiliser on the growth and yield response

Treatment	Plant height (cm)		Stem length (cm)		Rooting Depth (cm)		No of leaves		Fresh weight (gm)		Dry weight (gm)	
	Ipomoea aquatica	*Basella alba*	*Ipomoea aquatica*	*Basella alba*	*Ipomoea aquatica*	*Basella alba*	*Ipomoea aquatica*	*Basella alba*	*Ipomoea aquatica*	*Basella alba*	*Ipomoea aquatica*	*Basella alba*
T_0	19.83b	15.17c	15.8b	11.72c	4.04a	3.44a	10.27a	6.62b	14.47a	30.03b	1.43a	1.75b
T_1	22.17a	17.06a	18.03a	13.64a	4.14a	3.53a	10.97a	7.67a	16.65a	34.72a	1.67a	2.00a
T_2	20.33b	16.00b	16.04b	12.47b	3.99a	3.36a	10.3a	6.61b	14.85a	32.78a	1.47a	1.87b

Table 6. Total nutrients of plant

Treatment	Potassium (mgg^{-1})		Phosphorus (mgg^{-1})		Sulfur (mgg^{-1})	
	Ipomoea aquatica	*Basella alba*	*Ipomoea aquatica*	*Basella alba*	*Ipomoea aquatica*	*Basella alba*
T_0	34.05b	42.61c	14.58b	18.24b	7.07b	8.85c
T_1	37.38a	45.48a	15.99 a	19.46a	7.76a	9.44a
T_2	33.44b	42.60b	14.31b	18.23b	6.94b	8.84b

However, comparing with *Ipomoea aquatica* and *Basella alba* it was found that K content was higher in T_1 than T_0 and T_2. The casts of earthworms contained two to three times more available K than surrounding soils [25]. Alam et al. [1] and Narkhede et al. [16] found similar findings. Basker et al. [26] reported that the availability of K was enhanced significantly following soil ingestion by earthworm and this must be due to the changes in the distribution of K between non-exchangeable to exchangeable forms.

3.2.2 Phosphorus

The mean value of phosphorus concentration in plant as affected by different fertiliser treatments in two soil series have been presented in the Table 6. Phosphorus concentration ranged from 14.31 to 15.99 mgg^{-1} for *Ipomoea aquatica*. The maximum potassium concentration (14.3 mgg^{-1}) was observed in T_1 and the minimum (15.99 mgg^{-1}) was observed in T_2 (Table 6) and phosphorus concentration in plant decreased in the order of $T_1>T_0>T_2$. There found a significant *($P<0.05$)* change in treatment T_0, T_1 and T_2.

Phosphorus concentration ranged from 18.23 to 19.46 mgg^{-1} for *Basella alba*. The maximum potassium concentration (19.46 mgg^{-1}) was observed in T_1 and the minimum (18.23 mgg^{-1}) was observed in T_2 (Table 6) and phosphorus concentration in plant decreased in the order of $T_1>T_0>T_2$. There found a significant *($P<0.05$)* change in treatment T_1 and T_0, T_2 but there found an insignificant change in treatment T_0 and T_2.

However, comparing with *Ipomoea aquatica* and *Basella alba* it was found that P content was higher in T_1 than T_0 and T_2. The availability of P was enhanced in casts compared to non-ingested soil [27]. Alam et al. [1] and Narkhede et al. [16] found similar findings. Basker et al. [28] reported that the available P was higher compared to the surrounding soil due to soil ingestion by earthworm.

3.2.3 Sulfur

The mean value of sulfur concentration in shoot as affected by different fertiliser treatments in two soil series have been presented in the Table 6. Sulfur concentration ranged from 6.94 to 7.76 mgg^{-1} for *Ipomoea aquatica*. The maximum sulfur concentration (7.76 mgg^{-1}) was observed in T_1 and the minimum (6.94 mgg^{-1}) was observed in T_2 (Table 6) and sulfur concentration in plant decreased in the order of $T_1>T_0>T_2$. There found a significant *($P<0.05$)* change in treatment T_0, T_1 and T_2.

Sulfur concentration ranged from 8.84 to 9.44 mgg^{-1} for *Basella alba*. The maximum potassium concentration (9.44 mgg^{-1}) was observed in T_1 and the minimum (8.84 mgg^{-1}) was observed in T_2 (Table 6) and sulfur concentration in plant decreased in the order of $T_1>T_0>T_2$. There found a significant *($P<0.05$)* change in treatment T_1 and T_0, T_2 but there found an insignificant change in treatment T_0 and T_2.

However, comparing with *Ipomoea aquatica* and *Basella alba* it was found that sulfur content was higher in T_1 than T_2 and T_0. The causes of variation may due to the nutrient availability in soil. Alam et al. [1] and Narkhede et al. [16] found similar findings.

4. CONCLUSION

A pot experiment was conducted to investigate the effect of vermicompost and chemical fertiliser on the growth of yield and nutrient content of *Ipomoea aquatic* and *Basella alba*. Yield contributing characters like plant height, stem length, rooting depth, number of leaves, fresh weight and dry weight were significantly influenced by different (vermicompost and chemical fertiliser) treatments. Among the treatment, T_1 (vermicompost) produced the tallest plant for both plants *Ipomoea aquatica* and *Basella alba*. There found a significant *($P<0.05$)* change in treatment T_1 toT_2 and T_0 but insignificant between T_2 and T_0 for *Ipomoea aquatic*. In both plants stem length and root depth were also highest in the T_1 (vermicompost). Comparing with *Ipomoea aquatica* and *Basella alba* it was found that the stem length showed significant variations by the applications of treatments. It has been observed for the number of leaves per plant that it ranged from 10.27 to 10.97 for *Ipomoea aquatic* and from 6.61 to 7.67 for *Basella alba.* There found a significant *($P<0.05$)* change in treatment T_1 toT_2 and T_0 but insignificant between T_2 and T_0. Fresh weight and dry weight of *Ipomoea aquatica* and *Basella alba* both were highest in the T_1 (vermicompost). The concentration of P, K, S in plants varied significantly with the treatments $T_1>T_0>T_2$. From the experiments it has been observed that the effect of vermicompost and chemical fertiliser on the growth of yield and nutrient content of *Ipomoea aquatic* and *Basella alba* were $T_1>T_2>T_0$ and $T_1>T_0>T_2$, respectively.

The highest yield was found for the vermicompost treatment (T_1) due to nutrient availability of the soil.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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