EFFECT OF MANURES AND ITS APPLICATION TIME ON GROWTH AND YIELD OF CAULIFLOWER

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CERTIFICATE

*This is to certify that the thesis entitled **"EFFECT OF ORGANIC MANURES AND ITS APPLICATION TIME ON GROWTH AND YIELD OF CAULIFLOWER"** submitted to the Faculty of Agriculture, Sher-E-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (MS)** in **HORTICULTURE,** embodies the results of a piece of bona fide research work carried out by **SANJIDA AKHTER,** Registration. No. **12-04747** under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.*

I further certify that such help or source of information as has been availed of during the course of this investigation has duly been acknowledged.

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TO

MY BELOVED PARENTS

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ABSTRACT

An experiment was conducted at the Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka, during October 2017 to February 2018. The experiment consisted of two factors, Factor A: Four types of organic manures, viz. M_0 = Control; M_1 = Cowdung (36 t/ha), M_2 = Mustard oil cake (3.6 t/ha), and M_3 = Vermicompost (9 t/ha) . 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 Randomized Complete Block Design with three replications. In case of organic manures, the highest yield (38.70 t/ha) was found from M_2 treatment, whereas the lowest yield (19.71t/ha) was recorded from M_0 treatment. In case of application time the highest yield the (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 (4,74,421 tk) and BCR (2.20) was obtained from M_2T_1 treatment combination while the lowest yield (17.90 t/ha) with lowest return (44,211 tk) and BCR (1.17) from M_0T_3 treatment. So, 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.

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ABBREVIATION AND ACRONYMS

AEZ	=	Agro-Ecological Zone
Agric.	=	Agriculture
BBS	=	Bangladesh Bureau of Statitics
cm	=	Centimeter
CV	=	Coefficient of Variance
DAT	=	Days after Transplanting
et al.	=	And others
FAO	=	Food and Agriculture
FYM	=	Farm yard manure
gm	=	Gram
ha	=	Hectare
Hort.	=	Horticulture
i.e.	=	That is
In.	=	International
kg	=	Kilogram
J.	=	Journal
LSD	=	Least Significant Difference
mg	=	Milligram
no	=	number
NS	=	Non significant
NPK	=	Nitrogen , Phosphorus and Potassium
%	=	Percentage
SAU	=	Sher-e-Bangla Agriculture University
Sci.	=	Science
SRDI	=	Soil Resources and Development Institute
TSP		Triple super phosphate
Technol.	=	Technology
UK	=	United kingdom
Viz.	=	Namely

CHAPTER-I

INTRODUCTION

Cauliflower (*Brassica oleracea* var. *botrytis* sub-var. *cauliflora*) belongs to the family Cruciferae is one of the most important cole crop. lt 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 (Haque, 1999). It supplies 50mg vitamin C, 40 IU carotene, 30 calorie, 8 gm carbohydrate and 90% water per 100 gm edible part. In our country it is used only as fry and ingredient of curry. In western countries it is used as pickle also. The edible part of cauliflower is known as 'Curd'. According to botanical consideration, it is the pre-condition of inflorescence. It is a winter crop. The lifecycle of cauliflower can be divided into three phases, such as growth phase, curd phase, flower and seed phase. Vegetable consumption in Bangladesh is very low, only 32 g per person per day against the minimum recommended quantity of 200 g per day (FAO, 1986). The total vegetable production in Bangladesh is far below the requirement. In 2014-2015 cauliflower covered an area of 48,295 acres with a total production of 2,68,480 metric tonnes (BBS, 2016).

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.

Growth and yield of cauliflower depend on nutrient availability in soil, which is related to the judicious application of manures and fertilizers. Nutrient may be applied through two sources viz. organic and inorganic. The continuous use of chemical fertilizer badly affects the soil texture, structure, color, aeration, water holding capacity and microbial activity of soil. A good soil has an organic matter content of more than 3%. But in Bangladesh soil of most region have less than 1.5%,some soil have less than 1% organic matter. For continuous cropping, organic manures applied to the crop fields through cowdung, vermicompost, mustard oil cake etc. are insufficient. Now a days, gradual deficiency in soil organic matter and reduce yield of crops are alarming factors and burning issues for the farmers and agriculturists. In recent year poultry and livestock farming are increasing. So manure like poultry litter, cowdung etc. are becoming available. Large quantities of crop wastes are produced from agricultural activities. These organic wastes, after being converted into compost, whether through conventional composting or vermicomposting, can be profitably used for fertilizing crops, particularly for food crop production. On an average, well rotten cowdung contains 0.5% N, 0.2% P_2O_5 and 0.5% K_2O (Yawalkar *et al.*, 1984).

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 (Sinha *et al.*, 2010). 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% P_2O_5, 0.65% K_2O. 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, (BARC,1997). 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 (Hussain *et al.,* 1989) 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 (Ndukwe *et al*., 2011). 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 (Thomsen, 2005).

Different manures contain different amount of nutrient in different proportion and their mode of nutrient release is not same. So, different manures may influence the growth, yield in different angles. Considering the above facts, the present research was under taken with the following objectives:

- ✓ To find out suitable organic manures and its optimum dose on growth, yield and economic return of Cauliflower.
- ✓ To identify the optimum time of application of the organic manure on growth, yield and economic return of cauliflower.
- ✓ To observe combined effect of organic manures and their application time on growth, yield and economic return of cauliflower.

CHAPTER-II

REVIEW OF LITERATURE

The benefits of using organic manures in crop production had long been known. Now-a-days, many experimental evidences are available regarding the usefulness of using organic manure in the soil. Research findings regarding the effect of organic manure applied at different growth stages of cauliflower on yield and yield components and curd size under Bangladesh condition is very limited. However, some of the available literature related to the present experiment have been reviewed in this chapter.

2.1. EFFECT OF ORGANIC MANURES

The result of organic Cauliflower trials conducted in the UK (2004) investigating the effects plant spacing, composted waste and FYM on the yield of 16 cultivars. The study showed a large variation in the categories of marketable yield among the cultivars.

Hsieh (2004) conducted an experiment on conventional farming and partial organic farming and showed that growth and yield of cabbage and cauliflower in the organic treatments were greater than in the control. Poultry manure compost treatment gave the highest weight/plant, head diameter and yield, which was 26.28% higher than that of the control, followed by pig manure compost treatment, which was 18.38% higher.

Pathak and Nishi Keshari (2003) conducted a pot experiments with the supply of neem seed cake, mustard cake and press mud at 25 and 10 g/kg soil, and 10 and 20 mg carbofuran/kg soil, alone or combination and reported that the heighest mean plant height (28.6 cm) and mean root length (19.3 cm) were obtained with 20 mg carbofuran/kg soil. The highest mean fresh shoot (30.3 g) and root weight (6.8 g) were obtained with 25 kg need seed cake /kg soil. The lowest mean number of galls per pant foot (6.67) was obtained with 25 g neem seed cake, 10 gm neem seed cake + 10 mg carbofuran, and 10 gm mustard cake /kg soil. The lowest mean number of galls per g root (1.00) was obtained with 25 kg neem seed cake/kg soil. The lowest mean nematode population in the soil (-763) was obtained with 20 mg carbofurun /kg soil.

Thakur and singh (2001) conducted a field experiment in Cauliflower CV. Pusa snow ball K-1 plants were supplied with 0 (to), 600 (t1), 800 (T2) and (1000) (T3) Kg recycle commercial organic manure (ORGO)/ha to determine the effect of ORGO on the seed yield of Cauliflower and reported that plant mortality was highest with T2 (11%) and lowest with T3 application (6%). seed yield per plot and total yield were highest in plants supplied with T3 application (6%). seed yield per plot and total yield were highest in plants supplied with T2 (839.90 g / plot and 8.20 g/ha, respectively) and lowest in those supplied with T3 (540.15 g/ ha plot and 5.27 q/ ha, respectively). No significant differences among the treatments in terms of the number of outer leaves of Cauliflower were observed.

Jin-Yan *et al*. (2002) were carried out a pot and plot experiments in which head lettuce (Lactuca sativa var. capitata), cauliflower (Brassica oleracea var. botrytis) and lettuce (Lactuca angustana) were supplied with sewage sludge compound fertilizer, NPK fertilizer and sewage sludge compost. Sewage sludge compound fertilizer significantly improved vegetable yield (303%) as compared with the unfertilized control.

Rodrigues and Casali (1999) Showed that the highest estimated yields of 119.5, 119.4 and 153.9 g/ plant were obtained with 37.7 t/ha organic compost t/ha with no mineral fertilizer application, 18.9 t/ha organic compost t/ha with half the recommended mineral fertilizer rate and 13 t/ha organic compost/ha with the recommended mineral fertilizer rate. Organic compost application resulted in lower foliar N and Ca concentrations and higher foliar P, K and Na concentrations compared with mineral fertilizer application.

Prestele and Maync (2000), a study was conducted on the effects of a wide variety of organic fertilizers (ricinus, rape, sunflower, pea and bean fragments and granules) on yields of Cauliflower and fennel were studied. N release from toasted, pre-germinated and untreated fertilizers was very similar, except for whole meals and rapeseed pellets, which decreased yields. All tested fertilizers were cheaper than conventional fertilizers. Utilization of substances which are not explicit fertilizers, such as fodder peas and sunflower meal pellets, requires prior determination of N content.

Magnani *et al.* (2003) conducted an experiment on the growth rate and qualitative characteristics of 3 vegetable (broccoli, cabbage and cauliflower) seedlings, grown with an organic method, were evaluated. The organic method consisted of using cocopeat as the growth medium and organic fertilizer for fertigation. This method was compared with a traditional one based on a peat growth medium and synthetic fertilizers for fertigation. The results showed different responses among the vegetables, regarding growth rate and quality. Broccoli grown with organic method presented an increase of growth rate, fresh weight, leaf number and area, height, root/shoot ratio and nutrient content compared to the traditional method. On the contrary, cabbage and cauliflower, grown with organic method, showed a reduction of growth rate, dry weight, leaf number and area, chlorophyll content, height and nutrient content. The different responses among these species could be related to the length of the nursery cycle, which is longer for cabbage (higher production of dry matter). Moreover, the leaf uptake of nutrients in cabbage was easier than cauliflower broccoli because of different characteristics of leaves.

Murlee *et al.* (2007) conducted a field experiment in Allahabad, Uttar Pradesh, India, during the 2003 and 2004 kharif seasons, to determine the influence of organic and inorganic fertilizers on growth and yield of cauliflower. Treatment T< sub>3</ sub> (150 kg Gromor + 96 kg urea + 32 kg MOP/acre) showed significantly higher curd length (17.00 cm), curd weight (560 g), yield per plot (7.89 kg), yield (392 q/ha) and cost benefit ratio (1:2.88), whereas maximum plant height (53.33 cm) was recorded in treatment T< sub>1</ sub> (104 kg urea + 32 kg DAP + 32 kg MOP/acre).

Parmar *et al.* (2006). A field experiment was conducted at the experimental farm of the Himachal Pradesh Agricultural University in Kullu-Manali, India, over two years in a Western Himalayan Entisol to demonstrate the effects of synthetic fertilizers and organic manure on the productivity of a commonly used tomato (Lycopersicon esculentum Mill.)-tomato-Cauliflower (*Brassica oleracea* var *botrytis*) rotation.

Thilagam *et al.* (2011) reported that cauliflower (*Brassica oleracea* var *botrytis* L) is a heavy feeder of nutrients and it responds very well to all bulky nutrient addition through Farm Yard Manure (FYM), bio fertilizers, green manures and chemical fertilizers

Therefore efficient management of Integrated Plant Nutrient supply System (IPNS) is a prerequisite for achieving higher productivity of cauliflower. Application of N from 120 to 225 kg ha-1 increased the curd yield and quality depending on soil fertility. Besides, N cauliflower also responds well to phosphorus ranging between from 90-200 kg ha-1 and K up to 75 kg ha-1 and it also increases the quality of produce and yield. Application of Mo increases the curd yield and decreases the incidence of whiptail. Application of B reduces browning of curd that ultimately causes the brown rot of cauliflower. Judicious combination of chemical fertilizers along with organic manures based on soil available nutrients will increase the cauliflower yield at the same time it will sustain the soil fertility.

Wani *et al.* (2010) conducted an experiment during rabi of 2004-2005 to find out the optimum dose and best combination of organic and inorganic sources of nutrients for maximizing yield and improving quality of cauliflower cv Snowball-16. Combined application of 50% recommended dose of NPK and poultry manure at 3 t/ha recorded significantly higher curd yield (325.1 q/ha), followed by combined application of 50% recommended dose of NPK and mixture of FYM, poultry manure, sheep manure and pea straw. Highest net returns (Rs 178,096/ha) and benefit cost ratio (3.59) were also recorded for the treatment including combined use of 50% recommended dose of NPK and poultry manure at 3 t/ha. Application of 50% recommended dose of NPK +mixture of half dose of FYM, poultry manure, sheep manure and pea straw remained second in order.

Rahman *et al.* (1998) observed increase vegetative growth and yield of berry of brinjal was by using animal blood meal, mustard oil cake, epil-epil leaves or the combination of these three in the soil as organic manures. The vegetative growth was highest with blood meal and lowest with epil-epil leaves. The dates of flowering and maturity were earlier both with blood meal and the combined application of the 3 manures than the untreated control. The yield of berry was highest with the combined application of the manures. Of the 3 manures, yield was lowest with epil-epil leaves.

Petko (1972) showed that application of 40 tons FYM and two thirds of P and K (in trials of 120 kg N, 240 kg P and 180 kg K/ha) top dressing with the rest NPK increased yield by 43% compared to control.

Bevacqua *et al.* (1994) observed that onion seedlings transplanted to compost treated plots established more vigorously than those in the control plots. They also found that compost treatments increased yields (FW) of onions compared to controls.

Asiegbu *et al.* (1984) carried out an experiment in Nigeria on onion with farmyard manure and reported that bulb diameter and the percentage of grade I bulbs were increased with increasing FYM application. They also found that onion yields were maximum with 20 t FYM/ha.

Almeida *et al.* (2005) conducted an experiment from March to December 2001, in Rio de Janeiro, Brazil, to evaluate biological nitrogen fixation (BNF) for green manures pre-cropped and intercropped with aubergine in an organic cropping system, the use of N derived from BNF by the aubergine crop, and the impact of green manuring on aubergine yield and soil N balance. Plots with sunn hemp, millet and spontaneous weeds were established before aubergine planting. After 60 days, 53% of sunn hemp N came from BNF. Green manuring during precropping was cut in aubergine plantings under no-till system, except for half of the plot where spontaneous weeds were incorporated into the soil. Aubergine was either intercropped with sunn hemp and cowpea or cropped alone. At 52 days, the legumes were cut and left close to the aubergine crop. The BNF contribution depended on the pre-cropped species and varied between 20 and 90%. Using the 15N technique, it was verified that aubergine plants benefited from the green manure N under both pre-cropping and intercropping. BNF did not affect aubergine yield, but the BNF in legumes was enough to compensate for the exported N in the harvest fruits.

Godase and Patel (2001) studied the influence of organic manures and fertilizer doses on the intensity of sucking pests: (Amrasca biguttula bignttula Ishida) and Aphid (Aphid gossypii Glover) infesting brinjal. The nine treatments of organic manures and fertilizers, namely 100:37.5:37:5 kg NPK, 50 t FYM, 10 t FYM+50.T 8.75:18.75 kg

NPK, 4 t vermicompost, 1.7 t neem cake, 200:37.5:37.5 kg NPK, 50:37.5:75 kg NPK, 0.85 t neem cake+50:18.75:18.75 kg NPK and zero fertilizer application were evaluated against jassid (Amrasca biguttula biguttula) and aphid (Aphis gossypii) infesting aubergine at N.M.

Prasanna and Rajan (2001) showed that brinjal [aubergine] cv. Surya plants were supplied with farmyard manure (FYM, at 20 and 38 t/ha); poultry manure (at 6.67 and 12.92 t/ha); FYM at 20 t/ha and NPK at 75 : 40 : 25 kg/ha; and fertilizers equivalent to the NPK content in 20 and 38.5 t/ha FYM, and 6.67 and 12.92 t/ha poultry manure, in an experiment conducted during 1993-97. Fruits from the different treatments were harvested and stored in paper plates under open conditions. After 5 and 7 days of storage, the highest number of unmarketable fruits were from plants treated with inorganic fertilizers, while the lowest were from plants treated with organic fertilizers.

Steffen *et al.* (1994) carried out an experiment, on short-term and long-term impact of an initial large scale spent mushroom soil (SMS) amendment on vegetable crop productivity and resource use efficiency at Pennsylvania University, USA. They observed the effect of organic matter (spent mushroom compost at 64 mt/ha + rotten cattle manure at 57 mt/ha) applied in spring 1990 on growth and yield of broccoli. No fertilizer or other amendments were added to previously amended treatments, but 100 percent recommended NPK was added to all control treatments in all years. Broccoli yield and curd diameter were greater in the amended treatment.

Maynard (1994) stated that using spent mushroom and chicken manure compost in broccoli cultivation; composts were incorporated into the soil in 1989-1991 at rates of 56 and 112 t/ha. Yields of broccoli increased with increasing rate of compost application. Yields were higher in plots amended with chicken manure compost (nitrate-N content 54 ppm) than with spent mushroom concentrations in ground water beneath all compost amended plots remained below 10 ppm during the study.

Farahzety and Aishah (2013) was conducted to assess the potential of these organic fertilizers in replacing the chemical fertilizer for cauliflower production under protected structure. Three composts and two vermicomposts used were oil palm empty fruit bunches compost (EFBC), chrysanthemum residue compost (CRC), soybean waste compost (SWC), green waste vermicompost (GWV) and vegetable waste vermicompost (VWV). A chemical fertilizer (N:P2O5:K2O; 12:12:17) was used as control. The amount of fertilizer applied was calculated based on 180 kg/ha of N. It was observed that VWV and EFBC were comparable to the chemical fertilizer based on their effects on the growth and yield performance of cauliflower. VWV and EFBC showed promising results and can be used to replace chemical fertilizers in fulfilling the nutrient requirements of cauliflower. The yield and curd size of VWV and EFBC treated cauliflower were similar to chemically fertilized plants. Furthermore, curds of VWV treated plants can be harvested 7 days earlier than chemically fertilized plants. The use of compost and vermicompost have positive effects on the growth and crop yield of cauliflower, and have great potential to improve vegetable production in Malaysia.

Maynard (1994) conducted an experiment on sustainable vegetable production for three years using composted animal manures. Intensive broccoli 6 production trials in spring, summer and autumn were conducted for 3 years in Connecticut Windsor (sandy trace soil) and Mt. Carmel (Loamy upland soil) following annual application of spent mushroom compost (SMC) or chicken manure compost (CMC) applied at either 56 or 112 t/ha as the sole source of nutrients. Yields of broccoli from these amended plots were compared with yields from control plots receiving NPK fertilizer. Yields of broccoli increased with the rate of compost. Compost analysis and broccoli on all CMC amended plots at both rates and sites in all three years, were equal to or greater than yields from the control plots.

The benefits of compost applications on various soil types were demonstrated in greenhouse studies. Compost prepared from yard waste feedstock co composted with biosolids at a 1:1 ratio was used to grow broccoli at 0, 15, 30, and 60 dry tons per acre. Surface soil from three dominant regional soil types (Arnold loamy sand, Goleta loam and Todos-Lodos clay loam) was used in plastic pots in the greenhouse studies. All rates of compost applications increased the height and dry weight of broccoli. In loam and clay loam soil, optimal rates of compost application were 30 to 60 t/ha for broccoli. In loamy sand soil, optimal rates for broccoli was 30 t/a. Broccoli showed less phytotoxicity symptoms to higher compost loads, probably because of more tolerance to greater salt concentrations (Shiralipour *et al.,* 1996).

Organic manures increase the yield of crop. Application of 10 t/acre of fresh cattle manure increased the yield of pimento, eggplant and Chinese cabbage but reduced the yield of cucumber and tomato compared with normal (rate unspecified) applications. Fresh chicken manure at the rate of 5-10 t/acre could be used for pimento, eggplant and Chinese cabbage without deleterious effect. In the field cultivation without irrigation, organic fertilization and liming increased total and marketable yield of cabbage cv. Salva at the optimum level of mineral fertilization (Omori *et al.,* 1972).

Response of cabbage yields, head quality and leaf nutrient status to poultry manure fertilization was investigated by Hochmuth et al. (1993) and was found that the marketable yield of cabbage responded quadratically to increasing rates of poultry manure during 1990, with the maximum yield (28.4 t/ha) being obtained with 18.8 t/ha).

Vogtmann *et al.* (1993) pointed out that as a general trend, compost positively affected food quality, improved storage performance and yielded a somewhat superior sensory quality of tomato in particular. Compost significantly reduced nitrates and improved the nitrate to vitamin C ratio of vegetables.

Abedin *et al.* (1994) tried to find out a sustainable practice, using data collected from 85 selected farmers in the Cameron, involved pest (insect, disease, weed) control, fertilization and soil erosion and inorganic fertilizers were of more sustainable practices and did not suffer yield sacrifices. A sftategy to help farmers for spread adoption and sustainable practices was the most effective approach for sustainability.

Silva (1986) planted cabbage in hydromorphic soil and treated with 100 kg N/ha, 100 P205/ ha or 50 t/ha cattle manure, atone or in combination. Nitrogen increased the total yield but decreased commercial to total yield ratio. K20 alone decreased total yields. Cattle manure increased commercial and total yields but decreased commercial to total yield ratio. The highest commercial yield (49 t/ha) was obtained with cattle manure or N + K20 but there was no response to P205.

Farooque and Islam (1989) showed in an experiment that application of cowdung, oil cake, urea, triple superphosphate and muriate of potash combinedly gave better growth and maximum yield of cabbage. Similarly in another experiment maximum yield of cabbage was obtained (76.6 t/ha) from the combined effect of 180 kg N/ha, 60 kg P/ha and cowdung @ 5 t/ha and it was also stated a combination of the fertilizer was important rather than application of that single fertilizer for the production of cabbage (Anonymous, 1990).

The effects of compost and inorganic fertilizer on the growth, yield and pest damage on cabbage intercropped with tomatoes were investigated by Busayong (1996). He observed no significant differences in yield, growth and pest damage of cabbage applied with compost only or inorganic fertilizers only or mixture of composts and inorganic fertilizers.

Dixit (1997) investigated the effects of N (0, 40, 80, 120 or 160 kg/ha) and farmyard manure (FYM) (0 or 20 t/ha) on the growth of cabbages (cv. Pride of India) in Himachal Pradesh, India, in 1994. The yield increased with increasing N rate (from 136.8 to 175.1 q/ha after addition of 0 and 160 kg N/ha, respectively) and increasing FYM rate (from 129.5 to 144 q/ha). Addition of FYM to N treatments further increased yield (yield of 1761 q/ha in presence of FYM + 160 kgN/ha).

At the Horticulture Farm, Bangladesh Agricultural University, Mymensing, Rahman (2000) carried out an experiment and found that plant height of True Potato Seeds (TPS) seedlings was significantly influenced by the application of cowdung. The highest plant height (75.28cm) at 100 days was obtained from the highest dose of cowdung (100 t/ha)

Wright (1960) studied that Horse and cow manure contains approximately 0.5% N, 0.55% K and 0.25% Phosphoric acid. It thus supplies three of main elements needed by fruit plants.

Edmond *et al.* (1977) reported that organic matter increased the pore space of the soil and thus improved the rate of gas exchange. Application of compost to the soil increased water-holding capacity, reduced soil erosion and improved the physio-chemical and biological condition of the soil besides providing the plant nutrients.

Mustard oil cake (MOC) is a good source of N and S. Among different oil cakes, mustard oil cake is the most common in Bangladesh which contains 4.7% N, 1.8% P and 1.3% K (Ahmed, 1980).

Organic manures like cowdung, compost, farmyard manure, green manure and oil cake supply more or less complete food for plants. (Ahmed, 1982).

Prezotti *et al.* (1988) suggested that organic manure applications increased total productivity by 48% and improved the proportion of large fruits in the total yield.

An experiment was conducted at the Horticulture Farm of Sher-e-Bangla Agricultural University by Faysal (2005) to study the effect of different sources of organic manures on the growth and yield of broccoli. The experiment consisted of five different sources of manures; control (no manure), cowdung (26.5 t/ha), water hyacinth compost (10.6 t/ha), poultry litter (16.56 t/ha) and vermicompost (12.26 t/ha), and two cultivars of broccoli; Sotomidori and „Premium crop". Different sources of manures and cultivars had significant influence on plant height, height up to curd, number of leaves per plant, length of leaf, breadth of leaf, plant canopy, diameter of curd, diameter of stem, weight of primary curd, dry weight of curd, number of secondary curd, weight of secondary curd, yield per plant, yield per unit plot and yield per hectare. The maximum yield (14.50 t/ha) was obtained from poultry litter followed by vermicompost in „Sotomidori" (14.12 t/ha) cultivar. The minimum yield (7.37 t/ha) was recorded by no manure in „Premium crop". Control treatment showed the lowest values for all the parameters studied. Combination of poultry litter and „Sotomidori" cultivar was found the best among all other treatment combinations in respect of net return (Tk. 224381/ha) and BCR (4.41).

Mahamud (2005) conducted an experiment to study the effect of different sources of nutrients on the growth and yield of Broccoli and Cauliflower. The experiment consists of five different sources of nutrient; fertilizer; C0 (control), C1 (cowdung 20 t/ha), C2 (inorganic fertilizer urea 250 kg/ha, TSP 150 kg/ha and MP 200 kg/ha) and C3 (cowdung 10 t/ha, urea 250 kg/ha, TSP 150 kg/ha MP 200 kg/ha, agro-growgranular 20 kg/ha) and C4 (vermicompost 205 kg/ha) and two different cultivars Broccoli cv. ‘Premium crop’ (Br) and cauliflower cv. ‘BARI 1’ (Ca) were used in the experiment. The C3 treatment gave the maximum gross yield (16.22 and 22.70 t/ha) and the minimum marketable yield (15.59 and 20.04 t/ha) in Br and Ca, respectively. While, the C0 treatment gave the minimum gross yield (6.82 and 7.89 t/ha) and marketable yield (5.82 and 6.85 t/ha) in Br and Ca, respectively. Among the five different sources of nutrient treatments, the C3 treatment performed the best.

Hsieh *et al.* (1996) conducted an experiment on conventional farming and partial organic farming and showed that growth and yield of Broccoli in the organic treatments were greater than in the control. Poultry manure compost treatment gave the highest yield, which was 26.28% higher than that of the control, followed by pig manure compost treatment, which was 18.38% higher.

Naher (2007) conducted an experiment to study the effect of different organic manure and seedling age on growth and yield of Chinese cabbage. The experiment considered of two factors e.g. three level of organic manure (cowdung, poultry manure and mustard oil cake) and three seedling age (25, 30 and 35 days of seedling). Considerable highest values were recorded in plant height (27.10 cm), plant spread (43.96 cm), number of folded leaves per plant (30.21), head weight (1.63 kg), gross yield (95.02 t/ha) and marketable yield (81.30 t/ha) from mustard oil cake followed by cowdung as organic manure and the lowest value was recorded from poultry manure. Seedling age showed significant differences in all recorded characters. Considerable highest values was recorded in plant height (26.80 cm), plant spread (43.48 cm), number of folded leaves per plant (29.90), head weight (1.60 kg), gross yield (93.73 t/ha) and marketable yield (80.15 t/ha) from 30 days of seedling and the lowest value was recorded from 25 and 35 days of seedling. Interaction effect between different organic manure and seedling age also showed significant differences and the considerable yield and yield contributing characters was recorded from the treatment combination of mustard oil cake and 30 days of seedlings, while the treatment combination of poultry manure and 25 days of seedling gave the lowest value. The highest gross return (Tk. 521,640), net return (Tk. 329,834) and benefit cost ratio (2.72) was obtained from the treatment combination of mustard oil cake and 30 days of seedling and the lowest (Tk. 390.000, 190,366 and 1.95, respectively) was obtained from the treatment combination of poultry manure and 25 days of seedling.

To evaluate the response of Chinese cabbage (*Brussicu pekinensis*) to different forms of organic fertilizer an experiment was conducted by Thy and Buntha (2005) over the period May through August 2004. The four treatments were: raw cattle manure solids, composted cattle manure solids (in piles of 0.5 or 1.0 m3 volume) and the effluent from a mixing indigested (20 day retention time) charged with the liquid and small particles from raw cattle manure. The fertilizers were applied at the same level of nitrogen (150 kg N/ha) at 7 days interval with increasing quantities equivalent to 10, 20, 30, and 40% of the total amount over the first 28 days. A basal fertilization of 2 kg per m of fresh cattle manure was applied to all plots one week before starting the trials. In Trial 2, when seeding was directly in the field and the plots were protected with plastic sheet against the rain, biomass yield of the cabbage showed a 100% increase for use of indigested effluent (34 t/ha) compared with composted manure (14 to 17 t/ha), with lowest results for fresh manure solids (9 t/ha).

To study the effects of the combined application of organic manure and chemical fertilizer on the yield and quality of Chinese cabbage an experiment was conducted by Ye *el al.* (2004) in China and found that the combined application of organic manure and fertilizer improved the yield and quality of Chinese cabbage. Greater yield and quality were obtained when organic manure was applied at 3750 kg/667 m2 and when the chemical fertilizer was applied at 30 kg/667 m2.

Zhang *et al.* (2004) conducted an experiment to found the effects of organic-inorganic compound fertilizers and inorganic nitrogen fertilizers on the quality and yields of Chinese cabbage cv. Luxing. The results show that application of organic-inorganic compound fertilizer produced the highest yield among all treatments; the yield was higher by 14.4, 6.3, 10.6, 4.6 and 33.6% compared with the treatments of ammonium nitrate, ammonium sulfate, urea, organic-inorganic compound fertilizer and the control, respectively.

Edmond *et al.* (1977) reported that organic matter increased the pore space of the soil and thus improved the rate of gas exchange. Application of compost to the soil increased water-holding capacity, reduced soil erosion and improved the physio-chemical and biological condition of the soil besides providing with plant nutrients.

Palevich (1965) observed that nitrogenous fertilizer and organic manure improved total yield, weight per fruit, size of fruit and height of plants. He also reported that cowdung manure application in addition to N and P fertilizers significantly increased yield by 14-41 % in comparison with plots that received the same amount of N and P but without manure.

Kale (1998) found that the nutrient level, especially the (macro or micro-nutrients) were found to be always higher than the compost derived from other methods. One of the unique features of vermicompost is that during the process of conversion of various organic wastes by earthworms, many of the nutrients are changed to their available forms in order to make them easily utilizable by plants.

Buchanan *et al.* (1988) conduct to determine vermicomposts have higher level of available nutrients like nitrate or ammonium nitrogen, exchangeable phosphorous and soluble potassium, calcium and magnesium derived from the wastes. That attempted to evaluate comparative efficacies of vermicompost developed by indigenous method on tomato plants.

Tomati *et al.* (1988) observed that Root initiation, increased root biomass, enhanced plant growth and development and sometimes, altera-tions in plant morphology are among the most frequently claimed effects of vermicompost treatment.

Wirwille and Mitchil, (1950) observed that stem elongation, dwarfing and early flowering have been found to be because of the hormone effect in a wide variety of plants and in a number of physiological situations, stem elongation is promoted (or inhibited) by endogenous phytohormones, a class of growth regulating substances which inhibited stem elongation without affecting leaf or flower development (dwarfing agents). Plant and crop physiologists, microbiologists and agronomists agree that plant growth and development are strictly dependent on biological fertility factors. Earthworms stimulate microbial activities and metabolism and also influence microbial populations.

Ghosh *et al.* (1999) observed that the effect of different fertilizers showed significant increase of the fresh weight of leaves, dry weight of leaves, dry weight of fruits, number of branches, number of fruits and yields in terms of fruit production in all the treatments in comparison to controlled one. The yield of vermicompost treated plants was found to be 28,665 Kg/hectare, which was 47% more than the plants in control plots and was very nearer to inorganic fertilizer treated plants (Kg/hectare). This result was statistically significant at 1% level. It was also observed that the plants treated with vermicompost supplemented with chemical fertilizers displayed better results than the plants treated separately with vermicompost, chemical fertilizers, F.Y.M and F.Y.M. supplemented with chemical fertilizers treated plants. In this field trial experiment, it was observed that the plants treated with vermicompost supplemented with chemical fertilizers displayed better results than the plants treated separately with vermicompost, chemical fertilizer, F.Y.M and F.Y.M supplemented with chemical fertilizers treated plant.

The use of compost and vermicompost has also been observed to improve plant growth and quality. Numerous studies on vermicompost and compost from various sources have been found to promote root formation (Arancon *et al*., 2005), increase fruit setting and yield (Atiyeh *et al.,* 2002; Arancon *et al.,* 2004) and also increase plant dry mass (Subler *et al.,* 1998). It has also been reported that the increase in yield, chlorophyll production and fruit quality of tomatoes was due to improvement of uptake of N, P and K from vermicompost (Tejada *et al.* 2007). In addition, vermicompost and manure were reported to affect the chemical composition and quality of the marketable produce (Lazcano *et al.,* 2011).

2.2. EFFECT OF APPLICATION TIME

Response of cauliflower to organic amendment application time of soil was evaluated during august 97 to December,1997 at the experimental farm of bangabandhu sheikh mujibur Rahman agricultural university, salna, gazipur.the treatments were five different organic amendments of soil including control treatment and three varieties of cauliflower . there was a positive impact of organic amendments of soil on growth and yield of the crops. On an average T_3 treatment (cowdung +oil cake+ NPK) applying at the pit at 15DAP) increased yield by 18.39% over inorganic control (T_5) which was identical to T_4 (cowdung + oil cake + NPK appliying in pits at the time of planting) treatment. From the economic point of view it was found that maximum net benefit (340846 tk/ha) was obtained with T_3 but average rate of return was the maximum (930%) with T_1 (cowdung + NPK applying in pit 15DBP) (Ahmed 1999).

Groundwater has become increasingly degraded by NO_3, and this degradation has been partially attributed to the use of commercial inorganic N fertilizers. Conversion from conventional fertilizer management to organic farming has been proposed as a means to reduce groundwater degradation. Matching soil inorganic N supply with crop N requirement on a temporal basis is important to achieve high yield and low water degradation. Dynamics of N mineralization from two manures and N-uptake dynamics for two crops were derived from published data, and multi year simulations were done using the ENVIRON-GRO computer model, which accounts for N and irrigation management effects on crop yield and N leaching. The temporal N-mineralization and N-uptake curves did not match well. The potential N uptake for corn (*Zea mays* L.) exceeded the cumulative mineralized N during a significant period that would cause reduced yield. Wheat (*Triticum aestivum* L.) has a low and flat N-uptake peak, so that the cumulative mineralized N met N demand by wheat during the growing season. A crop with a very high maximum N-uptake rate, such as corn, would be difficult to fertilize with only organic N to meet peak demands without excessive N in the soil before and after crop growth. In order to satisfy crop N demand, a large amount of manure, which would leave much N or subsequent leaching, must be applied. It took two or more years after conversion to organic sources of N to reach maximum yield because of carryover of unmineralized manure and accumulation of mineralized N after crop uptake which was not completely leached during the winter. High initial applications to build up the organic pool followed by reduced inputs in subsequent years would be appropriate. (Pang and letey. 2000)

Harold *et, al.* (2006) observed that timing of manure application affects N leaching. This 3-yr study quantified N losses from liquid manure application on two soils, a Muskellunge clay loam and a Stafford loamy sand, as affected by cropping system and timing of application. Dairy manure was applied at an annual rate of 93 800 L ha^{-1} on replicated drained plots under continuous maize (*Zea mays* L.) in early fall, late fall, early spring, and as a split application in early and late spring. Variable rates of supplemental sidedress N fertilizer were applied as needed. Manure was applied on orchardgrass (*Dactylis glomerata* L.) in split applications in early fall and late spring, and early and late spring, with supplemental N fertilizer topdressed as NH_4NO_3 in early spring at 75 kg N ha^{-1} Drain water was sampled at least weekly when lines were flowing. Three-year FWM (flow-weighted mean) NO_3–N concentrations on loamy sand soil averaged 2.5 times higher (12.7 mg L^{-1}) than those on clay loam plots (5.2 mg L^{-1}), and those for fall applications on maize-cropped land averaged >10 mg L^{-1} on the clay loam and >20 mg L^{-1} on the loamy sand. Nitrate–N concentrations among application seasons followed the pattern early fall > late fall > early spring = early + late spring. For grass, average NO_3–N concentrations from manure application remained well below 10 mg L^{-1} Fall manure applications on maize show high NO_3–N leaching risks, especially on sandy soils, and manure applications on grass pose minimal leaching concern.

Organic manures are an important source of P which can make a significant economic contribution to farm fertilizer policies. In the region of 119000 tonnes of P are returned annually to UK agricultural land in the form of manures collected and handled on farms, with an estimated 66000 tonnes of P applied to tillage land and 53000 tonnes to grassland. Previous research on the utilization of manure P has tended to indicate a lower efficiency compared to inorganic fertilizer P in the season following application, but in the longer term manure and fertilizer P can be regarded as equivalent. Failure to adequately account for manure P additions to the land may result in soil enrichment which could increase the agricultural contribution to eutrophication, as a result of surface runoff or leaching (Al-Nasir. 2002)

To achieve high nitrogen (N)-use efficiency, N availability from organic fertilisers must be synchronised with crop uptake. In order to estimate when previously unmineralised N is plant-available in relation to fertilisation time-point, net N mineralisation was studied in incubations under natural temperature conditions. The fertilisers studied were meat and bone meal (Biofer), dairy slurry, dairy manure, chicken manure, and a by-product from yeast production (Vinasse). The fertilisers were mixed with soil and incubated in plastic bottles placed in topsoil in south-west Sweden on different dates throughout the year, simulating fertiliser application in autumn, early spring, spring, and early summer. Bottles were sampled for analysis of NH_4-N and NO_3-N on three to seven occasions until late autumn and the experiment was repeated in two consecutive years. Dairy slurry and dairy manure had a very slow, almost negligible, net N mineralisation after application. Slurry with rather high ammonium content should therefore be applied as close to crop demand as other circumstances allow, whereas dairy farmyard manure with very low mineral N content can be applied off-season. Chicken manure had a considerable proportion of mineral N initially, but released further mineral N after application. Vinasse and Biofer had almost no mineral N initially, but much of the N present mineralised rapidly. About 65% of total N in Biofer, Vinasse, and chicken manure was in mineral form within 30–50 days or 450 growing degree-days (GDD), after which net mineralisation ceased. This indicates that these three types of fertiliser should be applied at least one month before the end of crop N uptake and that autumn application is associated with a risk of N leaching unless a crop with high N uptake is present during winter (Delin and Lena 2008).

Everaats (1993) reported that Natural N abundances in plant and soil can be used as a powerful marker to reveal the history of N fertilization. To investigate whether N fertilizer source and timing of fertilization leave specific N signals in plant tissue and soil inorganic N, Chinese cabbage (*Brassica campestris* L. cv. Maeryok), one of the most popular vegetables in Asia, was grown in pots for 60 days with a single or split N applications of organic (composted manure) or inorganic N (urea). Seven N treatments were studied: (1) a single basal fertilization with compost or (2) urea; (3) a basal urea application followed by an additional (at 40 days after transplant, same below) compost or (4) urea application; (5) a basal compost application followed by an additional compost or (6) urea application; and (7) no N fertilization. Regardless of the time of N application, δ^{15}N of cabbage treated with compost was higher (>+9.0‰) than that (< +1.0‰) treated with urea, reflecting the effect of isotopically different N sources. In split N fertilization, only the addition of isotopically different N sources in the middle of the growth period significantly affected the δ^{15}N of the whole plant. Specific N signals of basal N inputs were detected in outer cabbage parts formed in the early growth stage, while those of additional N inputs were detected in inner cabbage parts formed in the latter growth stage. We conclude that measurements of temporal variations in N of plant parts formed in different growth stages could reveal the history of N fertilization.

Beckwith *et al.*(2006) reported that experiments were set up at two sites to measure nitrogen (N) leaching loss from applications of separated pig/cattle slurry and cattle farmyard manure(FYM), during winters 1990/91–1993/94 (site A) and from broiler litter and FYM, during winters 1990/91–1992/93 (site B). The manures were applied at a target rate of 200 kg ha^{-1} total N during the autumn and winter to overwinter fallow or top dressed onto winter rye. The total N in leachate was calculated from leachate N concentrations, in samples collected using ceramic cups buried at 90 cm, and an estimate of drainage volume. Nitrogen losses were greatest following manure applications in September, October and November but losses following applications in December or January were not significantly elevated above those from untreated controls. Losses were consistently lower from FYM than from broiler litter or separated slurry. The presence of a cover crop (winter rye) significantly reduced overall N leaching compared with the fallow, but only reduced the manure N leaching losses at one site during one winter when a high proportion of drainage occurred late.

The incorporation of a nitrification inhibitor (DCD) with manures applied in October did not significantly reduce the manure N leaching.

Appropriate poultry manure management is essential to ensure maximum crop N utilization and reduce risk of negative environmental impact. This study was conducted to evaluate the effect of three application times (late fall, winter, and spring preplant) on N availability from two sources of poultry manure [chicken (*Gallus domesticus*) and turkey (*Melleagris gallopavo*)] for corn (*Zea mays* L.) production. Manure was applied based on total N, intending to supply 84 and 168 kg total N ha^{-1} Urea fertilizer was applied at the same time as the manure at six rates (0, 34, 67, 100, 134, 168 kg N ha^{-1}). Soil classification used for the study was primarily Clarion (fine-loamy, mixed, superactive, mesic Typic Hapludolls) and Nicollet (fine-loamy, mixed, superactive, mesic Aquic Hapludolls). Effect of application timing was determined by response in grain yield, grain N uptake (GNU), leaf chlorophyll meter (CM) reading, and soil $NO3^{-}$–N measured in early June. Soil $NO3^{-}$–N concentrations were greater for manure and fertilizer N applied in spring compared with fall and winter application, but the same for both poultry manure sources. Grain yield, GNU, and CM reading response to manure N were not different among either poultry manure sources or application timings. Furthermore, estimated manure plant N availability was not different among poultry manure sources or time of application. Overall first year crop-available N from poultry manure, based on fertilizer N equivalence, using grain yield, GNU, and CM readings was estimated at 43 to 53% of total N. The supply of available N to corn was not affected by poultry manure application timing despite different lengths of time to crop uptake or delayed incorporation with winter application. (Dorivar *et al.,* 2008)

CHAPTER-III

MATERIALS AND METHODS

This chapter describes the materials and methods which were used in the field to conduct the experiment during the period from 01 October 2017 to 25 February 2018. The materials and methods that were used for conducting the experiment have been presented in this chapter. It comprises a short description of experimental site, soil and climate, variety, growing of the crops, experimental design and treatments and collection of data presented under the following headings:

3.1 Experimental site

The study was conducted at the Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh. Geographically the experimental area is located at 23041 N latitude and 90022 E longitudes at the elevation of 8.6 m above the sea level. The map showing the experimental site under study in Appendix I.

3.2 Characteristics of soil

Soil of the experimental field was silty loam in texture. The soil of the experimental area belongs to the Modhupur Tract (UNDP, 1988) under the AEZ No. 28. Soil sample of the experimental plot was collected from a depth of 0-30 cm before conducting the experiment and analyzed in the Soil Resources Development Institute (SRDI), Soil Testing Laboratory, Khamarbari, Dhaka and have been presented in Appendix I.

3.3 Climate and weather

The climate of the experimental site was under the subtropical climate, characterized by three distinct seasons, winter season from November to February and the pre-monsoon or hot season from March to April and the monsoon period from May to October (Edris *et al.,* 1979). Details of the meteorological data during the period of the experiment was collected from the Bangladesh Meteorological Department, Agargoan, Dhaka and presented in Appendix I.

3.4 Plating material

The hybrid variety of “Amaizing” cauliflower was used in the experiment. The seeds of the hybrid variety was produced by India and was collected from Masud Seed Company, 174, Siddique Bazar, Dhaka-1000.

3.5 Seedbed preparation

Seedbed was prepared on September 2017 for raising seedlings of cauliflower and the size of the seedbed was 3m×1m. For making seedbed, the soil was well ploughed to loose friable and dried masses to obtained good tilth. Weeds, stubbles and dead roots were removed from the seedbed. Cow dung was applied to prepared seedbed. The soil was treated by Sevin 50WP @ 5kg/ha to protect the young plants from the attack of mole crickets, ants and cutworm.

3.6 Seed treatment

Seeds were treated by Provax 200WP @ 3g/1kg seeds to protect some seed borne diseases.

3.7 Seed sowing

Seeds were sown on 1 October 2017 in the seedbed. Sowing was done thinly in lines spaced at 5cm distance. Seeds were sown at a depth of 2cm and covered with a fine layer of soil followed by light watering by water can. Thereafter the beds were covered with dry straw to maintain required temperature and moisture. The cover of dry straw was removed immediately after emergence of seed sprout. When the seeds were germinated, shade by white polythene was provided to protect the young seedlings from scorching sunshine and rain.

3.8 Raising of seedlings

Light watering and weeding were done several times. No chemical fertilizers were applied for rising of seedlings. Seedlings were not attacked by any kind of insect or disease. Healthy and 25 days old seedlings were transplanted into the experimental field on 26 October 2017.

3.9 Treatment of the experiment

The experiment consisted of two factors viz., Organic manures and application time

Factor A: Four levels of organic manure

i) M_0 = Control (No organic manure)
ii) M_1 = Cowdung (36 t/ha or, 10 kg/plot)
iii) M_2 = Mustard oil cake(3.6 t/ha or, 1 kg /plot)
iv) M_3 = Vermicompost (9 t/ha or, 2.5 kg/plot)

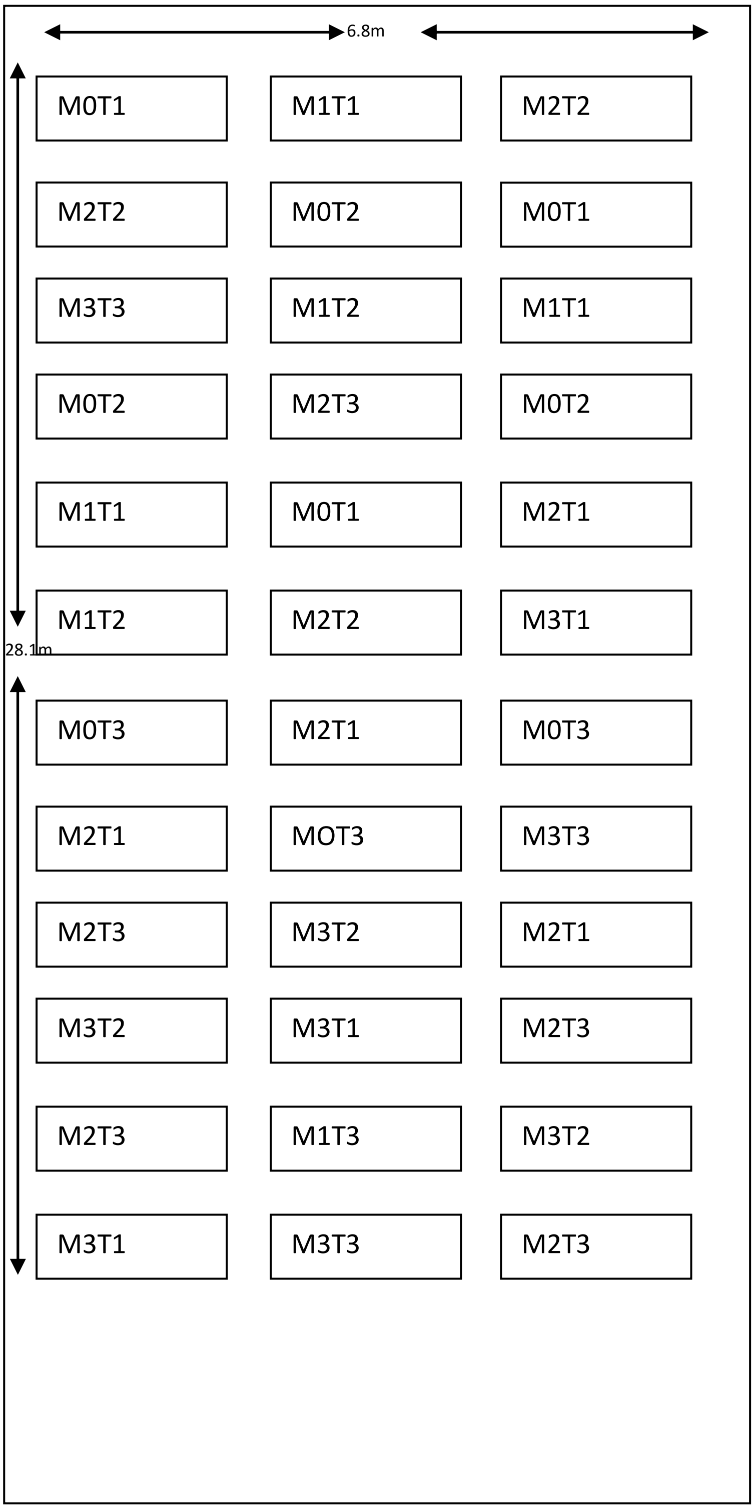
Factor B: Time of application

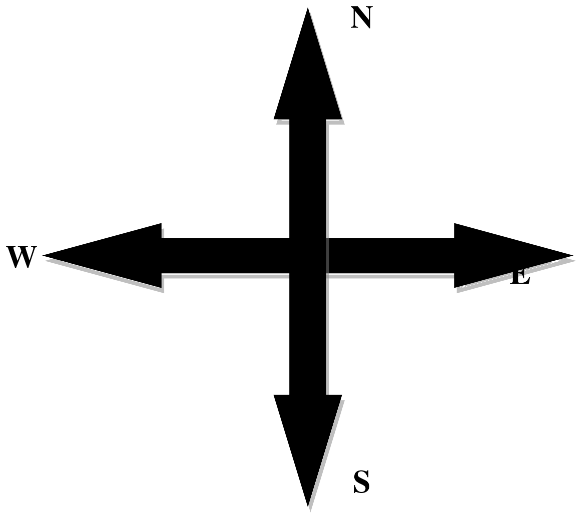
i) T_1 = Applied 15 days before transplanting
ii) T_2 = Applied at the time of transplanting
iii) T_3 = Applied 15 days after transplanting

There were 12 (4 × 3) treatments combination such as, M_0T_1, M_0T_2, M_0T_3, M_1T_1 , M_1T_2, M_1T_3, M_2T_1, M_2T_2, M_2T_3, M_3T_1, M_3T_2, M_3T_3 .

3.10 Design and layout of the experiment

The two factorial experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The total area of the experimental plot was 365.40 m^2 with length 34.8 m and width 10.5 m. The total area was divided into three equal blocks. Each block was divided into 12 plots where 12 treatments combination were distributed randomly. There were 36 unit plots altogether in the experiment. The size of the each plot was 1.8m × 1.6m. The distance maintained between two blocks and two plots were 1 m and 0.5 m, respectively. The plots were raised up to 10 cm. In the plot with maintaining distance between row to row and plant to plant were 60 cm and 40 cm, respectively. The layout of the experiment is presented in Figure 1.





Plot Size: 1.8m×1.6m

Spacing: 60cm×40cm

Plot Spacing: 0.5m

Between Replication: 1m

M0=Control

M1=Cowdung

M2=Mustard Oil Cake

M3=Vermicompost

T1=Applied 15 days before transplanting

T2= Applied at the time of transplanting

T3= Applied 15 days after transplanting

Fig. 1. Field layout of the two factors experiment in the Randomized Complete Block Design

3.11 Land preparation

The plot selected for conducting the experiment was opened in the 1st week of October 2017 with a power tiller and left exposed to the sun for a week. After one week the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain good tilth. Weeds and stubbles were removed and finally obtained a desirable tilth of soil was obtained for transplanting of seedling. In order to avoid water logging due to rainfall during the study period, drainage channels were made around the land. The soil was treated with Furadan 5G @ 15 kg ha-1 when the plot was finally ploughed to protect the young seedlings from the attack of cut worm. Experimental land was devided into unit plots following the experimental design.

3.11.1 Application of organic manure

Only organic manure was used as the source of nitrogen, phosphorus and potassium. Three different level of organic manure were used as treatments. Organic manure was applied as per treatment. Different organic manure with available amount of nutrient were given below:

Table. 1. Organic manure with available amount of nutrient

Name of organic manures	Available amount of nutrient (%)		
	N	P_2O_5	K_2O
Cowdung	1.0-1.1	0.3-0.33	0.46-0.51
Mustard oil cake	4.93	0.53	0.65
Vermicompost	1.5-2.5	1.25-2.25	1.2

Source: Department of soil science, Bangladesh Agriculture University

3.11.2 Transplanting

The seedbed was watered before uprooting the seedlings to minimize the damage of roots. Twenty five days old healthy seedlings were transplanted at the spacing of 60 cm × 40 cm in the experimental plots on 26 October 2017. Thus the 12 plants were accommodated in each unit plot. Planting was done in the afternoon. Light irrigation was given immediately after transplanting around each seedling for their better establishment. The transplanting seedlings were shaded for five days with the help of banana leaf sheath to protect them from scorching sunlight, watering was done up to five days until they became capable of establishing on their own root system.

3.12 Intercultural operations

3.12.1 Thinning

Establishing of seedling completed within 10 days after transplanting. Excess seedlings were removed 15 days after transplanting.

3.12.2 Gap filling

Very few seedlings were damaged after transplanting and new seedlings from the same stock were replaced these.

3.12.3 Weeding

The plants were kept under careful observation. Weeding was done at four to five times according to necessity. First weeding was done two weeks after transplanting and later weeding was done after 12-15 days interval as per necessity.

3.12.4 Irrigation

Light irrigation was given immediately after transplanting around each seedling for their better establishment. Watering was done up to five days until they become capable of establishing on their own root system. Irrigation was given by observing the soil moisture condition. Four times irrigation were done during crop period.

3.12.5 Earthing-up

Earthing-up was done only on each plot by taking the soil from the space between the rows at 15days after transplanting.

3.12.6 Insects and diseases management

Cauliflower is sensitive to various insect pest and diseases. So various precautionary measures were taken. Dithane M-45 @ 2 g /liter water was applied against fusarium rot. The crop was attacked by cutworms, mole cricket and field cricket during the early stage of growth of seedlings in the month of February. This insect was controlled initially by beating and hooking afterwards by spraying Dieldrin 20 EC @ 0.1%. The insecticide application was made fortnightly from 10 days after transplanting to a week before first harvesting. Furadan 10 G was applied as precaution against soil insecticide.

3.12.7 General observation

The field was frequently observed to notice any changes in plants, pest and disease attack and necessary action was taken for normal plant growth.

3.12.8 Harvesting

Curds were harvested at different dates according to maturity indices. Harvesting was started on 18 January 2018 and was completed on 25 February 2018. The curds were harvested with 10 cm of stem attached with the sprouts. Randomly selected 10 plants were harvested from each unit plot for recording growth and quality parameter and together with rest of entire plot per plot for estimating yield. Harvesting was done very carefully. Different yield contributing data have been recorded from the mean of 10 randomly harvested plants of every harvesting stage.

3.13 Collection of data

The data pertaining to following characters were recorded from ten plants randomly selected from each plot except yield of curds which was recorded plot wise.

3.13.1 Plant height (cm)

Plant height was measured from base to the tip of the longest leaf at 30, 45 and 60 days after transplanting (DAT). A meter scale was used to measure plant height of the plant and their mean value was calculated for each unit plot and expressed in centimetre (cm).

3.13.2 Number of leaves per plant

Total number of leaves produced by each selected plant was counted at 30, 45 and 60 DAT. Data were recorded as the average of 10 plant selected at random of each plot and their mean was recorded.

3.13.3 Largest leaf length (cm)

The length of the largest leaf was measured from the base of the petiole to the tip at 30, 45 and 60 DAT. A meter scale was used to measure the length of the leaves and their mean value was recorded and expressed in centimetre (cm).

3.13.4 Largest leaf breadth (cm)

The breadth of largest leaf was measured at 30, 45 and 60 DAT taking the widest part of the lamina. A meter scale was used to measure the breadth of the leaves and the average largest leaf breadth of selected 10 plants of a single plot was recorded and expressed in centimetre (cm).

3.13.5 Root length (cm)

After harvest root length was recorded from the root-shoot junction to the tip of the main root and was expressed in centimetre with the help of a meter scale and then recorded in per plants.

3.13.6 Days required for 1st curd initiation

Total number of days from the date of transplanting to the date of visible curd initiation was recorded and their mean value was calculated out.

3.13.7 Curd length(cm)

Curd length was measured from one side of the curd to another side after harvest. A meter scale was used to measure the crown length and their mean was calculated from randomly selected 10 plants and expressed in centimetre (cm).

3.13.8 Curd Diameter (cm)

Curd diameter was taken by using a meter scale at the final harvest. Diameter of the curd was measured at different directions and finally the average of all directions was recorded and expressed in centimetre (cm).

3.13.9 Weight of curd (g)

Weight of the curds was recorded individually after harvest and average weight of 10 curds was recorded and expressed in gram (g).

3.13.10 Curd stem diameter (cm)

Curd stem diameter was recorded after harvest with a scale as the horizontal distance from one side of the upper most level of the stem to another side after sectioning the stem longitudinally at the middle portion and expressed in centimetre (cm).

3.13.11 Dry matter content (%) of curd

At first 100g fresh curd from selected plants was collected, cut into pieces and dried under sunshine for a few days and then dried in oven at 70^0 C for 72 hours. The sample was then transferred into desiccators and allowed to cool down at room temperature. The final weight of the sample was taken. The dry matter contents of the curd was computed by the simple calculation from the weight recorded by the following formula:

$$\text{Dry matter content (\%)} = \frac{\text{Dry weight}}{\text{Fresh weight}} \times 100$$

3.13.12. Dry matter content (%) of leaf

At first 100g fresh leaf from selected plants was collected, cut into pieces and dried under sunshine for a few days and then dried in oven at 70^0 C for 72 hours. The sample was then transferred into desiccators and allowed to cool down at room temperature. The final weight of the sample was taken. The dry matter contents of the leaf was computed by the simple calculation from the weight recorded by the following formula:

$$\text{Dry matter content (\%)} = \frac{\text{Dry weight}}{\text{Fresh weight}} \times 100$$

3.13.13 Yield per plant

The yield per plant was calculated by averaging the weights of ten randomly harvested curds and expressed in kilogram (kg).

3.13.14 Yield per plot

The yield per unit plot was calculated by adding the yields of all plants of each unit plot and expressed in kilogram (kg).

3.13.15 Yield per hectare

The yield of curd per hectare was calculated by conversion of the curd weight per plot and recorded in ton.

3.16 Statistical analysis

The data collected on various parameters were statistically analysed 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.

3.17 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. Analyses were done according to the procedure of Alam et al. (1989). The benefit cost ratio (BCR) was calculated as follows:

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

CHAPTER IV

RESULTS AND DISCUSSION

The results of the study regarding the effect of organic manure and its application time on growth characters, yield and yield related traits of cauliflower have been presented and possible interpretations have been made in this chapter which is given below:

4.1 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) (Table 2, Appendix II). 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. 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. This result is supported by Prestele and Maync (2000) 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 (Figure 3, Appendix II). 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. 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 (2000), on growth of cauliflower.

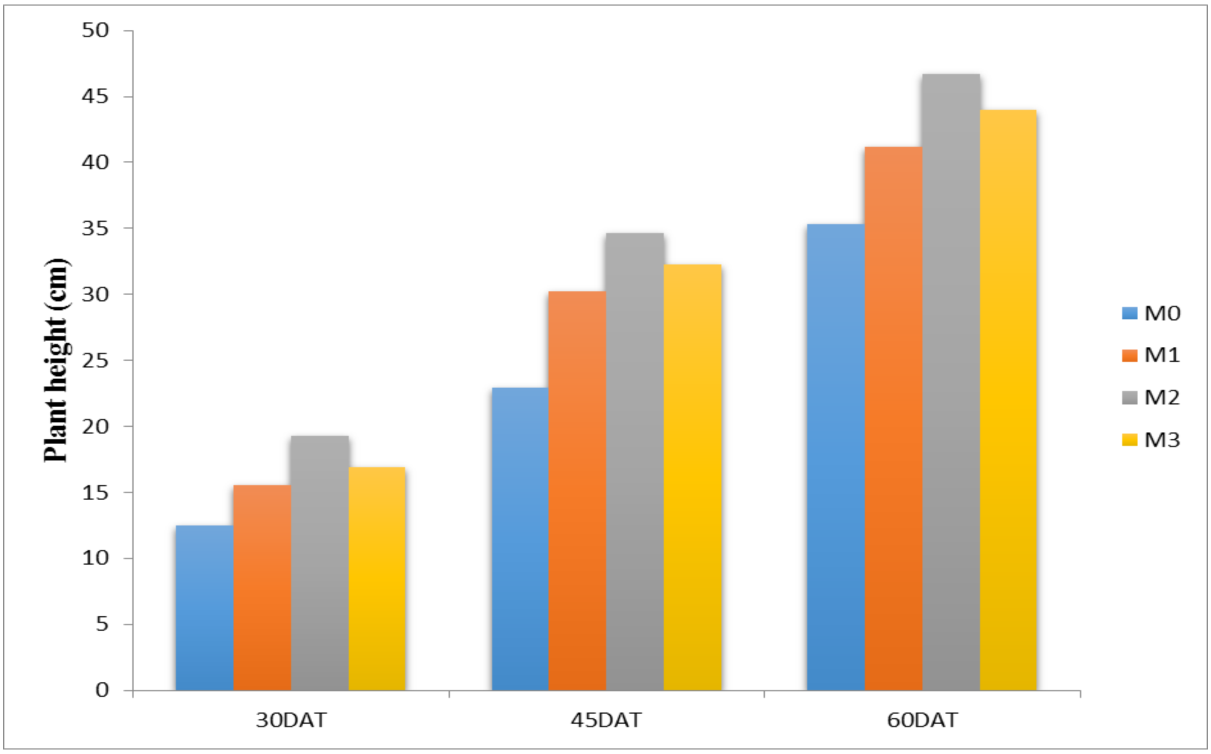
Table 2. Effect of organic manure and its time of application on plant height at different days after transplanting of cauliflower

Treatments	Plant height (cm)at		
	30DAT	45DAT	60DAT
Effect of organic manure			
M_0	12.50 d	22.90 d	35.29 d
M_1	15.55 c	30.22 c	41.17 c
M_2	19.26 a	34.66 a	46.66 a
M_3	16.93 b	32.28 b	43.95 b
LSD (0.05)	1.21	0.75	1.07
Effect of application time			
T_1	16.22	30.31 a	43.06 a
T_2	16.07	29.63 b	41.06 b
T_3	15.89	30.10 b	41.18 b
LSD(0.05)	NS	0.64	0.93
Combination of organic manure and application time			
M_0T_1	12.10 e	22.53 f	35.40 f
M_0T_2	12.66 e	22.33 f	34.67 f
M_0 T_3	12.73 e	23.86 e	35.80 f
M_1T_1	15.93 cd	30.73 cd	43.46 d
M_1T_2	15.87 cd	29.60 d	40.20 e
M_1T_3	14.86 d	30.33 d	39.87 e
M_2T_1	19.80 a	35.20 a	48.47 a
M_2T_2	18.95 ab	34.67 a	46.13 b
M_2T_3	19.03 ab	34.13 a	45.40 bc
M_3T_1	17.07 bc	32.80 b	44.93 bcd
M_3T_2	16.80 cd	31.93 bc	43.26 d
M_3T_3	16.93 bcd	32.11 b	43.67 cd
CV %	5.41	7.67	7.25
LSD (0.05)	2.10	1.29	1.86

In a colum means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 levels of probability

Note: M_0 = Control, M_1 = Cowdung, M_2 = Mustard oil cake, M_3 = Vermicompost
T_1 = applied 15 days before planting T_2 = applied at the time of planting
T_3 = applied 15 days after planting

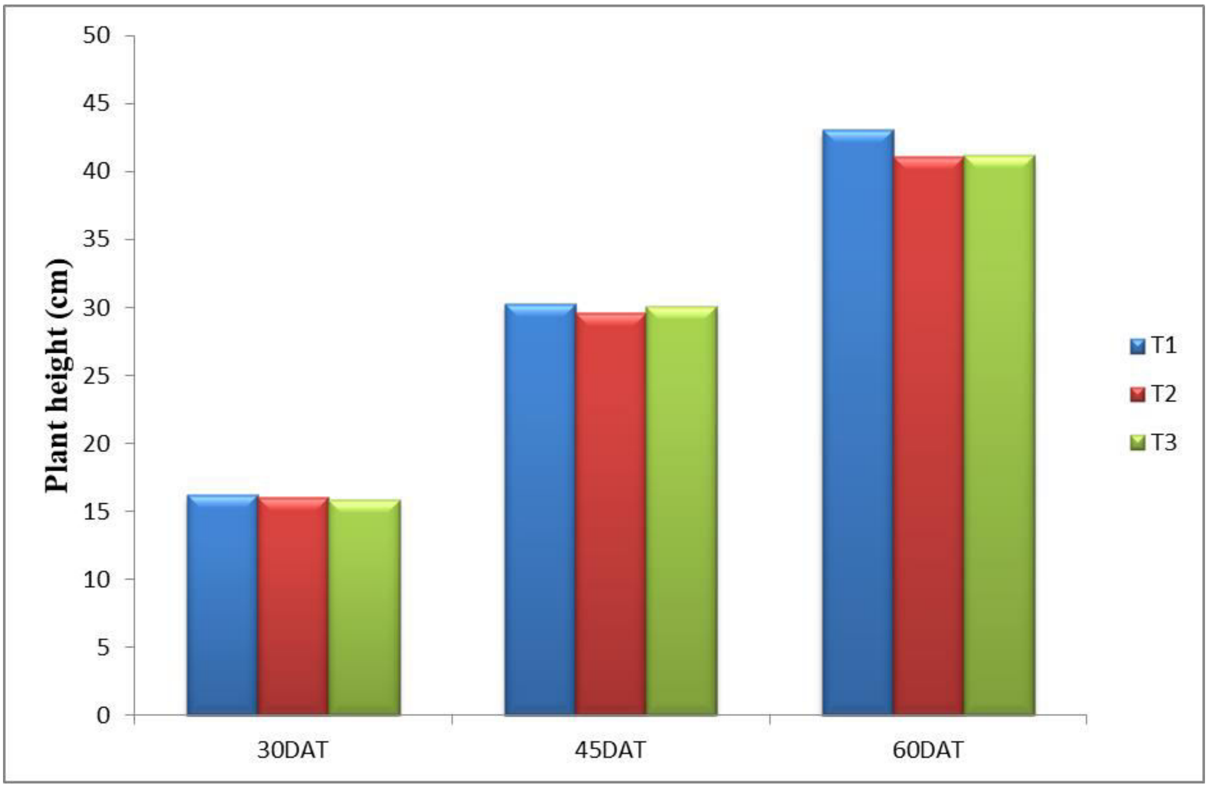
Significant variation was found at plant height due to the combined effect of organic manure and application time at 30, 45 and 60 DAT (Table 2, Appendix II). The highest plant height (48.47cm) was measured from M_2T_1 (Mustard oil cake applied 15 days before planting) treatment and the shortest (34.67cm) 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.



Days After Transplanting (DAT)

Fig. 2. Effect of organic manures on plant height of cauliflower

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



Days After Transplanting (DAT)

Fig. 3. 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
T_3 = applied 15 days after planting

4.2 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 3, Appendix III). 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 (2007) 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 (Figure 5, Appendix III). 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. The number of leaves per plant increased with different organic manure application.

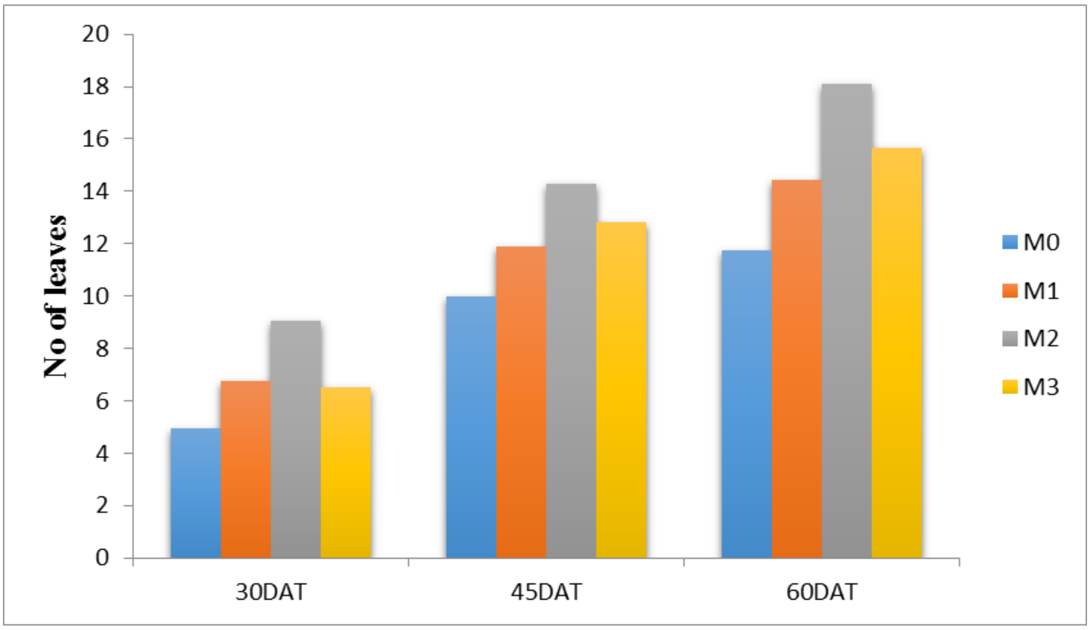
The number of leaves showed significant difference influenced by the combined effect of organic manure and its application at 30, 45 and 60 DAT (Table 3, Appendix III). At 60 DAT, the maximum numbers of leaves (20.73) were observed in M_2T_1 (Mustard oil cake applied 15 days before planting) treatment 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, 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.* (1989). also found the maximum plant leaf number by using different organic manure from their experiment.

Table 3. Effect of organic manures and time of application on leaf number of cauliflower

Treatments	Number of leaf at		
	30DAT	45DAT	60DAT
Effect of organic manure			
M_0	4.93 d	9.97 d	11.74 d
M_1	6.77 b	11.89 c	14.44 c
M_2	9.04 a	14.31 a	18.11 a
M_3	6.50 c	12.83 b	15.64 b
LSD (%)	0.22	0.81	0.57
Effect of application time			
T_1	6.71	12.79 a	15.89 a
T_2	6.87	12.26 b	14.98 b
T_3	6.84	11.70 b	14.08 c
LSD (%)	NS	0.69	0.49
Combination of organic manure and application time			
M_0T_1	4.33 g	10.60 f	12.07 h
M_0T_2	4.80 f	10.80 f	12.03 h
M_0T_3	5.67 e	8.53 g	11.13 h
M_1T_1	6.33 d	11.75 def	14.73 f
M_1T_2	6.93 c	11.07 ef	15.00 ef
M_1T_3	7.06 c	12.87 bcd	13.60 g
M_2T_1	9.73 a	15.53 a	20.73 a
M_2T_2	8.87 b	14.20 ab	17.07 b
M_2T_3	8.53 b	13.20 bc	16.53 bc
M_3T_1	6.47 d	13.30 bc	16.03 cd
M_3T_2	6.91 c	12.99 bcd	15.83 cde
M_3T_3	6.13 d	12.20 cde	15.07 def
CV %	8.98	8.16	9.97
LSD (0.05)	0.38	1.39	0.97

In a colum means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 levels of probability

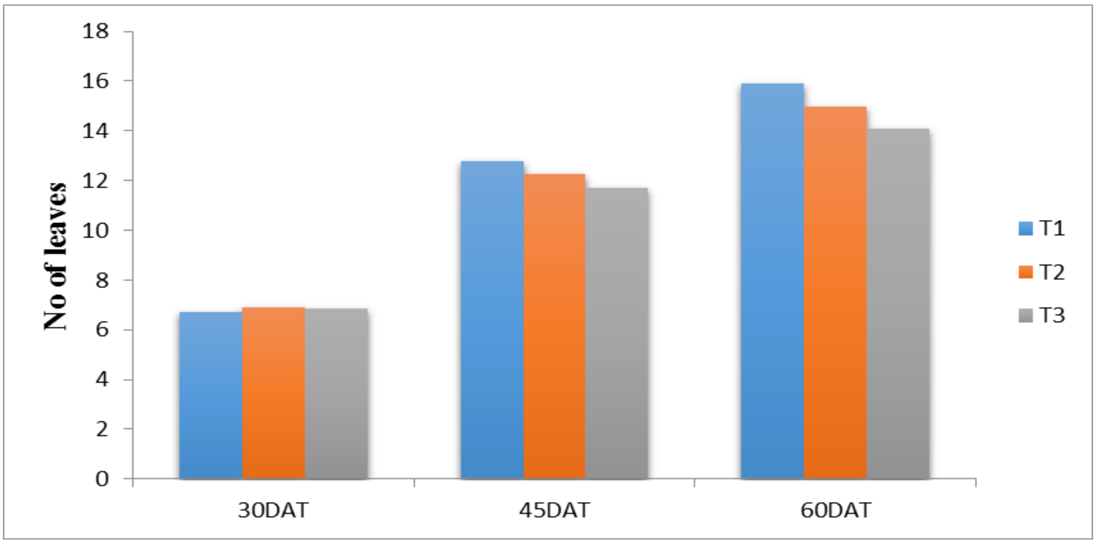
Note: M_0 = Control, M_1 = Cowdung, M_2 = Mustard oil cake, M_3 = Vermicompost
T_1 = applied 15 days before planting T_2 = applied at the time of planting
T_3 = applied 15 days after planting



Days after transplanting (DAT)

Fig. 4. Effect of organic manures on number of leaves of cauliflower

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



Days after transplanting (DAT)

Fig 5. 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
T_3 = applied 15 days after planting

4.3 Largest leaf length (cm)

Organic manure had a significant influence on the length of leaves of cauliflower plants at 30, 45 and 60 DAT (Table 4, Appendix IV). 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. This is supported by Tomati et al.,(1988). 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

Table 4. Effect of organic manures on largest leaf length of cauliflower

Treatments	Largest leaf length (cm) at		
	30DAT	45DAT	60DAT
M_0	11.97 c	20.15 d	31.66 c
M_1	14.98 b	24.28 c	34.77 b
M_2	15.80 a	28.48 a	39.04 a
M_3	14.89 b	25.22 b	34.71 b
CV %	11.68	10.58	7.45
LSD (0.05)	0.45	0.93	0.69

In a colum means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 levels of probability

Note: M_0 = Control, M_1 = Cowdung, M_2 = Mustard oil cake, M_3 = Vermicompost

Largest leaf length showed significant difference due to the application time of organic manure on cauliflower plants at 30, 45 and 60 DAT (Table 5, Appendix IV). At 60 DAT, the longest leaf (36.15 cm) was recorded from T_1 (applied 15 days before planting) treatment and the shortest leaf (34.40 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. Similar result was observed by Ahmed (1999). 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.

Table 5. Effect of application time of manure on largest leaf length of cauliflower

Treatments	Largest leaf length (cm) at		
	30DAT	45DAT	60DAT
T_1	14.64 a	25.88 a	36.15 a
T_2	14.15 b	24.34 b	34.60 b
T_3	14.43 b	23.38 c	34.40 b
CV %	11.68	10.58	7.45
LSD (0.05)	0.39	0.80	0.58

In a colum means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 levels of probability

Note: T_1 = applied 15 days before planting T_2 = applied at the time of planting
T_3 = applied 15 days after planting

The leaf length was significantly influenced by the combined effect of organic manure and application time at 30, 45 and 60 DAT (Table 6, Appendix IV). At 60 DAT, the longest leaf (41.87 cm) was measured from M_2T_1 (Mustard oil cake applied 15 days before planting) treatment while the shortest (30.47 cm) was recorded from M_0T_1 (Control) treatment. This result support the result found by Thy and Buntha (2005)

Table 6. Combined effect of organic manures and its application time on largest leaf length of cauliflower

Treatments	Largest Leaf length (cm) at		
	30DAT	45DAT	60DAT
M_0T_1	12.73 d	20.73 f	30.47 j
M_0T_2	11.27 e	21.00 f	32.20 i
M_0T_3	11.93 e	18.73 g	32.33 hi
M_1T_1	14.40 c	25.60 c	35.80 de
M_1T_2	15.47 b	23.93 de	35.13 ef
M_1T_3	15.07 bc	23.33 e	33.40 gh
M_2T_1	16.33 a	30.80 a	41.87 a
M_2T_2	15.40 b	28.53 b	37.87 b
M_2T_3	15.67 ab	26.13 c	37.40 bc
M_3T_1	15.13 bc	26.40 c	36.47 cd
M_3T_2	14.47 c	23.93 de	33.20 hi
M_3T_3	15.08 bc	25.33 cd	34.47 fg
CV %	11.68	10.58	7.45
LSD (0.05)	0.79	1.61	1.10

In a colum means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 levels of probability

Note: M_0 = Control, M_1 = Cowdung, M_2 = Mustard oil cake, M_3 = Vermicompost
T_1 = applied 15 days before planting T_2 = applied at the time of planting
T_3 = applied 15 days after planting

4.4 Leaf breadth (cm)

A significant variation was recorded in leaf breadth of cauliflower plants at 30, 45 and 60 DAT (Table 7, Appendix V). At 60 DAT, the highest leaf breadth (16.46 cm) was measured from M_2 (Mustard oil cake) treatment while the lowest (11.73 cm) was recorded from M_0 (control) treatment Similar result was found by Thakur and singh (2001) on cauliflower.

Table 7. Effect of organic manures on largest leaf breadth of cauliflower

Treatments	Largest leaf breadth (cm) at		
	30DAT	45DAT	60DAT
M_0	4.51 c	7.80 c	11.73 d
M_1	5.75 b	10.53 b	14.60 c
M_2	6.93 a	12.02 a	16.46 a
M_3	5.82 b	10.37 b	15.27 b
CV %	8.62	10.66	11.43
LSD (0.05)	0.41	0.86	0.61

In a colum means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 levels of probability

Note: M_0 = Control, M_1 = Cowdung, M_2 = Mustard oil cake, M_3 = Vermicompost

Time of application of organic manure had significant influence on leaf breadth of cauliflower plants at different DAT (Table 8, Appendix V). At 60 DAT, the highest leaf breadth (15.06 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 8. Effect of different time of application on largest leaf breadth of cauliflower

Treatments	Largest leaf breadth(cm) at		
	30DAT	45DAT	60DAT
T_1	5.85	10.83	15.06 a
T_2	5.63	10.06	14.31 b
T_3	5.78	10.40	14.17 b
CV %	8.62	10.66	11.43
LSD (0.05)	NS	NS	0.53

In a colum means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 levels of probability

Note: T_1 = applied 15 days before planting, T_2 = applied at the time of planting, T_3 = applied 15 days after planting

The leaf breadth was significantly varried by the combined effect of organic manure and mulching at 30, 45 and 60 DAT (Table 9, Appendix V). Result support the research findings of Hsieh (2004) on cabbage. This could be due to promote of nitrogen uptake which enhanced vegetative growth of cauliflower plants.

Table 9. Effect of organic manures and application time on Leaf breadth of cauliflower

Treatments	Largest leaf breadth(cm) at		
	30 DAT	45 DAT	60 DAT
M_0T_1	4.20 f	7.13 d	11.60 f
M_0T_2	4.73 ef	8.00 d	11.60 f
M_0T_3	4.60 f	8.27 d	12.00 f
M_1T_1	5.47 d	10.07 bc	15.47 bc
M_1T_2	5.87 bcd	10.73 bc	14.33 de
M_1T_3	5.93 bcd	10.80 bc	14.00 e
M_2T_1	7.93 a	13.00 a	17.40 a
M_2T_2	6.53 b	11.53 ab	16.40 ab
M_2T_3	6.33 bc	11.53 ab	15.60 bc
M_3T_1	5.80 cd	10.13 bc	15.80 bc
M_3T_2	5.40 de	10.00 bc	14.93 cde
M_3T_3	6.27 bc	11.00 bc	15.08 cd
CV %	8.62	10.66	11.43
LSD(%)	0.71	1.50	1.06

In a colum means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 levels of probability

Note: M_0 = Control, M_1 = Cowdung, M_2 = Mustard oil cake, M_3 = Vermicompost
T_1 = applied 15 days before planting T_2 = applied at the time of planting
T_3 = applied 15 days after planting

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. 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 (1990) found the same results in his investigations.

4.5 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 (Table 10, Appendix VI). The minimum days (63.66) 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. Application of organic manure hastened the crop to reach reproductive stage which was agreed with the present findings Mitra *et al*. (1990).

Application time of manure significantly influenced the number of days required for curd initiation (Table 10, Appendix VI). 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.

Days required for curd initiation was significantly varied among the treatment combinations (Table 10, Appendix VI). 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) treatment and M_3T_1 (Vermicompost applied 15 days before planting) treatment. Thy and Buntha (2005) reported that organic manure ensure the favorable condition for the growth and development of Chinese cabbage and the ultimate result is the shortest duration for attaining head formation.

4.6 Length of curd (cm)

A statistically significant variation was observed from the application of organic manure on length of curd of cauliflower plants (Table 10, Appendix VI). 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 . 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 (Table 10, Appendix VI). 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) treatment which was statistically identical to that of T_2 (applied at the time of planting) treatment .

Length of curd showed significant influence by the combined effect of organic manure and time of application (Table 10, Appendix VI). 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. Length of curd is an important yield character. Length of curd was significantly influenced by organic manure application. This results support the findings Palevich (1965).

Table 10. Effect of organic manures and application time on days required to curd initiation and curd length of cauliflower

Treatments	Days of curd initiation	Curd length(cm)
Effect of organic manure		
M_0	67.33 a	13.44 c
M_1	65.66 b	17.02 b
M_2	63.66 c	18.73 a
M_3	64.00 c	17.33 b
LSD(%)	1.16	0.75
Effect of time of application		
T_1	64.50 b	17.11 a
T_2	65.75 a	16.56 b
T_3	65.25 b	16.21 b
LSD (%)	1.01	0.65
Combination of organic manure and application time		
M_0T_1	67.00 ab	13.93 d
M_0T_2	68.00 a	13.20 d
M_0T_3	67.00 ab	13.20 d
M_1T_1	65.00 bcd	16.27 c
M_1T_2	66.00 abc	17.87 b
M_1T_3	66.00 abc	16.93 bc
M_2T_1	63.00 d	20.40 a
M_2T_2	64.00 cd	18.13 b
M_2T_3	64.00 cd	17.67 b
M_3T_1	63.00 d	17.87 b
M_3T_2	65.00 bcd	17.07 bc
M_3T_3	64.00 cd	17.06 bc
CV%	9.27	9.56
LSD(0.05)	2.02	1.31

In a colum means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 levels of probability

Note: M_0 = Control, M_1 = Cowdung, M_2 = Mustard oil cake, M_3 = Vermicompost
T_1 = applied 15 days before planting T_2 = applied at the time of planting
T_3 = applied 15 days after planting

4.7 Curd stem diameter (cm)

Application of organic manure shows a significant differeence on stem diameter of curd of cauliflower plants (Table11, Appendix VI). The highest stem diameter of curd (3.46 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 recorded in M_0 (control) treatment. 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 (Table 11, Appendix VI). The maximum stem diameter of curd (3.33 cm) was measured from T_1 (applied 15 days before planting) treatment while the minimum (3.04 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.

Significant variation was recorded in the curd stem diameter of cauliflower by the combined effect of organic manure and time of application (Table 11, Appendix VI). 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. Stem diameter of curd is important for curd yield. Stem diameter of curd was significantly influenced by organic manure application. Murlee *et al* (2007) found the same result on cauliflower.

4.8 Curd diameter (cm)

Application of organic manure exhibited a significant influence on curd diameter of cauliflower plants (Table 11, Appendix VI). 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. 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 (Table 11, Appendix VI). The maximum curd diameter (15.13 cm) was measured from T_1 (applied 15 days before planting) treatment while the minimum (13.91 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. This results revealed that the curd diameter increase with time of application of organic manure.

Curd diameter was significantly varried by the combined effect of organic manure and application time (Table 11, Appendix VI). 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 (11.20 cm) was recorded from M_0T_2 (control) treatment. This findings matches with the observation of Petco (1972). 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.

Table 11. Effect of organic manures and application time on curd stem diameter and curd diameter of cauliflower

Treatments	Curd stem diameter(cm)	Curd diameter(cm)
Effect of organic manure		
M_0	2.55 c	11.84 d
M_1	3.29 ab	15.15 b
M_2	3.46 a	15.86 a
M_3	3.27 b	14.42 c
CV%	10.42	12.87
LSD(%)	0.18	0.43
Effect of application time		
T_1	3.33 a	15.13 a
T_2	3.05b	13.91 b
T_3	3.04 b	13.91 b
CV%	10.42	12.87
LSD(%)	0.16	0.37
Combination of organic manure and application time		
M_0T_1	2.50 d	12.13 g
M_0T_2	2.66 d	11.20 h
M_0T_3	2.49 d	12.20 g
M_1T_1	3.60 ab	15.73 b
M_1T_2	3.10 c	14.73 cde
M_1T_3	3.17 c	15.00 cde
M_2T_1	3.84 a	17.60 a
M_2T_2	3.34 bc	15.47 bc
M_2T3	3.22 c	14.53 def
M_3T_1	3.40 bc	15.07 bcd
M_3T_2	3.13 c	14.26 ef
M_3T_3	3.30 bc	13.93 f
CV%	10.42	12.87
LSD (%)	0.32	0.75

In a colum means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 levels of probability

Note: M_0 = Control, M_1 = Cowdung, M_2 = Mustard oil cake, M_3 = Vermicompost
T_1 = applied 15 days before planting T_2 = applied at the time of planting
T_3 = applied 15 days after planting

4.9 Curd weight (kg)

Application of organic manure exhibited a statistically significant influence on diameter of curd of cauliflower plants (Table 12, Appendix VII). 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. 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 (Table 13, Appendix VII). 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 . 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 Rahman *et al*. (1989).

Curd weight was noticeablly varried by the combined effect of organic manure and application time (Table 14, Appendix VII). The maximum curd weihgt (1042.90 g) was measured from M_2T_1 (Mustard oil cake applied 15 days before planting) treatment while the minimum (429.60 g) was recorded from M_0T_3 (control) treatment . 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 *et al* (1994).

4.10 Root length(cm)

Significant variation was recorded in the root length of cauliflower plants (Table 12, Appendix VI) due to organic manure application. The maximum root length (36.730 cm) was measured from M_2 (Mustard oil cake) treatment while the minimum root length (30.77 cm) was recorded from M_0 (control) treatment. It was revealed that the root length increased with organic manure application. This might be caused that organic manures such as cowdung , mustard oil cake, vermicompost improves the soil structure, aeration, water holding capacity , slow release nutrient which support root development leading to higher growth and yield of cauliflower. Similar result was found by Tomati *et al*., (1988).

Time of application showed no significant influence on root length of cauliflower plants (Table 13, Appendix VI). The maximum root length (34.33 cm) was measured from T_1 (applied 15 days before planting) treatment while the minimum root length (33.54 cm) was recorded from T_3 (applied 15 days after planting) treatment.

Root length of cauliflower plant was highly significantly influenced by the combined effect of organic manure and its application time (Table 14, Appendix VI). The maximum root length (37.33 cm) was measured from M_2T_1 (Mustard oil cake applied 15 days before planting) which was statistically similar to that of M_2T_3 (Mustard oil cake applied 15 days after planting) while the minimum (30.00 cm) was recorded from M_0T_3 which was statistically similar to that of M_0T_1 and M_0T_2. Root length is important for vegetative and reproductive growth of cauliflower.

4.11 Dry matter content (%) of leaf

Application of organic manure represented a significant influence on dry matter (%) content of leaf of cauliflower plants (Table 12, Appendix VII). The maximum dry matter content of leaf (12.09%) was measured from M_2 (Mustard oil cake) treatment while the minimum (8.78%) was measured from M_0 (Control) treatment. It was revealed that the dry matter (%) content of leaf increased with organic manure application.

Application time of organic manure had a noticeable influence on dry matter (%) content of cauliflower plants (Table 13, Appendix VII). The maximum dry matter (%) content (11.15%) was measured from T_1 (applied 15 days before planting) treatment while the minimum (10.16%) was recorded from T_2 (applied at the time of planting) treatment. This result was revealed that the dry matter (%) content increased with application time of organic manure. These results support the findings of Almeida *et al*. (2004).

Dry matter (%) content was significantly influenced by the combined effect of organic manure and application time (Table 14, Appendix VII). The maximum dry matter (%) content (13.30 %) was measured from M_2T_1 (Mustard oil cake applied 15 days before planting) while the minimum (8.17%) was recorded from M_0T_1 (Control) treatment. Dry matter (%) content was significantly influenced by organic manure and its application time.

4.12 Dry matter content (%) curd

Application of organic manure exhibited a significant influence on dry matter (%) content of curd of cauliflower plants (Table 12, Appendix VII). The maximum dry matter (%) content of curd (6.64%) was measured from M_2 (Mustard oil cake) treatment while the minimum (5.13%) was measured from M_0 (Control) treatment. It was revealed that the dry matter (%) content of curd increased with organic manure application. This might be due to slow and continuous nutrient supply. That helps in uniform and compact curd formation.

Application time of organic manure had a significant variation on dry matter (%) content of curd of cauliflower plants (Table 13, Appendix VII). The maximum dry matter (%) content (6.08%) was measured from T_2 (applied at the time of planting) treatment while the minimum (5.76%) was recorded from T_1 (applied 15 days before planting) treatment . This result was revealed that the dry matter (%) content of curd varied with application time of organic manure.

Dry matter (%) content of curd of cauliflower was significantly influenced by the combined effect of organic manure and application time (Table 14, Appendix VII). The maximum dry matter (%) content (6.85%) was measured from M_2T_1 (Mustard oil cake applied 15 days before planting) treatment which was statistically identical to that of M_2T_2 (Mustard oil cake applied at the time of planting) treatment while the minimum (4.97%) was recorded from M_0T_1 (control) treatment which was statistically identical to that of M_0T_3 (control) treatment. Dry matter (%) content is important for curd yield of cauliflower. Dry matter (%) content of curd was significantly influenced by organic manure and its application time. Similar results were also noted by Aseigbu *et al* (1984) in broccoli.

Table.12 Effect of organic manure on curd weight, root length, dry matter (%) of leaf and dry matter (%) of curd

Treatments	Curd weight(g)	Root length (cm)	Dry matter content (%) of leaf	Dry matter content (%) of curd
M_0	473.18 d	30.77 d	8.78 d	5.13 c
M_1	715.28 c	32.99 c	10.44c	5.95 b
M_2	928.90 a	36.73 a	12.09 a	6.64 a
M_3	760.55 b	34.98 b	11.23 b	6.01 b
CV%	9.37	5.67	7.54	8.62
LSD (0.05)	9.64	1.46	0.16	0.14

In a colum means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 levels of probability

Note: M_0 = Control, M_1 = Cowdung, M_2 = Mustard oil cake, M_3 = Vermicompost

Table.13 Effect of time of application of organic manure on curd weight, root length, dry matter (%) of leaf and dry matter (%) of curd

Treatments	Curd weight(g)	Root length (cm)	Dry matter content (%) of leaf	Dry matter content (%) of curd
T_1	763.98 a	34.33	11.15 a	5.76 c
T_2	719.91 b	33.66	10.16 c	6.08 a
T_3	674.54 c	33.54	10.60 b	5.95 b
CV%	9.37	5.67	7.54	8.62
LSD(0.05)	8.35	NS	0.14	0.12

In a colum means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 levels of probability

Note: T_1 = applied 15 days before planting T_2 = applied at the time of planting
T_3 = applied 15 days after planting

Table.14 Combined effect of organic manure and time of application on curd weight, root length, dry matter (%) of leaf and dry matter (%) of curd

Treatments	Curd weight(g)	Root length (cm)	Dry matter content (%) of leaf	Dry matter content (%) of curd
M_0T_1	477.60 h	31.00 de	8.17 h	4.97 f
M_0T_2	512.30 g	31.33 de	8.58 g	5.35 e
M_0T_3	429.60 i	30.00 e	9.60 f	5.09 f
M_1T_1	685.70 f	34.33 bc	11.02 d	5.50 e
M_1T_2	718.30 e	31.33 de	9.80 f	6.01 c
M_1T_3	741.90 de	33.33 cd	10.51 e	6.35 b
M_2T_1	1042.90 a	37.33 a	13.30 a	6.85 a
M_2T_2	895.50 b	36.33 b	11.70 c	6.73 a
M_2T_3	848.30 c	36.53 ab	11.29 d	6.35 b
M_3T_1	849.70 bc	34.67 bc	12.11 b	5.75 d
M_3T_2	753.50 d	35.67 bc	10.56 e	6.25 bc
M_3T_3	678.40 f	34.33 bc	11.02 d	6.03 c
CV%	9.37	5.67	7.54	8.62
LSD(0.05)	16.70	2.54	0.28	0.24

In a colum means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 levels of probability

Note: M_0 = Control, M_1 = Cowdung, M_2 = Mustard oil cake, M_3 = Vermicompost

T_1 = applied 15 days before planting T_2 = applied at the time of planting

T_3 = applied 15 days after planting

4.13 Yield per plot

Yield per plant is important for increasing total yield. Application of organic manure exhibited a statistically significant influence on yield per plot of cauliflower (Figure 6, Appendix VII). The maximum yield (11.14kg) was recorded from M_2 (Mustard oil cake) treatment while the minimum (5.67 kg) was measured in M_0 (control) treatment. 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*. (1994) 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 were greater in the amended treatment.

Application time of organic manure exhibited a significant influence on total yield per plot (Figure 7, Appendix VII). The maximum yield (9.16 kg) was recorded from T_1 (applied 15 days before planting) treatment to while the minimum (8.09 kg) was measured in T_3 (applied 15 days after planting) treatment. 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* (1994).

Yield per plot was highly significantly influenced by the combined effect of organic manure and application time (Table 15, Appendix VII). The maximum yield (12.51 kg) was measured in M_2T_1 (Mustard oil cake applied 15 days before planting) treatment while the minimum (5.15 kg) was recorded from M_0T_3 (control) treatment which was statistically similar to that of M_0T_1 (control) treatment.

4.14 Yield per hectare

A significant influence on yield per hectare of cauliflower plants (Figure 8, Appendix VII) was observed by the application of organic manure. The maximum yield (38.70 t/ha) was recorded from M_2 (Mustard oil cake) treatment which was while the minimum (19.71 t/ha) was measured in M_0 (control) treatment. Cauliflower yield and curd diameter were greater in organic manure treatment. This result is supported by Maynard (1994).

Application time of organic manure exhibited a significant influence on total yield per hectare of cauliflower plants (Figure 9, Appendix VII). The maximum yield (31.83 t/ha) was recorded in T_1 (applied 15 days before planting) treatment while the minimum (28.10 t/ha) was measured in (T_3) (applied 15 days after planting) treatment.

Total yield per hectare was significantly influenced by the combined effect of organic manure and application time (Table 15, Appendix VII). The maximum yield per hectare (43.45 t/ha) was measured in M_2T_1 (Mustard oil cake applied 15 days before planting) treatment while the minimum (17.90 t/ha) was recorded from M_0T_3 (control) treatment which was statistically similar to that of M_0T_1 (control) treatment.

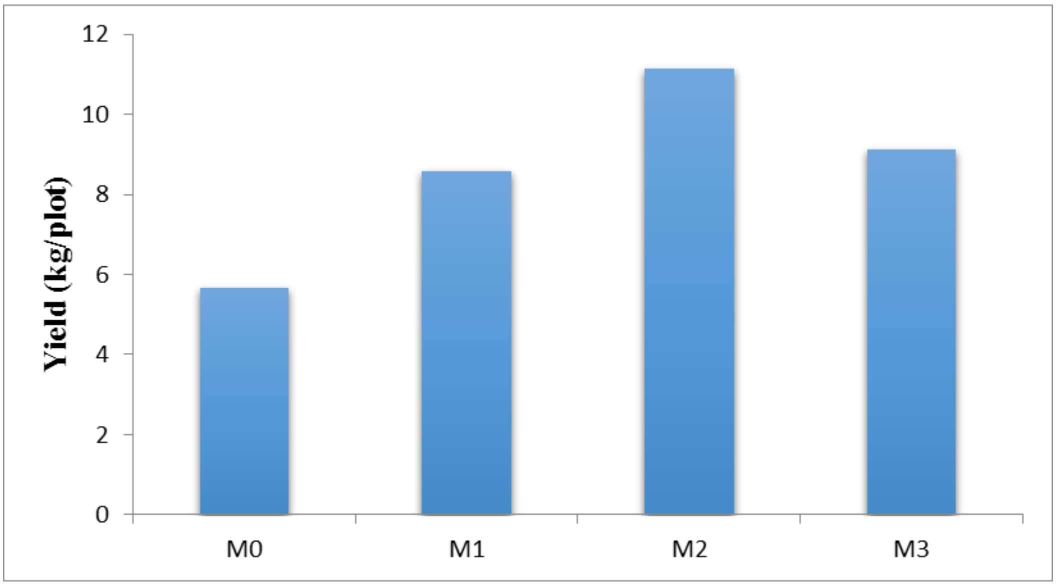
Table 15. Effect of different organic manure and application time on per plot yield and per hector yield of cauliflower

Treatments	Yield per plot (kg)	Yield per hactor (ton)
Effect of organic manure		
M_0	5.67 d	19.71 d
M_1	8.58 c	29.80 c
M_2	11.14 a	38.70 a
M_3	9.12 b	31.69 b
CV %	12.87	11.74
LSD (0.05)	0.11	0.40
Effect of application time		
T_1	9.16 a	31.83 a
T_2	8.63 b	29.99 b
T_3	8.09 c	28.10 c
CV%	12.87	11.74
LSD(0.05)	0.12	0.34
Combined effect of organic manure and application time		
M_0T_1	5.73 hi	19.90 hi
M_0T_2	6.14 g	21.34 g
M_0T_3	5.15 i	17.90 i
M_1T_1	8.22 f	28.57 f
M_1T_2	8.61 e	29.92 e
M_1T_3	8.90 de	30.91 de
M_2T_1	12.51 a	43.45 a
M_2T_2	10.74 b	37.31 b
M_2T_3	10.17 c	35.34 c
M_3T_1	10.19 bc	35.40 bc
M_3T_2	9.04 f	31.39 d
M_3T_3	8.14 f	28.26 f
CV%	12.87	11.74
LSD(0.05)	0.20	0.69

In a colum means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 levels of probability

Note: M_0 = Control, M_1 = Cowdung, M_2 = Mustard oil cake, M_3 = Vermicompost

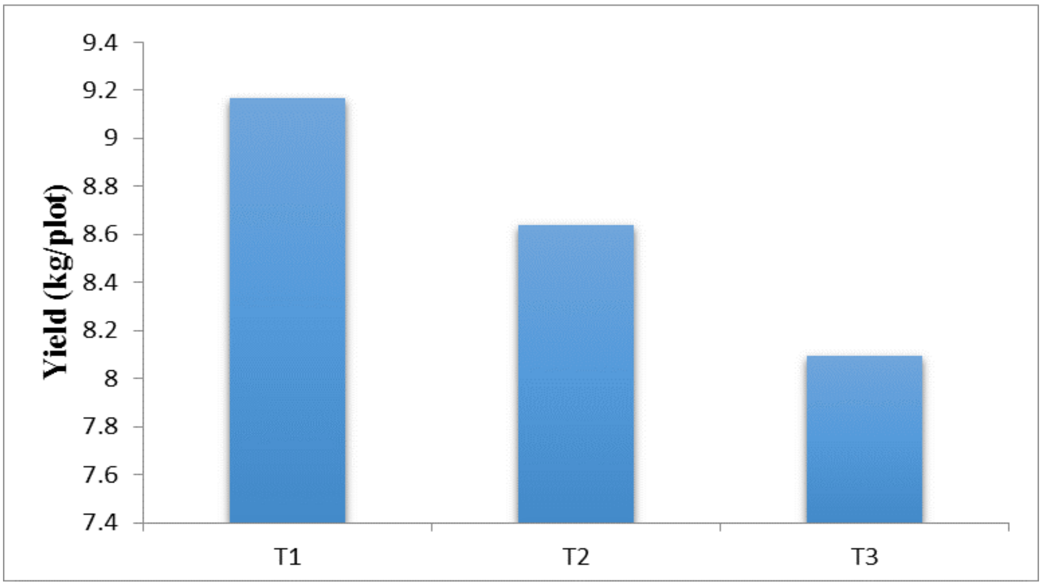
T_1 = applied 15 days before planting T_2 = applied at the time of planting
T_3 = applied 15 days after planting



Organic manure

Fig. 6. Effect of organic manures on per plot yield of cauliflower

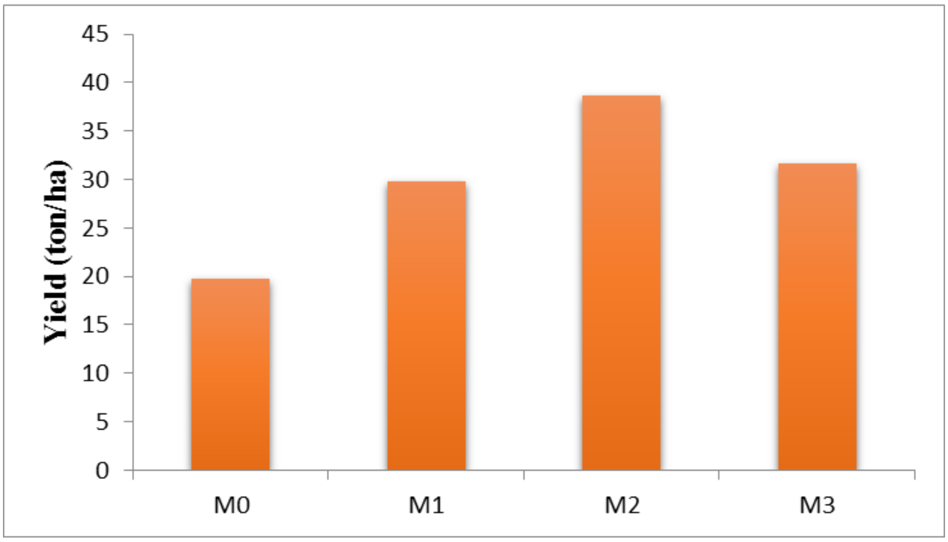
Where,
M_0 = Control, M_1 = Cowdung, M_2 = Mustard oil cake, M_3 = Vermicompost



Application time

Fig. 7. Effect of different time of application of organic manure on per plot yield of cauliflower

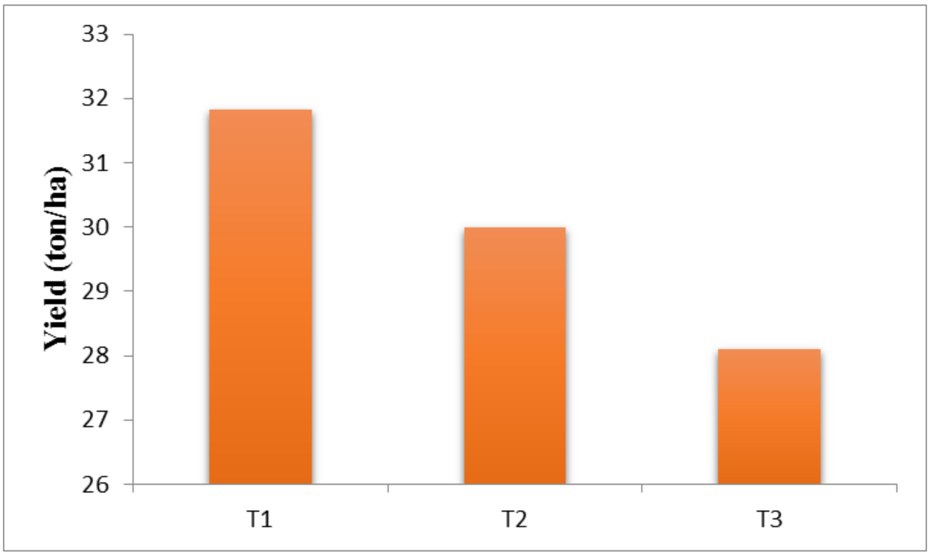
Where,
T_1 = applied 15 days before planting T_2 = applied at the time of planting
T_3 = applied 15 days after planting



Organic manure

Fig. 8. Effect of organic manures on per hectare yield of cauliflower

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



Application time

Fig. 9. Effect of different application time of manure on per hectare yield of cauliflower

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

4.15 Economic analysis

Input costs for land preparation, fertilizer, irrigation and manpower required for all the operations from seed sowing to harvesting of cauliflower were recorded as per experimental plot and converted into cost per hectare. Price of cauliflower was considered as per market rate. The economic analysis presented under the following headings-

4.15.1 Gross return

The combination of different organic manure and application time showed different value in terms of gross return under the trial (Table 16). The highest gross return (Tk. 869,000) was obtained from the treatment combination M_2T_1 (Mustard oil cake applied 15 days before planting) treatment and the second highest gross return (Tk. 746,200) was found in M_2 T_2. The lowest gross return (Tk. 298,950) was obtained from M_0T_3 (control) treatment.

4.15.2 Net return

Different value of net return was found from different organic manure and application time. Highest net return 474,421 tk was obtained from M_2T_1 treatment combination and second highest 351,621 was obtained from treatment combination M_2T_2 lowest net return 44,211 tk was obtained from M_0T_3 treatment combination (Table 16).

4.15.3 Benefit cost ratio

Application of different organic manure at different time the highest benefit cost ratio (2.20) was noted from the combination of M_2T_1 (Mustard oil cake applied 15 days before planting) treatment and the second highest benefit cost ratio (1.89) was estimated from the combination of M_2T_2 and the lowest benefit cost ratio (1.17) was obtained from M_0T_3 (control) treatment (Table 16). From economic point of view, it is apparent from the above results that the combination of M_2T_1 (Mustard oil cake applied 15 days before planting) treatment was more profitable treatment combination than rest of the combination.

Table 16. Cost and return of cauliflower cultivation as influenced by organic manure and planting time

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

Note: M_0 = Control, M_1 = Cowdung, M_2 = Mustard oil cake, M_3 = Vermicompost
T_1 = applied 15 days before planting T_2 = applied at the time of planting
T_3 = applied 15 days after planting

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the Horticulture Research Farm of Sher-e-Bangla Agricultural University (SAU), Dhaka during the period from October 2018 to February 2019 to observe the effect of organic manure and its application time on growth and yield of cauliflower. The test crop used in the experiment was hybrid cauliflower variety 'Amaizing'. The experiment consisted of two factors: Factor A: Organic manure (four levels) as M_0 : Control i.e. no manure application; M_1: Cowdung @ 33 tn/ha; M_2: Mustard oil cake @ 3.5 t/ha and M3: Vermicompost @ 9 t/ha. Factor B: Application time (three levels) as T1: 15 days before planting; T2: At the time of planting; T3: 15 days after planting. There were 12 (3 × 4) treatments combination. Data on different growth and yield parameter were recorded and significant variation was recorded for each of the parameters.

The experiment was laid out in randomized complete block (RCBD) design with 3 replications. The total number of treatments were twelve and the number of plots were 36. Data were collected on the following parameter – plant height, number of leaves per plant, largest leaf length, largest leaf breadth, root length, days required for first curd initiation, curd diameter, curd weight, curd stem diameter, dry matter (%) content of leaf, dry matter (%) content of curd, yield per plant, yield per plot, yield per hactor. The data were analysed statistically by variance (ANOVA) of data on different characters and yields of cauliflower.

In case of organic manure application, the tallest plant (46.667 cm) was recorded from M_2 treatment at 60 DAT, whereas the shortest plant (35.29 cm) was recorded from M_0 treatment, At 60 DAT the maximum number of leaves per plant (18.11) was recorded from M_2 treatment, again the minimum number (11.743) was recorded from M_0 treatment. The maximum largest leaf length at 60 DAT (39.04cm) was recorded from M_2 treatment while the minimum largest leaf length (31.667 cm) was recorded from M_0 treatment. The maximum largest leaf breadth at 60 DAT (16.46cm) was recorded from M_2 treatment while the minimum largest leaf breadth (11.73 cm) was recorded from M_0 treatment. The minimum days from transplanting to first visible card (63.66) was found from M_2 treatment and the maximum days (67.33) was recorded from M_0 treatment .The highest diameter of curd stem (3.46 cm) was recorded from M_2 treatment, while the lowest (2.55 cm) was recorded from M_0 treatment. The highest length of curd (18.73 cm) was recorded from M_2 treatment, again the lowest (13.44 cm) was recorded from M_0 treatment. The maximum curd diameter (15.867 cm) was recorded from M_2 treatment, while the minimum curd diameter (11.843 cm) was attained from M_0 treatment. The maximum fresh weight of curd (928.90 g) was attained from M_2 treatment whereas the minimum fresh weight of curd (473.18 g) was attained from M_0 treatment. The highest length of root (36.73 cm) was recorded from M_2 treatment, whereas the lowest length (30.77 cm) was found from M_0 treatment. The maximum dry matter (%) content of leaf per plant (12.097 g) was found from M_2 treatment, again the minimum dry matter (%) content (8.78 g) was attained from M_0 treatment. The highest dry matter (%) content of curd (6.64 g) was recorded from M_2 treatment, whereas the lowest (5.136g) was found from M_0 treatment. The highest yield per plot (11.147 kg) was found from M_2 treatment, whereas the lowest (5.678 kg) was recorded from M_0 treatment. The highest yield per hectare (38.704 ton) was recorded from M_2 treatment, while the lowest (19.717 ton) was recorded from M_0 treatment.

In case of application time, at 60 DAT the tallest plant (43.065 cm) was recorded from T_1 treatment, whereas the shortest plant at 60 DAT (41.065) was recorded from T_2 treatment. Maximum number of leaves at 60 DAT (15.89) was recorded from T_1 treatment, again the minimum number (14.083) was recorded from T_3 treatment. The maximum largest leaf length at 60 DAT (36.153cm) was recorded from T_1 treatment while the minimum largest leaf length (34.40 cm) was recorded from T_3 treatment. The maximum largest leaf breadth at 60 DAT (15.068cm) was recorded from T_1treatment while the minimum largest leaf breadth at 60 DAT (14.17cm) from T_3 treatment. The minimum days from transplanting to first visible card (64.5) was found from T_1 treatment and the maximum days (65.75) was recorded from T_2 treatment. The highest diameter of curd stem (3.335 cm) was recorded from T_1 treatment, while the lowest (3.045 cm) was recorded from T_3 treatment. The highest length of curd (17.117 cm) was recorded from T_1 treatment, again the lowest (16.215 cm) was recorded from T_3 treatment. The maximum curd diameter (15.132 cm) was recorded from T_1 treatment, while the minimum curd diameter (13.915 cm) was attained from T_2 treatment and T_3 treatment. The maximum fresh weight of curd (763.98 g) was attained from T_1 treatment whereas the minimum fresh weight of curd (674.54g) was attained from T_3 treatment. The highest length of root (34.332 cm) was recorded from T_1 treatment, whereas the lowest length (33.547 cm) was found from T_3 treatment. The maximum dry matter (%) content of leaf per plant (11.15 g) was found from T_1 treatment, again the minimum dry matter (%) content (10.16 g) was attained from T_2 treatment. The highest dry matter (%) content of curd (6.085 g) was recorded from T_2 treatment, whereas the lowest (5.767g) was found from T_1 treatment. The highest yield per plot (9.167 kg) was found from T_1 treatment, whereas the lowest (8.094 kg) was recorded from T_3 treatment. The highest yield per hectare (31.832 ton) was recorded from T_1 treatment, while the lowest (28.107 ton) was recorded from T_3 treatment.

Due to the combined effect of organic manure and application time, at 60 DAT the tallest plant (48.47 cm) was recorded from M_2T_1 treatment combination, whereas the shortest plant (34.67 cm) was recorded from M_0T_2 treatment combination. At 60 DAT the maximum number of leaves per plant (20.73) was recorded from M_2T_1 treatment combination, again the minimum number at 60 DAT (12.03) was recorded from M_0T_2 treatment combination. The maximum largest leaf length at 60 DAT (41.87cm) was recorded from M_2T_1 treatment combination while the minimum largest leaf length (30.47 cm) was recorded from M_0T_1 treatment combination. The maximum largest leaf breadth at 60 DAT (17.4 cm) was recorded from M_2T_1 treatment combination while the minimum largest leaf breadth (11.60 cm) was recorded from M_0T_1 treatment combination. The minimum days from transplanting to first visible card (63) was found from M_2T_1 treatment combination and M_3T_1 treatment combination and the maximum days (68) was recorded from M_0T_2 treatment combination . The highest diameter of curd stem (3.84 cm) was recorded from M_2 T_1 treatment combination, while the lowest (2.49 cm) was recorded from M_0T_3 treatment combination. The highest length of curd (20.40 cm) was recorded from M_2 T_1 treatment combination, again the lowest (13.2 cm) was recorded from M_0T_2 treatment combination and M_0T_3 treatment combination. The maximum curd diameter (17.6 cm) was recorded from M_2T_1 treatment combination , while the minimum curd diameter (11.2 cm) was attained from M_0T_2 treatment combination . The maximum fresh weight of curd (1042.9 g) was attained from M_2T_1 treatment combination whereas the minimum fresh weight of curd (429.6 g) was attained from M_0T_3 treatment combination. The highest length of root (37.33 cm) was recorded from M_2T_1 treatment combination, whereas the lowest length (30.00 cm) was found from M_0T_3 treatment combination. The maximum dry matter (%) content of leaf per plant (13.30 g) was found from M_2T_1 treatment combination, again the minimum dry matter (%) content (8.17 g) was attained from M_0T_1 treatment combination . The highest dry matter (%) content of curd (6.85 g) was recorded from M_2T_1 treatment combination, whereas the lowest (4.97g) was found from M_0T_1 treatment combination. The highest yield per plot (12.515 kg) was found from M_2T_1 treatment combination, whereas the lowest (5.155 kg) was recorded from M_0T_3 treatment combination. The highest yield per hectare (43.454 ton) was recorded from M_2T_1 treatment combination, while the lowest (17.903 ton) was recorded from M_0T_3 treatment combination.

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 .

It was revealed that the above results that the combination of M_2T_1 treatment combination was more suitable in consideration of yield contributing characters and yield and consideration value for money concept.

Considering the situation of the present experiment, further studies in the following areas may be suggested:

1. Different level of organic manure may be used for further study.

2. Another experiment may be carried out with another application time.

3. Such study is needed in different agro-ecological zones (AEZ) of Bangladesh for regional compliance and other performance.

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APPENDICES

Appendix I. Characteristics of the soil of experimental field analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

A. Morphological characteristics of the soil of experimental field

Morphological features	Characteristics
Location	Horticulture Garden , SAU, Dhaka
AEZ	Horticulture Garden , SAU, Dhaka
General Soil Type	Shallow red brown terrace soil
Land types	High land
Soil series	Tejgaon
Topolography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained

B. Physical and chemical properties of the initial soil

Characteristics	Value
% Sand	27
% Silt	43
% Clay	30
Textural class	Silty -clay
pH	5.6
Organic carbon(%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

C. Monthly records of temperature rainfall, relative humidity of experiment site during the period from October 2017 to February 2018

Year	Month	Air Temperature ^{0}C			Relative humidity (%)	Rainfall (mm)	Sunshine (hr)
		Maximum	Minimum	Mean			
2017	October	30.97	23.31	27.14	75.25	208	208.9
	November	29.5	18.6	24.0	69.5	0.0	233.2
	December	26.9	16.2	21.5	70.6	0.0	210.5
2018	January	24.5	13.9	19.2	68.5	1.0	194.1
	February	28.9	18.0	23.4	61.0	2.0	121.5

Source: Bangladesh Meteorological Department (Climate division), Agargaon Dhaka.

Appendix II. Analysis of variance of the data on plant height of cauliflower at different days after transplanting (DAT) as influenced by organic manure and application time

Source of variation	Degrees of freedom (df)	Mean Square of Plant height (cm) at		
		30 DAT	45DAT	60 DAT
Replication	2	5.533	66.809	0.353
Factor A (O. Manure)	3	57.377**	88.242**	7.767**
Factor B (A. Time)	2	16.576 NS	95.986**	12.098**
A x B	6	31.049*	67.771*	4.026*
Error	22	11.566	21.538	1.152

* Significant at 0.05 level of probability; ** Significant at 0.01 level of probability and NS Non-significant

Appendix III. Analysis of variance of the data on number of leaves per plant of cauliflower at different days after transplanting (DAT) as influenced by organic manure and its application time

Source of variation	Degrees of freedom (df)	Mean Square of Leaf number per plant at		
		30 DAT	45 DAT	60 DAT
Replication	2	0.486	3.021	0.787
Factor A (O. Manure)	3	13.380**	26.481*	44.896 **
Factor B (A. Time)	2	3.015 NS	29.095*	49.280**
A x B	6	12.704*	22.282*	19.005*
Error	22	4.713	7.458	6.046

* Significant at 0.05 level of probability; **Significant at 0.01 level of probability and NS Non-significant

Appendix IV. Analysis of variance of the data on large leaf length of plant of cauliflower at different days after transplanting (DAT) as influenced by organic manure and its application time

Source of variation	Degrees of freedom (df)	Mean Square of Large leaf length of per plant at		
		30 DAT	45 DAT	60 DAT
Replication	2	8.902	20.701	0.041
Factor A (O. Manure)	3	87.875**	94.121**	1.262*
Factor B (A. Time)	2	85.623**	104.005**	4.093**
A x B	6	55.516*	78.951*	1.406*
Error	22	17.932	31.059	0.643

* Significant at 0.05 level of probability; **Significant at 0.01 level of probability and NS Non-significant

Appendix V. Analysis of variance of the data on large leaf breadth of plant of cauliflower at different days after transplanting (DAT) as influenced by organic manure and its application time

Source of variation	Degrees of freedom (df)	Mean Square of Large leaf length of per plant at		
		30 DAT	45 DAT	60 DAT
Replication	2	5.472	249.51	2.290
Factor A (O. Manure)	3	101.372*	1406.03*	29.637**
Factor B (A. Time)	2	25.430 NS	201.43 NS	24.808**
A x B	6	61.426*	411.14*	19.771*
Error	22	21.988	132.67	7.142

* Significant at 0.05 level of probability; ** Significant at 0.01 level of probability and NS Non-significant

Appendix VI. Analysis of variance of the data on yield contributing characters of cauliflower as influenced by organic manure and application time

Source of variation	Degrees of freedom (df)	Mean Square of				
		Days from transplanting to curd Initiation	Length of curd (cm)	Diameter of curd stem (cm)	Diameter of curd (cm)	Length of root (cm)
Replication	2	2.108	0.021	0.184	9.991	1.003
Factor A (O. Manure)	3	64.250**	6.195**	1.504**	97.014**	8.215**
Factor B (A. Time)	2	75.811**	9.876**	1.251**	52.570**	2.517 NS
A x B	6	35.811**	3.697*	1.488**	44.302	3.415*
Error	22	23.237	1.005	0.196	15.549	1.136

* Significant at 0.05 level of probability; ** Significant at 0.01 level of probability and NS Non-significant

Appendix VII. Analysis of variance of the data on yield contributing characters of cauliflower as influenced by organic manure and application time

Source of variation	Degrees of freedom (df)	Mean Square of				
		Curd weight (g)	Dry matter (%) content of leaves(g)	Dry matter (%) content of curd(g)	Yield per plot (kg)	Yield per hector (ton)
Replication	2	443.5	0.458	1.208	2.554	2.321
Factor A (O. Manure)	3	2409.3**	4.714*	12.686**	98.936**	33.389**
Factor B (A. Time)	2	45510.2**	5.989*	78.063**	89.951**	29.186*
A x B	6	6428.8**	4.353*	10.935**	48.768*	20.602*
Error	22	535.4	1.452	1.917	15.443	6.867

* Significant at 0.05 level of probability; **Significant at 0.01 level of probability and NS Non-significant

Appendix VIII. Per hectare production cost of cauliflower as influenced by organic manure and application time

A. Input cost

Treatment Combination	Labour Cost	Ploughing cost	Seed Cost	Insecticide/ pesticides	Organic Manure			Sub Total (A)
					Cowdung	Mustard oil cake	Vermi compost	
M_0T_1	21000	18000	15700	25000	0	0	0	79700
M_0T_2	21000	18000	15700	25000	0	0	0	79700
M_0T_3	21000	18000	15700	25000	0	0	0	79700
M_1T_1	21000	18000	15700	25000	150000	0	0	229700
M_1T_2	21000	18000	15700	25000	150000	0	0	229700
M_1T_3	21000	18000	15700	25000	150000	0	0	229700
M_2T_1	21000	18000	15700	25000	0	160000	0	239700
M_2T_2	21000	18000	15700	25000	0	160000	0	239700
M_2T_3	21000	18000	15700	25000	0	160000	0	239700
M_3T_1	21000	18000	15700	25000	0	0	250000	329700
M_3T_2	21000	18000	15700	25000	0	0	250000	329700
M_3T_3	21000	18000	15700	25000	0	0	250000	329700

Note: M_0 = Control, M_1 = Cowdung, M_2 = Mustard oil cake, M_3 = Vermicompost
T_1 = applied 15 days before planting T_2 = applied at the time of planting
T_3 = applied 15 days after planting

Appendix VIII. Contd.

B. Overhead cost (Tk./ha)

Treatment Combination	Cost of lease of land for 6 months (13% of value of land Tk. 800,000/year	Miscellaneous cost (Tk. 5% of the input cost)	Interest on running capital for 6 months (Tk. 13.0% of cost/year	Sub total (Tk) (B)	Total cost of production (Tk./ha) [Input cost (A)+ overhead cost (B)]
M_0T_1	97500	3985	23554	125039	204739
M_0T_2	97500	3985	23554	125039	204739
M_0T_3	97500	3985	23554	125039	204739
M_1T_1	97500	11485	44029	153014	382714
M_1T_2	97500	11485	44029	153014	382714
M_1T_3	97500	11485	44029	153014	382714
M_2T_1	97500	11985	45394	154879	394579
M_2T_2	97500	11985	45394	154879	394579
M_2T_3	97500	11985	45394	154879	394579
M_3T_1	97500	16485	57679	171664	451364
M_3T_2	97500	16485	57679	171664	451364
M_3T_3	97500	16485	57679	171664	451364

Note: M_0 = Control, M_1 = Cowdung, M_2 = Mustard oil cake, M_3 = Vermicompost
T_1 = applied 15 days before planting T_2 = applied at the time of planting
T_3 = applied 15 days after planting

Plate 1: Photograph of Experimental plot

Plate 2: Photograph of Harvested Cauliflower