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Cauliflower Cultivation on Rooftop Garden Using Various Composts: Morphological and Economic Analysis

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Abstract: Cauliflower is one of the most important and commercial cole crop in Bangladesh. Cauliflower is a very tasty and much popular vegetable in Bangladesh as well as all over the world. Therefore, the present study was undertaken to investigate the impacts of vermicompost, sawdust, and cowdung on the growth and yield of cauliflower on rooftops, as well as to evaluate the economic performance of various organic manures on cauliflower yield. The experiment was carried out on the sixth floor of housing no. 64, road no. 6/A, Dhanmondi 13 during the period from November 2019 to July 2020. The experiment was designed in CRD having single factor with three replications. The treatments of this experiment were T_0= Control (recommended dose of chemical fertilizers), T_1= Vermicompost (10 t ha^{-1}) + recommended dose of chemical fertilizers, T_2= Sawdust (15 t ha^{-1}) + recommended dose of chemical fertilizers and T_3= Cowdung (20 t ha^{-1}) + recommended dose of chemical fertilizers. The seedlings of the cole crop (BARI Fulkopi-2) were collected from Bangladesh Agricultural Research Institute, Joydebpur, Gazipur. Results revealed that the maximum pure curd weight per plant (551.60 g), yield per plot (3.95 kg) and yield per hectare (19.75 t) were obtained from T_1 (vermicompost @ 10 t ha^{-1} + recommended dose of chemical fertilizers) treatment. The benefit cost ratio (BCR) was found to be the highest (3.33) in the treatment of T_1 (vermicompost @ 10 t ha^{-1} + recommended dose of chemical fertilizers). Thus, it was apparent that the vermicompost treatment gave the highest yield per hectare (19.75 t) than the other treatments (sawdust and cowdung) and the highest gross return (Tk. 395000.00). The results clearly showed that rooftops are suitable for cauliflower vegetable production using vermicompost manure to maintain yield as well.

Keywords: Cauliflower; Rooftop garden; Yield; Gross return; Benefit cost ratio.

INTRODUCTION

Cauliflower (*Brassica oleracea* var. *botrytis*) is the most important cole crop in the tropics and temperate regions of the world (Siddique 2004). Cauliflower was introduced and widely in India (Saha *et al.* 2015). Cauliflower is a delicious and widely consumed vegetable in Bangladesh and around the world. Cauliflower edible component comprises 89% moisture, 8.0 g carbohydrate, 2.3 g protein, 40 IU carotene, 0.13 mg B1, 0.11 mg B2, 50 mg vitamin C, 30 mg calcium, and 0.8 mg iron, as well as 30 calories (Rashid 1999). Edible part of cauliflower is commonly known as 'Curd'. Cauliflower occupies an area of 19425.33 hectares in 2017-2018, with a total production of 274000 tons (BBS 2019). According to FAO (2018), the production of cauliflower is about 140962 kg per hectare.

Farming on rooftop of the buildings in urban areas is usually done by using green roof, hydroponics, organic, aeroponics or container gardens (Asad and Roy 2014). It can reduce air pollution by enhancing storm water retention capacity, improving public health, boosting the aesthetic value of the urban environment, and improving community functions (Localize 2007).

Implementing rooftop farming in Dhaka, one of the world's fastest growing megacities, may be an appropriate way to solving food supply issues, make urban living more self-sufficient, and make fresh vegetables more accessible to urban residents, as agricultural land is being depleted at an alarming rate (Islam and Ahmed 2011). It is estimated that 10,000 hectares of Dhaka city may be brought under rooftop farming, and citizens will be able to eat vegetables that are fresh, with rooftop farming meeting more than 10% of demand (Wardard 2014).

Cauliflower growth and production are dependent on soil nutrient availability, which is related to the appropriate application of manures and fertilizers. Nutrients can be applied in two ways: organic and inorganic. Compost and vermicomposting boost plant growth and quality. The vermicompost promotes growth by 50-100% more than conventional compost and 30-40% more than chemical fertilizers, with a cheap production cost (Sinha *et al*. 2010). Cowdung contains a number of nutrients that can improve physical, chemical and biological properties of soil (Suparman and Supiati 2004). Cowdung can help various crops grow and yield more, including maize, soybeans, cucumbers, and several vegetable crops (Mucheru-Muna and Mugendi 2007; Mahmoud *et al.* 2009 and Jahan *et al*. 2014). Chipped wood or wood shavings from specific tree or shrub species are becoming a more important organic amendment source in agricultural soils (Owolabi *et al.* 2003). According to Odedine *et al.* (2003), there is a lack of knowledge on the optimal amount at which sawdust ash and wood ash may be utilized to produce crop seedlings in the nursery. Therefore, the purpose of this study was to examine the impacts of vermicompost, sawdust, and cowdung on the growth and yield of cauliflower on rooftops, as well as to assess the economic performance of various organic manures on cauliflower yield.

MATERIALS AND METHODS

Study area: The study was conducted at the sixth floor of housing no. 64, road no. 6/A, Dhanmondi 13. Geographically the experimental area is located at 23°75′ N latitude and 90°22.6′ E longitudes at the elevation of 23 m above the sea level. The experimental site's environment is characterized by high rainfall from November to March (Rabi season) and scarce rainfall the rest of the year (Rabi season). The vitimati soils utilized in this experiment were sourced from Savar Upazilla. This soil had a sandy loam texture and was grayish in color. The cole crop was used as planting material *viz.* BARI Fulcopi-2 (*Brassica oleracea* var. *botrytis*) variety. Seedlings of cauliflower cultivars were used in the experiment. Seedlings were collected from Bangladesh Agricultural Research Institute (BARI), Gazipur.

Experimental design: The experiment was laid out in CRD having single factors with three replications. The treatments of this experiment were T_0= Control (recommended dose of chemical fertilizers), T_1= Vermicompost (10 t ha^{-1}) + recommended dose of chemical fertilizers, T_2= Sawdust (15 t ha^{-1}) + recommended dose of chemical fertilizers and T_3= Cowdung (20 t ha^{-1}) + recommended dose of chemical fertilizers. A 9 m × 4 m area was divided into three equal blocks. Each block has 4 plots with 4 treatments assigned at random. The experiment included 12 unit plots. Each plot was 2 m × 1 m in size and included 8 plants with a spacing of 0.6 m × 0.45 m. The space between two blocks and two plots was fixed at 1.5 and 0.25 meters, respectively. The entire experimental site (rooftop) was partitioned into three blocks by a brick wall. The dimensions of each block were 9 m × 1 m × 0.50 m. Each block was divided into 2 m × 1 m plots with 0.25 m plot space.

Application of manures and fertilizers: The crop was fertilized with per hectare at the rate of 275 kg urea, 175 kg triple superphosphate (TSP), and 220 kg muriate of potash (MoP) were applied. N_2, P_2O_5 and K_2O were obtained from urea, TSP, and MoP, respectively. During the final plot and block preparation, the complete amount of TSP and MoP was used. Urea was applied in three equal installments at 15 days, 30 days, and 45 days after the seedlings were planted. As par treatments, well-rotten cowdung, vermicompost and sawdust were used during final block preparation. 5 plants selected from each unit plot and recorded.

Data collection: Data were collected to evaluate plant growth, yield characteristics and yields as they were influenced by the experiment's various treatments. The data collected for various parameters were statistically evaluated in order to determine the morphological traits and economic considerations of cauliflower production on a rooftop garden using various composts. The mean values of all the characters were calculated. All input cost included the cost for net house and interests of running capital in computing the cost of production. The interests were calculated @ 11% in simple rate. The benefit cost ratio (BCR) was calculated as follows:

$$\text{Benefit Cost Ratio} = \frac{\text{Gross return per hectare (Tk.)}}{\text{Total cost of production per hectare (Tk.)}}$$

Data analysis: MSTAT-C was used for processing and analysis of data. The mean differences were adjusted by Least Significance Difference (LSD) test at 5% level of significance (Gomez and Gomez 1984). The cost of production was analyzed in order to find out the most economic treatment of different composts.

RESULTS AND DISCUSSION

Plant height: The plant height varied significantly due to application of different composts on rooftop garden. The effect of compost demonstrated that the treatment T_1 produced the tallest plant (49.27 cm at 60 DAT). On the other hand, T_0 treatment produced the shortest plant (41.33 cm at 60 DAT) (Table 1). The findings of the experiment was coincided with the findings of Sharma and Sharma (2010), Simarmata *et al.* (2016) and Ara *et al.* (2009)

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reported that plant height is an essential component that influences crop productivity.

Number of leaves plant^{-1}: Number of leaves plant^{-1} was significantly influenced by the application of different composts. The maximum number of leaves plant^{-1} (26.28 at 60 DAT) was obtained from the T_1 treatment while the minimum number of leaves plant^{-1} (20.08 at 60 DAT) was produced by the T_0 treatment (Table 1). Similar results also found by Ara *et al.* (2009) reported that the use of various composts in conjunction with mineral fertilizers influenced all vegetative growth parameters such as plant height, number of leaves per plant, overall plant weight, weight of marketable curd per plant, and yield t/ha.

Length of largest leaf plant^{-1}: Significant influence on length of largest leaf at 60 DAT was observed in terms of the application of different composts. The maximum length of largest leaf at 60 DAT (42.10 cm) was observed from T_1 treatment which was statistically similar to T_3 treatment. The minimum length of the largest leaf at 60 DAT (35.59 cm) was recorded on T_0 treatment (Table 1). The results also similar with the findings of Kumar *et al.* (2002) who reported that the application of vermicompost gave the maximum leaves length which declined with sawdusts application.

Breadth of largest leaf plant^{-1}: Statistically significant influence on breadth of largest leaf at 60 DAT was observed because of the application of different compost. The maximum breadth of largest leaf at 60 DAT (20.50 cm) was observed from T_1 treatment which was statistically similar to T_3 treatment. The minimum breadth of the largest leaf at 60 DAT (17.00 cm) was recorded on T_0 treatment (Table 1). Alam (2006) reported that vermicomposting with 100% recommended doses of chemical fertilizers yielded the biggest leaf breadth of cabbage.

Fresh weight of leaves plant^{-1}: The fresh weight of leaves per plant was significantly influenced by applying different composts in terms of the production of cauliflower on rooftop garden. Result revealed that treatment T_1 produced the maximum fresh weight of leaves per plant (216.71 g at 60 DAT) which was statistically similar with T_3 treatment at 60 DAT, respectively while the minimum fresh weight of leaves per plant (174.49 g at 60 DAT) was obtained from T_0 treatment (Table 1).

Dry weight of leaves plant^{-1}: The dry weight of leaves per plant was significantly influenced by different composts application in the production of cauliflower on rooftop garden. Result revealed that treatment T_1 produced the maximum dry weight of leaves per plant (112.28 g at 60 DAT) while the minimum dry weight of leaves per plant (69.22 g at 60 DAT) was observed from T_0 treatment. The findings were also consistent with those of Ouda and Mahadeen (2008), who noticed that the use of various dosages of composts with mineral fertilizers influenced the dry weight of cauliflower shoots.

Stem diameter plant^{-1}: Significantly influenced by different composts application was observed on the stem diameter per plant. From the result, it was revealed that the treatment T_1 produced the highest stem diameter per plant (1.90 cm at 60 DAT) which was statistically similar to T_3 treatment at 60 DAT, respectively. On the other hand, the lowest stem diameter per plant (1.61 cm at 60 DAT) was noted from T_0 treatment (Table 2). The experimental findings were consistent with those of Mahmoud *et al.* (2009) and Jahan *et al.* (2014), who found that composts and organic manures can improve the growth characteristics and yield of cauliflower.

Root length plant^{-1}: Different compost significantly influenced the root length per plant. Result from the experiment observed that T_1 treatment produced the highest root length per plant (26.10 cm at 60 DAT) which was statistically similar to T_3 treatment at 60 DAT, respectively. On the other hand, the lowest root length per plant (22.67 cm at 60 DAT) was recorded from T_0 treatment (Table 2). Tripathi and Sharma (1991) found a similar result when they reported that increasing the supply of organic manures can increase the root length of cauliflower.

Table 1. Effect of composts on growth parameters of cauliflower.

Treatments	Plant height (cm)	No. of leaves plant^{-1}	Length of largest leaf plant^{-1} (cm)	Breadth of largest leaf plant^{-1} (cm)	Fresh weight of leaves plant^{-1} (g)	Dry weight of leaves plant^{-1} (g)
T_0	41.33 b	20.08 b	35.59 b	17.00 b	174.49 b	69.22 c
T_1	49.27 a	26.28 a	42.10 a	20.50 a	216.71 a	112.28 a
T_2	42.80 b	23.17 ab	36.51 b	17.93 b	185.96 b	81.21 bc
T_3	45.06 ab	25.00 a	40.80 a	18.90 ab	194.51 ab	91.52 b
CV (%)	6.86	8.78	5.42	7.10	7.25	9.46

In a column, values with same letter(s) do not differ significantly at 5% level by LSD

Curd height plant^{-1}: The pure curd height per plant was significantly varied by the application of different composts. During the period of plant growth, the maximum pure curd height per plant (17.18 cm at 60 DAT) was observed in T_1 treatment. On the other hand, shortest pure curd height per plant (11.94 cm at 60 DAT) was observed in T_0 treatment (Table 2). Similar results were found by Kumar *et al.* (2002), who reported that compost provides available essential nutrients for the plant and that compost gave the maximum pure curd height per plant when compared to control.

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Curd diameter plant^{-1}: The curd diameter significantly varied by the application of different compost. The maximum curd diameter per plant (15.25 cm at 60 DAT) was revealed in T_1 treatment. On the other hand, the shortest curd diameter per plant (12.02 cm at 60 DAT) was noted in T_0 treatment (Table 2). Sharma and Sharma (2010), Kumar *et al.* (2002), and Mahamud (2006) revealed similar findings, reporting that compost provides a number of nutrients that can boost cauliflower growth and productivity.

Curd weight plant^{-1}: A significant influence was observed on curd weight per plant by the effect of different compost in cauliflower production on rooftop garden. The maximum curd weight per plant (551.60 g) was recorded from T_1 treatment while the minimum curd weight per plant (335.02 g) was recorded from T_0 treatment (Table 2). Simarmata *et al.* (2016) showed similar results, whereas Ara *et al.* (2009) revealed that using various composts alongside mineral fertilizers boosted curd weight and yield. Rabbee *et al.* (2020) observed that when compared to farmyard manure, vermicompost treated plants had the highest marketable curd weight, net curd weight, and yield/plot, whereas control plants had the lowest statistics.

Yield per plot: Yield per plot of cauliflower influenced significantly due to the effect of different compost in rooftop garden. The maximum curd yield per plot (3.95 kg) was found from T_1 treatment while the minimum curd yield per plot (2.17 kg) in this term was found from T_0 treatment (Table 2). Noor *et al.* (2007) observed similar results in terms of yield per plot, reporting that cauliflower yield is significantly influenced by organic and inorganic fertilizer management, requiring an integrated approach to ensure yield sustainability and soil fertility. According to Mal *et al.* (2015), a nutrient schedule that included a higher level of vermicompost (10 t ha^{-1}) and 100% of the recommended inorganic fertilizers resulted in a many fold improvement in advanced head maturity, higher yield, and superior head quality when compared to other nutrient combinations.

Yield per hectare: Yield of cauliflower per hectare showed significant influence by the application of different compost in rooftop garden. The maximum curd yield (19.75 t ha^{-1}) was obtained from T_1 treatment while the minimum curd yield (10.85 t ha^{-1}) in this respect was recorded from T_0 treatment (Table 2). Mutalib *et al.* (2013) revealed similar trends, reporting that the yield and curd production in vegetable waste vermicomposting were significantly greater than in the control condition. According to Bashyal (2011), biofertilizers and vermicomposts boosted the efficacy of nitrogen fertilizer, which increased the output and quality of cauliflower.

Cost and benefit analysis: The cost and benefit (BCR) analysis was done and presented in Table 3. Materials, non-materials and overhead costs were recorded for all the treatments of unit plot and calculated on per hectare basis the price of cauliflower at the local market rate were considered. Among the various treatment combinations, the total cost of production ranges between Tk. 84850 and Tk. 118600 per hectare. The difference was attributable to the varied costs of various types of composts. The treatment of T_1 had the highest production cost of Tk. 118600 per ha, while the combination of T_0 had the lowest production cost of Tk. 84850 per ha. The gross return from the various treatments' ranges from Tk. 395000 to Tk. 217000 per ha. T_1 had the highest net return (Tk. 276400 per ha) among the treatments, whereas T_0 produced the lowest net return (Tk. 132150). The benefit cost ratio (BCR) was calculated by dividing the total cost of production (Tk.) by the gross return per hectare (Tk.). It was found to be the highest (3.33) in the T_1 treatment and the lowest (2.55) in the T_0 treatment. As a result, the T_1 treatment produced the best yield (19.75 t ha^{-1}) and the highest gross return (Tk. 395000.00). The benefit cost ratio (BCR) was calculated as follows:

$$\text{Benefit Cost Ratio} = \frac{\text{Gross return per hectare (Tk.)}}{\text{Total cost of production per hectare (Tk.)}}$$

Table 2. Effect of composts on yield contributing parameters and yield of cauliflower.

Treatments	Stem diameter plant^{-1} (cm)	Root length plant^{-1} (cm)	Curd height plant^{-1} (cm)	Curd diameter plant^{-1} (cm)	Curd weight plant^{-1} (g)	Yield per plot (kg)	Yield per hectare (t)
T_0	1.61 b	22.67 c	11.94 b	12.02 b	335.02 c	2.17 c	10.85 c
T_1	1.90 a	26.10 a	17.18 a	15.25 a	551.60 a	3.95 a	19.75 a
T_2	1.68 b	23.43 bc	13.71 ab	13.27 ab	381.94 c	2.87 b	14.35 bc
T_3	1.76 ab	24.80 ab	14.42 ab	14.00 ab	446.98 b	3.35 ab	16.80 ab
CV (%)	6.19	4.09	12.93	8.54	7.04	10.40	13.74

In a column, values with same letter(s) do not differ significantly at 5% level by LSD

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Table 3. Cost and return of cauliflower using different composts.

Treatments	Yield (t/ha)	Gross return (Tk./ha)	Total cost of production (Tk./ha)	Net return (Tk./ha)	Benefit cost ratio (BCR)
T_0	10.85	217000	84850	132150	2.55
T_1	19.75	395000	118600	276400	3.33
T_2	14.35	287000	110162	176838	2.60
T_3	16.80	336000	107350	228650	3.12

CONCLUSION

Based on the findings of the experiment, it may be concluded that T_1 treatment gave the maximum curd yield (19.75 t ha^{-1}) of cauliflower than the other composts (cowdung, sawdust) as well as control treatment. Moreover, the economic output considering BCR (3.33) was also found more in T_1 applied plots. Therefore, in rooftop, T_1 (vermicompost @ 10 t ha^{-1} + recommended dose of chemical fertilizers) treatment may be a good organic manures option for cauliflower production in the rooftop condition.

Conflict of Interest

There is no conflict of interest to declare.

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