Asian Journal of Agricultural and Horticultural Research

4(3): 1-14, 2019; Article no.AJAHR.51590
ISSN: 2581-4478

Effect of Organic Manure and Its Application Timing on the Growth and Yield of Cauliflower (*Brassica oleracea* var. *botrytis*)

Sanjida Akhter[1], Tahmina Mostarin[1], Khaleda Khatun[1], Md. Ehsanul Haq[2*], Ismita Akter Soniya[1], Shirajum Monira[1], Iffat Sharmin[1] and Avijit Ghosh[3]

[1]Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh.
[2]Plant Breeding Division, Bangladesh Rice Research Institute, Gazipur, Bangladesh.
[3]Institute of Seed Technology, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh.

Authors' contributions

This work was carried out in collaboration among all authors. Authors TM and KK planned the experiment and lead the research. Authors TM, KK and SA designed and carried out the research. Author MEH performed the statistical analysis. Authors SA and IAS carried out the research on the field. Authors SA, SM, IS and AG collected the data. Authors SA and MEH wrote the manuscript. Authors IAS, SM, IS and AG managed the literature searches. All authors provided critical feedback and helped shape the research, analysis and manuscript. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJAHR/2019/v4i330026
Editor(s):
(1) Dr. Magdaléna Valšíková, Professor, Department of Vegetables Production, Faculty of Horticulture and Landscape Engineering, Slovak University of Agriculture (SUA), Nitra, Slovakia.
Reviewers:
(1) Rahim Foroughbakhch, University of Nuevo Leon, Mexico.
(2) Eko Hanudin, Universitas Gadjah Mada, Indonesia.
Complete Peer review History: https://sdiarticle4.com/review-history/51590

Original Research Article

Received 11 July 2019
Accepted 23 September 2019
Published 01 October 2019

ABSTRACT

An experiment was conducted at the Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka, from October 2017 to February 2018. The experiment consisted of two factors, Factor A: Four levels of organic manures, viz. M_0 = Control; M_1 = Cowdung (35 t ha-1), M_2 = Mustard oil cake (3.5 t ha-1) and M_3 = Vermicompost. Factor B: Three application times, viz. T_1 = 15 days before transplanting, T_2 = Application at the time of transplanting and T_3 = 15 days after transplanting. The experiment was laid out in a randomized complete block design (RCBD) with three replications. In the case of organic manure, the highest yield (38.70 t/ha) was found from M_2 treatment, whereas

**Corresponding author: Email: shawonjess01@gmail.com;*

the lowest yield (19.71t/ha) was recorded from M_0 treatment. In the case of application time, the highest yield (31.83t/ha) was found from T_1 treatment, whereas the lowest yield (28.10 t/ha) was recorded from T_3 treatment. Due to combined effect maximum yield (38.704 t/ha) with net return (4,74,421tk) and BCR (2.20) was obtained from M_2T_1 treatment combination while the lowest yield (17.90 t/ha) with the lowest income (44,211 tk) and BCR (1.17) from M_0T_3 treatment combination. So, the economic analysis revealed that the M_2T_1 treatment combination appeared to be best for achieving the higher growth, yield and economic benefit of cauliflower.

Keywords: Organic manure; application time; growth; yield; cauliflower.

1. INTRODUCTION

Cauliflower (*Brassica oleracea* var. *botrytis* sub-var. *cauliflora*) belongs to the family Cruciferae is one of the most important cole crop. It is very popular winter vegetable and grown as annual plant without branching but it has biennial variety also in many countries of the world even in Bangladesh. Cauliflower was introduced in India in 1822. The leading cauliflower producing countries of the world are china, Pakistan and India in respect of yield per hectare of land. It is a highly nutritious and delicious vegetable, rich in Vitamin A, C and minerals like calcium, iron and iodine [1]. It supplies 50 mg vitamin C, 40 IU carotene, 30 calorie, 8 gm carbohydrate and 90% water per 100 gm edible part. The average yield per hectare of cauliflower is far below than its actual yield potentiality. The low yielding of the vegetable in Bangladesh, is not an indication of low yielding ability of the crop, but of the fact that low yielding variety, poor crop management practices and lack of improved technologies. The yield of cauliflower depends on variety, cultivation methods, climatic conditions, soil fertility as well as edaphic factors etc.

The cultivation of cauliflower requires proper supply of nutrient. Besides nitrogen, phosphorous, potassium and sulfur, a considerable amount of micronutrients is also present in organic matter. Utilization of organic matter has been well documented to improve physical, chemical and biological properties of soil and the addition of compost to soil generally improves tilth , soil structure, infiltration, drainage and water holding capacity. On an average, well rotten cowdung contains 0.5% N, 0.2% P2O5 and 0.5% K_2O [2]. The use of compost and vermicompost has also been observed to improve plant growth and quality. The vermicompost promote growth from 50-100% over conventional compost and 30-40% over chemical fertilizers [3]. Leachates from vermicompost is full of vitamins, antibiotics, microelements, minerals and enzymes and that lead into plants' growth and performance improvement and even cause the increased resistance of plants against diseases and it has a huge storage of microorganisms fixing atmospheric nitrogen plays a significant role in raising phosphorus of soil. Among the organic manures mustard oil cake contain higher amount of nutrient such as 4.93% N, 0.53% P2O5, 0.65% K2O. It release nutrient slowly and hence plant can get nutrient for long time. Mustard oil cake contains high amount of secondary and micronutrients in addition to N, P and K @ 5.1-5.2, 1.8-1.9 and 1.1-1.3%, respectively [4]. Among the organic amendments, oil cakes have been found to be the most prospective because they do not only reduce nematode development but also stimulate plant growth supplying plant nutrients of some sorts [5] also supply sufficient amount of S, Zn and B for the growth. Timing of nutrient application, therefore, ensures the availability of the nutrients when the crop needs them. This will also avoid nutrient losses which can be before and after periods of crop demand which in the long run result in wastage of resources [6]. Application timing is a crucial component to maximizing N use efficiency in manures. Application time is also very important for phosphorus use efficiency as it quickly becomes unavailable for the plants in the process called 'Fixation'. Management of manure fertilizers is much more difficult than that of mineral fertilizers, primarily because manure and other organic fertilizers are affected by the handling during storage and application as well as the timing of incorporation and distribution [7].

2. MATERIALS AND METHODS

2.1 Experimental Site and Experimental Framework

The study was conducted at the Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh. Geographically the

experimental area is located at 24º09 N latitude and 90º26 E longitudes at the elevation of 8 m above the sea level. Soil of the experimental field was silty loam in texture. Soil was having the texture of sandy loam with p^H 5.6. The soil of the experimental area belongs to the Modhupur Tract under the AEZ No. 28. The experiment was laid out in Randomized Complete Block Design with three replications. Factor-A had four levels of organic manure as M_0 = No Control Manure (Control), M_1 = Cowdung (36 t/ha or, 10kg/plot), M_2 = Mustard oil cake (3.6 t/ha or 1 kg/plot) and M_3 = Vermicompost (9 t/ha or, 2.5 kg/plot) and Factor-B had three level of time applications as T_1= Applied 15 days before transplanting , T_2 = Applied at the time of transplanting, T_3 = Applied 15 days after transplanting.

2.2 Raising of Seedlings

Seeds were sown in the seedbed on 01st October 2017. Seeds were treated by Provax 200WP @ 3g/1kg seeds to protect some seed borne diseases. No chemical fertilizers were applied for rising of seedlings. Healthy and 25 days old seedlings were transplanted into the experimental field on 26 October 2017.

2.3 Application of Manure

Organic manures were applied at 36, 3.6 and 9 ton per ha for cowdung, mustard oil cake and vermicompost respectively (Table 1).

Table 1. Manure dose in the main field

Manure	Quantity
Cowdung	36 t/ha
Mustard oil cake	3.6 t/ha
Vermicompost	9 t/ha

Source: Department of soil science, Bangladesh Agriculture University

2.4 Economic Analysis

The cost of production was analysed in order to find out the most economic combination of organic manure and application time. All input cost included the cost for lease of land and interests on running capital in computing the cost of production. The interests were calculated @ 14% in simple rate. The market price of cauliflower was considered for estimating the cost and return. The benefit cost ratio (BCR) was calculated as follows:

BCR = Gross return per hectare (tk)/Cost of production per hectare (tk)

2.5 Statistical Analysis

The data collected on various variables were statistically analyzed to find out the statistical significance of the treatment effect. The mean values of all the treatments were calculated and analyses of variance for all the characters were performed by the F-test (variance ratio). The significance of the difference among the treatment combinations of means was estimated by least significance difference (LSD) at 5% level of probability.

3. RESULTS AND DISCUSSION

3.1 Plant Height (cm)

Plant height of cauliflower differed statistically due to the application of different organic manure at 30, 45 and 60 days after transplanting (DAT). At 60 DAT, the highest plant height (46.667 cm) was measured from M_2 (Mustard oil cake) treatment and the lowest (35.290 cm) was recorded from M_0 (control) treatment (Table 2). It was revealed that the plant height increased with the increase in days after transplanting (DAT) i.e., 30, 45 and 60 DAT and also revealed that the plant height increased with different organic manure application as well. Mustard oil cake gives the highest result and cowdung the lowest. The result was supported by Prestele and Maync, [8] on cauliflower. This might be due to organic manure improve soil fertility, productivity and continuous nutrient supply throughout the growing period and mustard oilcake provide more nitrogen than other two manure throughout the growth period of plants. Application time of organic manure showed significant influence on the height of cauliflower plants at 30, 45 and 60 DAT. At 60 DAT, the highest plant height (43.065 cm) was measured from T_1 (applied 15 days before planting) treatment and the lowest height (41.06 cm) was recorded from T_2 (applied at the time of planting) treatment which was statistically similar to that of T_3 (applied 15 days after planting) treatment (Table 3). It was revealed that the plot treated with organic manure 15 days before planting gave better plant height than control. This might be due to application of organic manure 15 days before planting increased crop growth rate (CGR), net assimilation rate (NAR), leaf area index (LAI) and relative growth rate (RGR). Similar result was found by Prestele and Maync, [8], on growth of

cauliflower. Significant variation was found at plant height due to the combined effect of organic manure and application time at 30, 45 and 60 DAT (Table 4). The highest plant height (48.47cm) was measured from M_2T_1 (Mustard oil cake applied 15 days before planting) treatment and the shortest (34.67 cm) was recorded from M_0T_2 (control) treatment which was statistically identical to M_0T_1 (Control) treatment and M_0T_3 (Control) treatment at 60 DAT. From the results, it is obvious that organic manure and application time has significant effect on increasing plant height of cauliflower.

3.2 Number of Leaves per Plant

Application of organic manure exhibited significant influence on number of leaves per plant of cauliflower at different DAT. Minimum numbers of leaves (11.74) were found with control treatment (M_0) and maximum numbers of leaves (18.11) were observed from M_2 (Mustard oil cake) treatment at 60 DAT (Table 2). It was revealed that the number of leaves increased with the increase in days after transplanting (DAT) i.e., 30, 45 and 60 DAT and also revealed that the leaf number increases with different organic manure application as well, Nahar, [9] found the same result on broccoli. Statistically significant variation was recorded in terms of Application of time of manure on the number of leaves of cauliflower plants at 30, 45 and 60 DAT. At 60 DAT, the maximum numbers of leaves (15.89) were observed from T_1 (applied 15 days before planting) treatment while the minimum (14.08) were found in T_3 (applied 15 days after planting) treatment (Table 3). The number of leaves per plant increased with different organic manure application. The number of leaves showed significant difference influenced by the combined effect of organic manure and its application at 30, 45 and 60 DAT. At 60 DAT, the maximum numbers of leaves (20.73) were observed in M_2T_1 (Mustard oil cake applied 15 days before planting)treatment and the minimum (11.13) were found from M_0T_3 (control) treatment which was statistically identical to M_0T_1 (control) treatment and M_0T_2 (control) treatment, (Table 4). The results indicated that different organic manure helps increases plant leaf number with ensuring maximum essential nutrients among them mustard oil cake was the best, Rahman et al. [10] also found the maximum plant leaf number by using different organic manure from their experiment.

3.3 Largest Leaf Length (cm)

Organic manure had a significant influence on the length of leaves of cauliflower plants at 30, 45 and 60 DAT. At 60 DAT, the longest leaf (39.047 cm) was measured from M_2 (Mustard oil cake) treatment while the shortest (31.66 cm) was recorded from M_0 (control) treatment (Table 5), this is supported by Tomati and Galli, [11]. Organic manures have slow release nutrients all over the growth season. Mustard oil cake is rich in nutrient content and especially in nitrogen. This may helped in better nutrient absorption and thus favoured the vegetative growth. Consequently highest leaf length was found by mustard oil cake. Largest leaf length showed significant difference due to the application time of organic manure on cauliflower plants at 30, 45 and 60 DAT. At 60 DAT, the longest leaf (36.153 cm) was recorded from T_1 (applied 15 days before planting) treatment and the shortest leaf (34.4 cm) was measured in T_3 (applied 15 days after planting) treatment which was statistically identical to T_2 (applied at the time of planting) treatment (Table 6), similar result was observed by Ahmed [12]. This might be due to application time has profound influence on plant growth viz., leaf area index (LAI), net assimilation rate (NAR), crop growth rate (CGR), relative growth rate (RGR), also influence on soil temperature and moisture and fertility. The leaf length was significantly influenced by the combined effect of organic manure and application time at 30, 45 and 60 DAT. At 60 DAT, the longest leaf (41.87 cm) was measured from M_2T_1 (Mustard oil cake applied 15 days before planting)treatmentwhile the shortest (30.47 cm) was recorded from M_0T_1 (Control) treatment (Table 7). This result support the result found by Thy and Buntha [13].

3.4 Largest Leaf Breadth (cm)

A significant variation was recorded in leaf breadth of cauliflower plants at 30, 45 and 60 DAT. At 60 DAT, the highest leaf breadth (16.467 cm) was measured from M_2 (Mustard oil cake) treatment while the lowest (11.73 cm) was recorded from M_0 (control) treatment (Table 5) Similar result was found by Thakur and Singh, [14] on cauliflower. Time of application of organic manure had significant influence on leaf breadth of cauliflower plants at different DAT. At 60 DAT, the highest leaf breadth (15.068 cm) was measured from T_1 (applied 15 days before planting) treatment while the lowest (14.17 cm) was recorded from T_3 (applied 15 days after planting) treatment which was statistically

identical to T_2 (applied at the time of planting) treatment (Table 6). The leaf breadth was significantly varied by the combined effect of organic manure and mulching at 30, 45 and 60 DAT. Result support the research findings of Hsieh [15] on cabbage. This could be due to promote of nitrogen uptake which enhanced vegetative growth of cauliflower plants. At 60 DAT, the highest leaf breadth (17.4 cm) was measured from M_2T_1 (Mustard oil cake applied 15 days before planting) treatment which was statistically similar to that of M_2T_2 (Mustard oil cake applied at the time of planting) treatment while the lowest (11.6 cm) was recorded from M_0T_1 (Control) treatment which was statistically identical to M_0T_2 (control) treatment and M_0T_3 (Control) treatment (Table 7). This might be due to organic manure has profound influence on plant growth viz., leaf area index (LAI), net assimilation rate (NAR), crop growth rate (CGR), relative growth rate (RGR), also influence on soil temperature and moisture. Ahmed, [12] found the same results in his investigations.

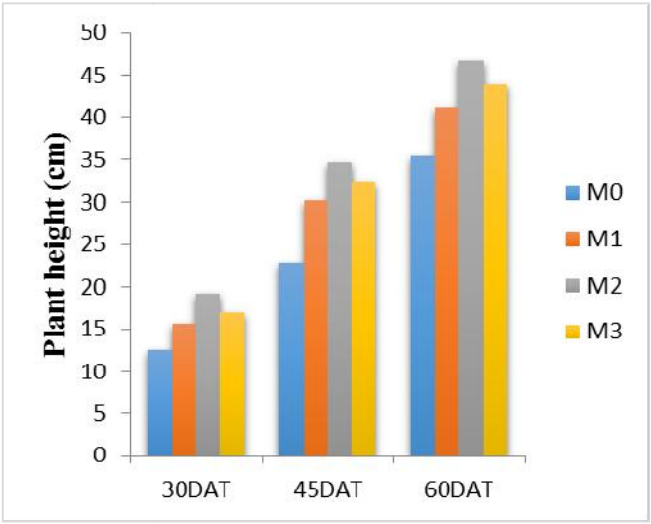

Fig. 1. Effect of organic manures on plant height of cauliflower
Where, M_0 = Control, M_1 = Cowdung, M_2 = Mustard oil cake, M_3 = Vermicompost

Table 2. Effect of organic manure on plant height (cm) and number of leaves of cauliflower

Treatments	Plant height (cm)			Number of leaves		
	30 DAT	45 DAT	60 DAT	30 DAT	45 DAT	60 DAT
M_0	12.50 d	22.90 d	35.29 d	4.93 d	9.97 d	11.74 d
M_1	15.55 c	30.22 c	41.17 c	6.77 b	11.89 c	14.44 c
M_2	19.26 a	34.66 a	46.66 a	9.04 a	14.31 a	18.11 a
M_3	16.93 b	32.28 b	43.95 b	6.50 c	12.83 b	15.64 b
CV %	5.41	7.67	7.25	8.98	8.16	9.97
LSD (0.05)	1.21	0.75	1.07	0.22	0.81	0.57

Table 3. Effect of time of application on plant height (cm) and number of leaves of cauliflower

Treatments	Plant height (cm)			Number of leaves		
	30 DAT	45 DAT	60 DAT	30 DAT	45 DAT	60 DAT
T_1	16.22	30.31 a	43.06 a	6.71	12.79 a	15.89 a
T_2	16.07	29.63 b	41.06 b	6.87	12.26 b	14.98 b
T_3	15.89	30.10 b	41.18 b	6.84	11.70 b	14.08 c
CV%	5.41	7.67	1.07	8.98	8.16	9.97
LSD(0.05)	NS	0.64	0.93	NS	0.69	0.49

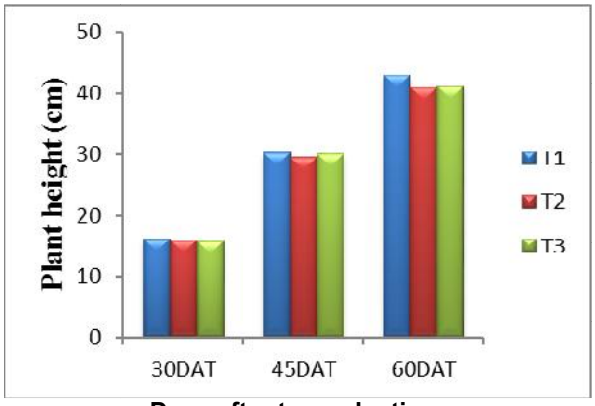

Fig. 2. Effect of different time of application of organic manure on cauliflower

Where, T_1 = applied 15 days before planting, T_2 = applied at the time of planting and T_3 = applied 15 days after planting

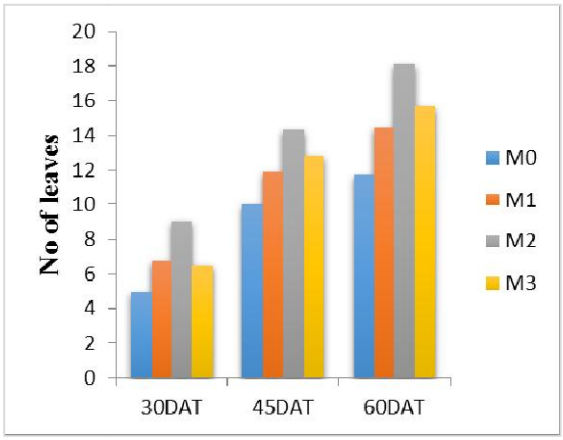

Fig. 3. Effect of organic manures on number of leaves of cauliflower

Where, M_0 = Control, M_1 = Cowdung, M_2 = Mustard oil cake and M_3 = Vermicompost

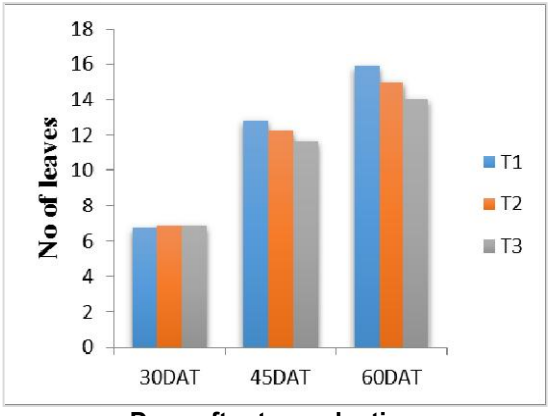

Fig. 4. Effect of different time of application of organic manure on number of leaves of cauliflower

Where, T_1 = applied 15 days before planting, T_2 = applied at the time of planting and T_3 = applied 15 days after planting

Table 4. Combined effect of organic manure and application time on plant height (cm) and number of leaves of cauliflower

Treatments	Plant height (cm)			Number of leaves		
	30 DAT	45 DAT	60 DAT	30 DAT	45 DAT	60 DAT
M_0T_1	12.10e	22.53f	35.40f	4.33g	10.60f	12.07h
M_0T_2	12.66e	22.33f	34.67f	4.80f	10.80f	12.03h
M_0T_3	12.73e	23.86e	35.80f	5.67e	8.53g	11.13h
M_1T_1	15.93cd	30.73cd	43.46d	6.33d	11.75def	14.73f
M_1T_2	15.87cd	29.60d	40.20e	6.93c	11.07ef	15.55ef
M_1T_3	14.86d	30.33d	39.87e	7.06c	12.87bcd	13.60g
M_2T_1	19.80a	35.20a	48.47a	9.73a	15.53a	20.73a
M_2T_2	18.95ab	34.67a	46.13b	8.87b	14.20ab	17.07b
M_2T_3	19.03ab	34.13a	45.40bc	8.53b	13.20bc	16.53bc
M_3T_1	17.07bc	32.80b	44.93bcd	6.47d	13.30bc	16.03cd
M_3T_2	16.80cd	31.93bc	43.26d	6.91c	12.99bcd	15.83cde
M_3T_3	16.93bcd	32.11b	43.67cd	6.13d	12.20cde	15.07def
CV %	5.41	7.67	7.25	8.98	8.16	9.97
LSD (0.05)	2.10	1.29	1.86	0.38	1.39	0.97

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

Table 5. Effect of organic manure on largest leaf length, largest leaf breadth, curd length and curd stem diameter of cauliflower

Treatments	Largest leaf length (cm)	Largest leaf breadth (cm)	Days required for curd initiation	Curd length (cm)	Curd stem diameter (cm)
M_0	31.66 c	11.73 d	67.33 a	13.44 c	2.55 c
M_1	34.77 b	14.60 c	65.66 b	17.02 b	3.29 ab
M_2	39.04 a	16.46 a	63.66 c	18.73 a	3.46 a
M_3	34.71 b	15.27 b	64.00 c	17.33 b	3.27 b
CV %	7.45	11.43	9.27	9.25	10.42
LSD (0.05)	0.69	0.61	1.16	0.75	0.18

Table 6. Effect of time of application on largest leaf length, largest leaf breadth, curd length and curd stem diameter of cauliflower

Treatments	Largest leaf length (cm)	Largest leaf breadth (cm)	Days required for curd initiation	Curd length (cm)	Curd stem diameter (cm)
T_1	36.15 a	15.06 a	64.50 b	17.11 a	3.33 a
T_2	34.60 b	14.31 b	65.75 a	16.56 b	3.05b
T_3	34.40 b	14.17 b	65.25 b	16.21 b	3.04 b
CV%	7.45	11.43	9.27	9.25	10.42
LSD(%)	0.58	0.53	1.01	0.65	0.16

3.5 Days Required for Curd Initiation

A significant variation was recorded in terms the number of days required for curd initiation influenced by organic manure application. The minimum days (63.667) required for 80% curd initiation were showed by M_2 (Mustard oil cake) treatment which was statistically similar to M_3 (Vermicompost) treatments while the maximum days (67.33) were required by M_0 (Control) treatments (Table 5). Application of organic manure hastened the crop to reach reproductive stage which was agreed with the present findings Mitra et al. [16]. Application time of manure significantly influenced the number of days required for curd initiation. The minimum days (64.50) required for 80% curd initiation were observed from T_1 (applied 15 days before planting)treatment which was statistically identical to that of T_3 (applied 15 days after

planting) treatments and the maximum (65.75) days were required by T_2 (at the time of planting) treatment (Table 6). Days required for curd initiation was significantly varied among the treatment combinations. The maximum days (68.00) were required in the M_0T_2 (Control) treatment which was statistically similar to M_0T_1 (Control) treatment, M_0T_3 (Control) treatment, M_1T_2 (Cowdung applied at the time of planting) treatment and M_1T_3 (Cowdung applied 15 days after planting) treatment while the minimum days (63.00) were required for 80% curd initiation in M_2T_1 (Mustard oil cake applied 15 days before planting) treatmentand M_3T_1 (Vermicompost applied 15 days before planting) treatment (Table 7). Thy and Buntha [13] reported that organic manure ensure the favourable condition for the growth and development of Chinese cabbage and the ultimate result is the shortest duration for attaining head formation.

3.6 Length of Curd (cm)

A statistically significant variation was observed from the application of organic manure on length of curd of cauliflower plants. The highest length of curd (18.733 cm) was measured from M_2 (Mustard oil cake) treatment which while the lowest (13.44 cm) was recorded in M_0 (control) treatment (Table 5). It was revealed that the length of curd increased with organic manure application. This might be due to N concentration was increased with the increase of mustard oil cake concentration which has significant role in photosynthesis, storage energy, cell division and cell enlargement that enhanced the length of the curd. Application time of manure showed highly significant influence on the length of curd of cauliflower plants. The maximum length of curd (17.117 cm) was measured from T_1 (applied 15 days before planting) treatment while the minimum (16.215 cm) was recorded from T_3 (applied 15 days after planting) treatmentwhich was statistically identical to that of T_2 (applied at the time of planting) treatment (Table 6). Length of curd showed significant influence by the combined effect of organic manure and time of application. The maximum length of curd (20.40 cm) was measured from M_2T_1 (Mustard oil cake applied 15 days before planting) treatment while the minimum (13.20 cm) was recorded from M_0T_1 (control) treatment which was statistically identical to that of M_0T_2 (control) treatment and M_0T_3 (control) treatment (Table 7). Length of curd is an important yield character. Length of curd was significantly influenced by organic manure application. This results support the findings Palevich et al. [17].

3.7 Curd Stem Diameter (cm)

Application of organic manure shows a significant difference on stem diameter of curd of cauliflower plants. The highest stem diameter of curd (3.4667 cm) was measured from M_2 (Mustard oil cake) treatment which was statistically similar to that of M_1 (Cowdung) treatment while the lowest (2.55 cm) was

Table 7. Combined effect of time of application on largest leaf length, largest leaf breadth, curd length and curd stem diameter of cauliflower

Treatments	Largest leaf length(cm)	Largest leaf breadth(cm)	Days required for curd initiation	Curd length (cm)	Curd stem diameter(cm)
M_0T_1	30.47 j	11.60 f	67.00 ab	13.93 d	2.50 d
M_0T_2	32.20 i	11.60 f	68.00 a	13.20 d	2.66 d
M_0T_3	32.33 hi	12.00 f	67.00 ab	13.20 d	2.49 d
M_1T_1	35.80 de	15.47 bc	65.00 bcd	16.27 c	3.60 ab
M_1T_2	35.13 ef	14.33 de	66.00 abc	17.87 b	3.10 c
M_1T_3	33.40 gh	14.00 e	66.00 abc	16.93 bc	3.17c
M_2T_1	41.87 a	17.40 a	63.00 d	17.87	3.84 a
M_2T_2	37.87 b	16.40 ab	64.00 cd	16.93 bc	3.34 bc
M_2T_3	37.40 bc	15.60 bc	64.00 cd	20.40 a	3.22 c
M_3T_1	36.47 cd	15.80 bc	63.00 d	18.13 b	3.40 bc
M_3T_2	33.20 hi	14.93 cde	65.00 bcd	17.67 b	3.13 c
M_3T_3	34.47 fg	15.08 cd	64.00 cd	17.07 bc	3.30bc
CV %	7.45	11.43	9.27	9.56	10.42
LSD (0.05)	1.10	1.06	2.02	1.31	0.32

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

recorded in M_0 (control) treatment (Table 5). The stem diameter of curd increased with organic manure application. The results indicated organic manure increases the growth and development of plant which ensure the maximum stem diameter of cauliflower. Application time of organic manure significantly influenced the stem diameter of curd of cauliflower plants. The maximum stem diameter of curd (3.335 cm) was measured from T_1 (applied 15 days before planting) treatment while the minimum (3.045 cm) was recorded from T_3 (applied 15 days after planting) treatment which was statistically identical to that of T_2 (applied at the time of planting) treatment (Table 6). Significant variation was recorded in the curd stem diameter of cauliflower by the combined effect of organic manure and time of application. The maximum stem diameter of curd (3.84 cm) was measured from M_2T_1 (Mustard oil cake applied 15 days before planting) treatment which was statistically similar to that of M_1T_1 (Cowdung applied 15 days before planting) treatment while the minimum (2.49 cm) was recorded from M_0T_3 (control) treatment which was statistically identical to that of M_0T_1 (control) treatment and M_0T_2 (control) treatment (Table 7). Stem diameter of curd is important for curd yield. Stem diameter of curd was significantly influenced by organic manure application. Murlee et al. [18] found the same result on cauliflower.

3.8 Curd Diameter (cm)

Application of organic manure exhibited a significant influence on curd diameter of cauliflower plants. The maximum curd diameter (15.867 cm) was recorded from M_2 (Mustard oil cake) treatment while the minimum (11.84 cm) was measured from M_0 (control) treatment (Table 8). It was revealed that the curd diameter increased with organic manure application. This might be due to slow and continuous nutrient supply. It helps to store energy, cell division and cell enlargement. Application time of organic manure significantly influenced the curd diameter of cauliflower plants. The maximum curd diameter (15.132 cm) was measured from T_1 (applied 15 days before planting) treatment while the minimum (13.915 cm) was recorded from T_2 (applied at the time of planting) treatment which was statistically identical to that of T_3 (applied 15 days after planting) treatment (Table 9). This results revealed that the curd diameter increase with time of application of organic manure. Curd diameter was significantly varied by the combined effect of organic manure and application time. The maximum curd diameter (17.60 cm) was measured from M_2T_1 (Mustard oil cake applied 15 days before planting) treatment while the minimum (11.2 cm) was recorded from M_0T_2 (control) treatment (Table 10). This findings matches with the observation of Ahmed [19]. Curd diameter is one of the most important yield character. Curd diameter was significantly influenced by organic manure and time of application of organic manure.

3.9 Curd Weight (kg)

Application of organic manure exhibited statistically significant influence on diameter of curd of cauliflower plants. The maximum curd weight (928.90 g) was measured from M_2 (Mustard oil cake) treatment while the minimum (473.18 g) was measured from M_0 (control) treatment (Table 8). It was revealed that the curd weight increased with organic manure application. This might be due to slow and continuous nutrient supply. That helps in uniform curd formation. During curd formation continuous nutrient supply is very much essential. Application time of organic manure had a significant effect on curd weight of cauliflower plants. The maximum curd weight (763.98 g) was measured from T_1 (applied 15 days before planting) treatment while the minimum (674.54 g) was recorded from T_3 (applied 15 days after planting) treatment (Table 9). This result was revealed that the curd weight varied with time of application. This might be caused that organic manure increase soil moisture that helps in water uptake by the plants. Similar trend of the result was found by [10]. Curd weight was noticeably varried by the combined effect of organic manure and application time (Table 10). The maximum curd weight (1042.9 g) was measured from M_2T_1 (Mustard oil cake applied 15 days before planting) treatmentwhile the minimum (429.6 g) was recorded from M_0T_3 (control) treatment (Table 10) . Curd weight is the most important yield character of cauliflower. Weight of the curd was significantly influenced by organic manure and time of its application. These findings support the result reported by Bevacqua and Mellano [20].

3.10 Yield per Plot (kg)

Yield per plant is important for increasing total yield. Application of organic manure exhibited a statistically significant influence on yield per plot of cauliflower. The maximum yield (11.147 kg) was recorded from M_2 (Mustard oil cake)

treatment while the minimum (5.678 kg) was measured in M_0 (control) treatment (Table 8). It was revealed that yield per plot increased with organic manure application. Cauliflower yield and curd diameter were greater in organic manure treatment. Steffen et al. [21] observed the effect of organic matter (spent mushroom compost + rotten cattle manure) on growth and yield of cauliflower and found that cauliflower yield and curd diameter was greater in the amended treatment. The maximum yield (9.1678 kg) was recorded from T_1 (applied 15 days before planting) treatment to while the minimum (8.0946 kg) was measured in T_3 (applied 15 days after planting) treatment (Table 9). This might be caused that organic manure release nutrient slowly throughout the growth period of cauliflower also influences the nutrient retention of soil and produce higher yield of cauliflower. Similar trend of the results on cauliflower were found by Steffen et al. [21]. Yield per plot was highly significantly influenced by the combined effect of organic manure and application time. The maximum yield (12.515 kg) was measured in M_2T_1 (Mustard oil cake applied 15 days before planting) treatment while the minimum (5.155 kg) was recorded from M_0T_3 (control) treatment which was statistically similar to that of M_0T_1 (control) treatment (Table 10).

3.11 Yield per Hectare (ton)

A significant influence on yield per hectare of cauliflower plants was observed by the application of organic manure. The maximum yield (38.704 ton/ha) was recorded from M_2 (Mustard oil cake) treatment which was while the minimum (19.717 ton/ha) was measured in M_0 (control) treatment (Table 8). Cauliflower yield and curd diameter were greater in organic manure treatment. This result is supported by Steffen et al. [21]. The maximum yield (31.832 ton/ha) was recorded in T_1 (applied 15 days before planting) treatment while the minimum (28.107 ton/ha) was measured in (T_3) (applied 15 days after planting) treatment (Table 9). Total yield per hectare was significantly influenced by the combined effect of organic manure and application time. The maximum yield per hectare (43.454 ton/ha) was measured in M_2T_1 (Mustard oil cake applied 15 days before planting) treatmentwhile the minimum (17.903 ton/ha) was recorded from M_0T_3 (control) treatment which was statistically similar to that of M_0T_1 (control) treatment (Table 10).

3.12 Economic Analysis

The highest gross return (Tk. 8,69,000) and net return (Tk. 4,74,421) was obtained from the treatment combination $M_2T_1$and the lowest gross return (Tk. 2,98,950) and net return (Tk. 44,211) was obtained from M_0T_3 treatment combination. In the different planting time and organic manure the highest benefit cost ratio (2.20) was noted from the combination of M_2T_1 and the lowest benefit cost ratio (1.17) was obtained from M_0T_3 treatment combination (Table 11).

Table 8. Effect of organic manure on yield characteristics of cauliflower

Treatments	Curd diameter(cm)	Curd weight (kg)	Yield per plot(kg/plot)	Yield per hectare(t/ha)
M_0	11.84 d	473.18 d	5.67 d	19.71 d
M_1	15.15 b	715.28 c	8.58 c	29.80 c
M_2	15.86 a	928.90 a	11.14 a	38.70 a
M_3	14.42 c	760.55 b	9.12 b	31.69 b
CV%	12.87	9.37	12.87	11.74
LSD(%)	0.43	9.64	0.11	0.40

Table 9. Effect of time of application on yield characteristics of cauliflower

Treatments	Curd diameter(cm)	Curd weight (kg)	Yield per plot(kg/plot)	Yield per hectare(t/ha)
T_1	15.13 a	763.98 a	9.16 a	31.83 a
T_2	13.91 b	719.91 b	8.63 b	29.99 b
T_3	13.91 b	674.54 c	8.09 c	28.10 c
CV%	12.87	9.37	12.87	11.74
LSD (%)	0.37	8.35	0.12	0.34

Table 10. Combined effect of organic manure and time of application on yield characteristics of cauliflower

Treatments	Curd diameter(cm)	Curd weight (kg)	Yield per plot(kg/plot)	Yield per hectare(t/ha)
M_0T_1	12.13 g	477.60 h	5.73 hi	19.90 hi
M_0T_2	11.20 h	512.30 g	6.14 g	21.34 g
M_0T_3	12.20 g	429.60 i	5.15 i	17.90 i
M_1T_1	15.73 b	685.70 f	8.22 f	28.57 f
M_1T_2	14.73 cde	718.30 e	8.62 e	29.92 e
M_1T_3	15.00 cde	741.90 de	8.90 de	30.91 de
M_2T_1	17.60 a	1042.90 a	12.51 a	43.45 a
M_2T_2	15.47 bc	895.50 b	10.74 b	37.31 b
M_2T3	14.53 def	848.30 c	10.17 c	35.34 c
M_3T_1	15.07 bcd	849.70 bc	10.19 bc	35.40 bc
M_3T_2	14.26 ef	753.50 d	9.04 f	31.39 d
M_3T_3	13.93 f	678.40 f	8.14 f	28.26 f
CV%	12.87	9.37	12.87	11.74
LSD (%)	0.75	16.70	0.20	0.69

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

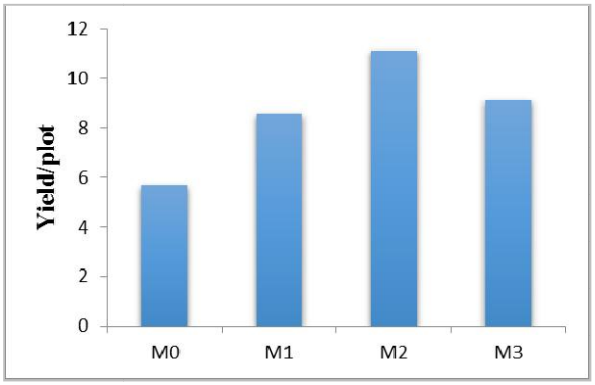

Fig. 5. Effect of organic manures on per plot yield of cauliflower
Where, M_0 = Control, M_1 = Cowdung, M_2 = Mustard oil cake and M_3 = Vermicompost

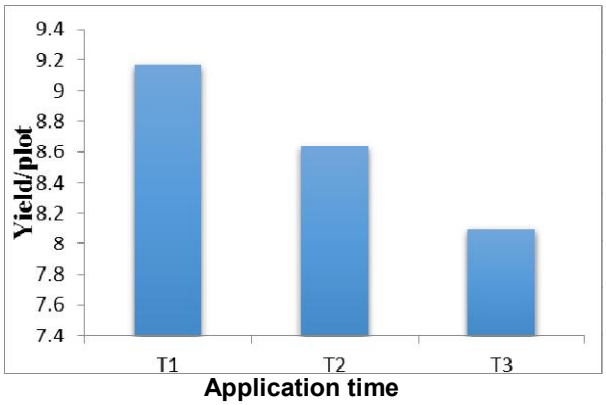

Fig. 6. Effect of different time of application of organic manure on per plot yield of cauliflower
Where, T_1 = applied 15 days before planting T_2 = applied at the time of planting and T_3 = applied 15 days after planting

Table 11. Economic analysis of cauliflower production as influenced by organic manure and its application timing

Treatment combination	Cost of production (Tk./ha)	Yield of cauliflower (t/ha)	Gross return (Tk./ha)	Net return (Tk/ha)	Benefit cost ratio
M_0T_1	254739	19.90	318000	63261	1.24
M_0T_2	254739	21.35	326800	72061	1.28
M_0T_3	254739	17.90	298950	44211	1.17
M_1T_1	382714	28.57	571400	188686	1.49
M_1T_2	382714	29.92	598400	215686	1.56
M_1T_3	382714	30.91	618200	235486	1.62
M_2T_1	394579	43.45	869000	474421	2.20
M_2T_2	394579	37.31	746200	351621	1.89
M_2T_3	394579	35.34	706800	312221	1.79
M_3T_1	451364	35.40	708000	256636	1.56
M_3T_2	451364	31.39	657800	206436	1.45
M_3T_3	451364	28.26	595200	143836	1.31

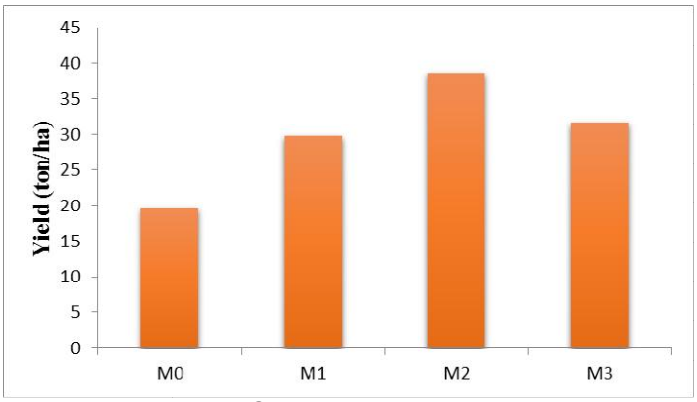

Fig. 7. Effect of organic manures on per hector yield of cauliflower
Where, M_0 = Control, M_1 = Cowdung, M_2 = Mustard oil cake and M_3 = Vermicompost

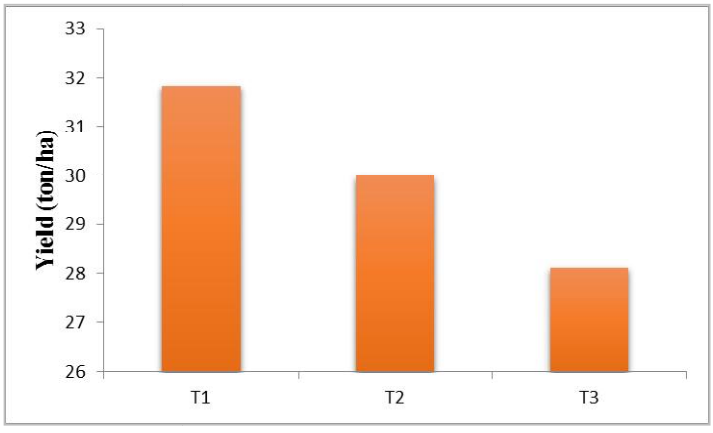

Fig. 8. Effect of different time of application of organic manure on per hectare yield of cauliflower
Where, T_1 = applied 15 days before planting T_2 = applied at the time of planting and T_3 = applied 15 days after planting

4. CONCLUSION

Both crop yield and economic benefit of the crop are important for crop production. Mustard oil cake applied 15 days before planting represents a higher yield in cauliflower plant. According to the results of the present experiment, it may be concluded that the efficient production of cauliflower is increased by the application of organic manure and time of application. Thus, the application of organic manure and its time of application may be helpful for higher and better qualitative cauliflower production in considering crop productivity and economic return of cauliflower. Based on the benefit-cost ratio, it may be suggested that mustard oil cake applied 15 days before planting gave the maximum and profitable yield of the cauliflower curd.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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