POTENTIALITY OF PRODUCING SUMMER CAULIFLOWER AS INFLUENCED BY ORGANIC MANURES AND SPACING

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CERTIFICATE

This is to certify that the thesis entitled, "POTENTIALITY OF PRODUCING SUMMER CAULIFLOWER AS INFLUENCED BY ORGANIC MANURES AND SPACING" submitted to the Department of Horticulture, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of Master of Science in Horticulture, embodies the result of a piece of bonafide research work carried out by LAILA FARZANA Registration No. **07-2439** *under my supervision and my guidance. No part of the 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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ABSTRACT

The experiment was conducted at the Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka during the period from April 2013 to August 2013 to study the potentiality of producing summer cauliflower as influenced by organic manures and spacing. In experiment, the treatment consisted of three organic manures viz. F_0: no organic manure, F_1: Cowdung, F_2: Vermicompost and three spacing viz. S_1 (60 × 30) cm, S_2 (60 × 40) cm, S_3 (60 × 50) cm. Two factorial experiments were laid out in the Randomized Complete Block Design with three replications. Significant variations in all parameter were observed due to organic manure and spacing at different days after transplanting. For organic manure, highest yield of cauliflower (12.98 t ha^{-1}) was obtained from F_2 and lowest (8.24 t ha^{-1}) from F_0. For spacing, highest yield of cauliflower (11.25 t ha^{-1}) was obtained from S_1 and lowest (10.57 t ha^{-1}) from S_3. For combined effect, highest yield of cauliflower (13.33 t ha^{-1}) was obtained from F_2S_1 and the lowest (7.91 t ha^{-1}) from F_0S_3. The highest BCR (3.79) was found from F_2S_1 and lowest (2.7) from F_0S_3. So, 60 × 30 cm spacing with vermicompost was found best for yield of cauliflower.

CONTENTS

CONTENTS (contd.)

CONTENTS (contd.)

LIST OF TABLES

LIST OF FIGURE

LIST OF ABBREVIATED TERMS

FULL NAME	ABBREVIATION
Agro-Ecological Zone	AEZ
And others	*et al.*
Bangladesh Bureau of Statistics	BBS
Centimeter	cm
Degree Celsius	°C
Dounum	Da
Date After Transplanting	DAT
Etcetera	etc
Food and Agriculture Organization	FAO
Gram	g
Hectare	ha
Hour	hr
Kilogram	kg
Meter	m
Millimeter	mm
Month	mo
Murate of Potash	MP
Number	no.
Percent	%
Randomized Complete Block Design	RCBD
Sher-e-Bangla Agricultural University	SAU
Square meter	m^2
Triple Super Phosphate	TSP
United Nations Development Program	UNDP

CHAPTER I

INTRODUCTION

Cauliflower (*Brassica oleracea* var *botrytis* sub var. *cauliflora)* is a cole crop belongs to the family Brassicaceae. It was introduced in India in the year of 1882 (Swarup and Chatterjee, 1972). Cauliflower is a very tasty and much popular vegetable in Bangladesh as well as all over the world. 100 g edible part of cauliflower contains 89% moisture, 8.0 g carbohydrate, 2.3 g protein, 40 IU carotene, 0.13 mg B1, 0.11 mg B2, 50 mg vitamin C, 30 mg calcium and 0.8 mg iron and also contains 30 calorie (Rashid, 1999). Edible part of cauliflower is commonly known as 'Curd'.

Vegetable consumption in Bangladesh is very low, only 32 g per person per day against the minimum recommended quantity of 200g per day (FAO, 1986). The total vegetable production in Bangladesh is far below than the requirement. In 2009-2010 cauliflower cover an area 16600 hectares with a total production of 160000 metric tones (BBS, 2011). The success or failure of cauliflower production is largely depends upon climate, especially temperature and this relationship is very intensive and complex the life cycle of cauliflower is divided into three stages based on the effect of temperature; they are vegetative growth stage, curd initiation stage and reproductive stage. The suitable temperature for growth stages ranging from 20 ± 5°C. The best temperature for curd growth and development is 15°C to 20°C.

Cauliflower requires a period of cold not only for curd production but also for flowering. Fujime (1983) reported that cold requirement for flower production is stronger than for curd production. Cauliflowers that are produced in autumn and winter season in the temperate region can not be grown in Bangladesh, because they do not initate curd in the mild winter of Bangladesh. Only summer varieties of those regions initiate curd easily. Cauliflower requires a period of cold to stimulate curd initiation (Wiebe, 1972).

Organic fertilizer has far served as a formidable alternative. Many research works have shown that many organic wastes produced in the tropics have the ability to provide nutrients and enhance soil quality.

Utilization of organic matter has been well documented to improve physical, chemical and biological properties of soil (Whalen *et al.* 2000; Tejada and Gonzalez 2003), Cook *et al*. (1994) and the addition of compost to soil generally improves tilth, soil structure, infiltration, drainage and water holding capacity.

Soil management practices have recently changed dramatically including an increased use in synthetic fertilizers and pesticides to help crop yields. However, some studies have suggested that the excessive use of these agrochemicals may actually increase pest problems in the long run (Altieri and Nicholls, 2003). Overall, these results propose a hypothesis that higher synthetic fertilizer inputs may lead to higher levels of herbivore damage to crops (Letourneau, 1996).

Variety is an important factor for successful crop yield. An improved variety represents higher yield than wild one. Generally nutrient requirement is determined by the variety of crops. High yielding variety requires more nutrients than the local or wild variety. Generally it depends on its vegetative and reproductive characters. And it was also mentioned that vegetable variety and history of fertilizer use are important factors to be considered in the development of a soil nutrient management program (Huang, 2006).

The benefits of organic production on food quality and safety have created high global demand for organic products. Utilization of organic wastes from agriculture as organic fertilizer for growing crops commercially is very much dependent on the availability of organic wastes and comparability with chemical fertilizers in plant growth and yield performance. Often organic fertilizers are associated with lower yield compared to chemical fertilizers.

In Bangladesh, cauliflower is mainly cultivated in winter season. Summer season cauliflower cultivation is constrained due to adverse weather condition along with absence of summer tolerant varieties and proper cultural practices. Introducing hot and summer tolerant cauliflower variety might help solving of cauliflower production in the country. The production of cauliflower in summer season is a challage wheather it will grow only in winter. The demand of cauliflower is increasing day by day in summer season because of its demand to consumer for taste and nutrient value.

Spacing is another factor that was reported to be having an influence on cauliflower production. Widders and Price (1989) defined spacing as the distance between the plants in the row and between the rows of planted crops. Ghanti, *et al;* (1982) observed maximum results of yield contributing characters at higher spacing and a decrease as spacing between plants decreased.

Considering the above factors, the present experiment was undertaken to study the following objectives-

- To identify the appropiate organic manure for cauliflower population.
- To study the effect of different spacing on growth and yield of cauliflower.
- To study the combined effect of organic manure and spacing on growth and yield of cauliflower.

CHAPTER II

REVIEW OF LITERATURE

Cauliflower is one of the important vegetable. Crop species differ in their nutrient requirements depending on the stage of development and part of the plant that is of economic importance. Most vegetables have a high requirement for nutrient for its growth and development. Though, plants get major nutrients from the soil, they are not adequate to meet the increasing demand for higher production. The literature on the potentiality of producing summer cauliflower as influenced by different organic nutrient sources and spacing is included in this chapter for better understanding of the subject.

2.1 Effect of organic manures on the growth and yield of cauliflower

The organic matter is called the life of the soil. Fertility of a particular soil is determined by the presence of organic matter. The organic matter content of soil varies from 0-5% and it depends on several factors like origin of soil, climatic conditions, vegetation, microbial activities etc. The physical, chemical and biological properties of soil are greatly influenced by organic matter. Although, organic matter content all the essential plant nutrients, but after application of organic manures required time to convert its available form to the plant. That is why the response of crops to organic manures is low. But due to the residual and beneficial effects on soil properties, applications of organic manures are encouraged. Some available information about the effects of organic manures on growth and yield of caulifower are reviewed here.

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 ($N:P_2O_5:K_2O$; 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.

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.

Little research has been carried out on the agronomic value of compost produced from garden organics for vegetable production. A field experiment was established in Camden, near Sydney, Australia, to (i) evaluate the effect of the compost on vegetable production and soil quality relative to conventional practice, (ii) compare vegetable production under high and low soil P status, and (iii) monitor the changes in soil P concentration under two compost treatments relative to conventional farmers' practice. After three successive crops (broccoli, eggplant and cabbage), results indicate that compost (120 dry t/ha) and half-compost (60 dry t ha^{-1} supplemented by inorganic fertilisers) treatments can produce similar yield to the conventional practice of using a mixture of poultry manure and inorganic fertilizer. Furthermore, similar yields were achieved for three different crops grown under high and low P soil conditions, clearly demonstrating that the high extractable soil P concentrations currently found in the vegetable farms of Sydney are not necessary for maintaining productivity. The compost treatments also significantly increased soil organic carbon and soil quality including soil structural stability, exchangeable cations, and soil biological properties. Importantly, the compost treatment was effective in reducing the rate of accumulation of extractable soil P compared with the conventional vegetable farming practice. Our results highlight the potential for using compost produced from source separated garden organics in reversing the trend of soil degradation observed under current vegetable production, without sacrificing yield (Chan *et al*. 2008).

Commercial brands of alternative, organic fertilizers were compared in Lednice (Czech Republic) in 2004 and 2005 with conventional, mineral fertilizers using head cabbage. There were six different treatments: conventional farmyard manure, Agro (made from poultry bedding and molasses), Dvorecky agroferm (granulated, made from dried, aerobically-fermented farmyard manure), Agormin (an organo-mineral fertilizer), compost manufactured from plant waste material, mineral fertilizer, and an unfertilized control. All the treatments were applied at rates providing approximately the same level of nutrients. After harvest, the levels of the minerals (K, Na, Ca, and Mg), ascorbic acid, nitrates and yield were measured. There were no significant differences between the treatments in levels of K, Na and Ca in the case of organic fertilizers (farmyard manure, Agro, Agormin and compost). The unfertilized control had the highest levels of ascorbic acid; it was significantly higher than in the case of farmyard manure which, in turn, had significantly higher values than compost. Significant differences between the treatments were found in the levels of nitrates; the lowest in the case of Dvorecky agroferm and in the control. The highest marketable yields were recorded with farmyard manure and Dvorecky agroferm, the latter being significantly higher than the control. This study shows that alternative, organic fertilizers (except for compost) have similar qualities as farmyard manure (Zahradnik and Petrikova 2007).

Vimala (2006) conduct and experiment to determined the effects of organic fertilizer (processed poultry manure) on the growth, yield and nutrient content of cabbage in tunnel-shaped structures with plastic roof and netted sides in Serdang, Malaysia. Treatments consisted of varying rates (0, 15, 30, 45 and 60 t ha^{-1}) of processed poultry manure. The control treatment was an inorganic fertilizer applied at 2 t ha^{-1}. A quadratic yield response to organic fertilizer rates, represented by the equation Y=9.832+0.636x-0.008x2, where Y=yield in t/ha and x=organic fertilizer in t/ha, was recorded. The optimum rate of fertilizer was 39.75 t ha^{-1}. Yields obtained at this rate was 22.47 t ha^{-1}. A quadratic response to fertilizer rates was also obtained for canopy width. A linear response was obtained for head diameter. Organic fertilizer rates had significant effects on the P and K contents of the crop. The N content increased with increasing rates of organic fertilizer, although the increase was significant only for the outer leaves. Organic fertilizer rates did not significantly affect Mg content. Nitrate contents did not differ significantly but were highest in the outer leaves with the application of inorganic fertilizer. All rates of organic fertilizer improved the soil chemical properties compared to inorganic fertilizer. It is concluded that about 40 t ha^{-1} of processed poultry manure as the sole source of nutrients can be used for organic cultivation of lowland cabbage grown on clay soils under shelter.

Lathiff and Maraikar (2003) conducted an experiments commencing in the season of 1999/2000, on a reddish brown latosolic soil, at Gannoruwa in the midcountry wet zone of Sri Lanka, to study the performance of different vegetable crops when grown as a monocrop and as mixed crops under an organic farming system. Cattle (CM) and poultry (PM) manure, applied at rates of 20, 30, 40 and 10, 20, 30 t/ha, were the only source of nutrients for the crops. For comparison, a chemical fertilizer treatment, using recommended quantities of NPK, was included in all experiments conducted. In the monocrop experiments, aubergine, cabbage and tomato gave comparable or sometimes higher yields when treated with manure than with NPK. The performance of bush bean [Phaseolus vulgaris], on the other hand, was poor when treated with manure than with NPK. In the mixed crop experiments, where the performance of different combinations of bush bean, cabbage, capsicum, carrot and knol khol [Brassica oleracea var. gongylodes], were tested, there was no significant yield increase with increasing rates of CM, but there was a significant difference between yields obtained with PM at 10 and 30 t/ha. Changes in soil quality, particularly pH and Olsen P content, were evident after 6 seasons of continuous manure application. The medium rate of manure used in this study seems sufficient to produce satisfactory organic vegetable yields.

The chemical composition of the juice obtained from three cabbage cultivars, i.e. Kamienna Gowa, Decema and Amager, was investigated. Ten enzymatic preparations were used to obtain the juices from these cultivars. In both the fresh material and the obtained juices, the contents of dry substance, total extract, total sugars, total acids, vitamin C [ascorbic acid], macro- and micro elements, proteins, raw fibre and total ash were determined. The results revealed that chemical composition and juice yield were influenced by the cultivar. The best cultivar was Decema, which was characterized by high dry substance (8.55%), total extract (7.33%), proteins (1.40%), total sugars (3.61%), total ash (0.84%) and vitamin C (36.40 mg) in the raw material. In terms of industrial use, however, Kamienna Gowa was the best cultivar, as it gave significantly higher juice yield (74.1%) and more profitable contents of total extract (6.04%), total acids (0.29 g/100 g), vitamin C (20.53 mg), potassium (1674.46 mg/kg), magnesium (104.44 mg/kg) and calcium (340.69 mg/kg). The addition of enzymatic preparations allowed to obtain juices with increased dietary value (Zalewska and Kalbarczyk, 2001).

Chemical and physical analysis, 27-d plant growth assays with carrot (Daucus carota) and Chinese cabbage (Brassica campestris var. chinensis), and 5-d phytotoxicity assays with Chinese cabbage and perennial ryegrass (Lolium perenne) were used to investigate the suitability of anaerobically digested poultry slaughterhouse waste for fertiliser in agriculture and the effect of aerobic post-treatment on the properties of the digested material. The digested material appeared to be rich in nitrogen. In 27-d assays with digested material as nitrogen source, carrots grew almost as well as those fertilised with a commercial mineral fertiliser used as reference, whereas, the growth of Chinese cabbage was inhibited. In further 5-d phytotoxicity assays, the digested material inhibited the germination and root growth of ryegrass and Chinese cabbage, apparently because of organic acids present in it. Aerobic post-treatment of the material reduced its phytotoxicity but, probably due to the volatilisation of ammonia, resulted in loss of nitrogen (Salminen, 2001).

Lu, N. and Edwards, J.H. (1994) conducted a greenhouse pot study with a Wynnville sandy loam surface soil to determine the influence of application rates of poultry litter (PL) on growth and nutrient uptake of collard [kale] cv. Champion, and the residual effects of PL on growth and nutrient uptake of cabbage cv. Rio Verde. PL at 0, 13, 26, 53 and 106 g/kg was incorporated into limed (pH 6.5) and non-limed (pH 5.2) soil. Collard plants were grown for 52 days. The residual effects of PL were evaluated by growing 3 successive crops of cabbage without further application of PL (total 218 days). Collard plants were severely damaged or killed within 7 days after transplanting when the application rate of PL exceeded 26 g/kg soil. The rate of PL application that resulted in maximum cabbage DM yield increased from 26 to 106 g PL/kg soil during 3 successive crops. After 4 successive growth periods, 6-37% of N, 3-62% of Ca, 20-120% of K, 5-60% of Mg and 3-25% of P added through PL was removed by plants. The decrease in water-extractable K accounted for the decrease in soil salinity. The results suggest that application rates of PL of <more or =>53 g/kg soil can result in elevated levels of salts and NH3 in soil, which can produce severe salt stress and seedling injury.

Hochmuth *et al*. (1993) conducted an experiment to investigate the response of cabbage yields, head quality and leaf nutrient status to poultry manure fertilization. They reported that the marketable yield of cabbage responded quadratically to increasing rates of poultry manure during 1990, with the maximum yield (28.4 t ha^{-1}) being obtained by 18.8 t ha^{-1}. Yields recorded with 1.0 to 1.4 of conventional NPK fertilizer/ha were same as those with the highest rate of manure. The results showed that manuring efficiency was initially higher with commercial fertilizer than the poultry manure alone, since lower amounts of total nutrients were applied using commercial fertilizer.

The growth of cabbage in loamy soils was severely inhibited and the yield of marketable head was reduced, as reported by Nishimune *et al*. (1994). They also found that repeated applications of compost alleviated the problem but yields were not higher compared to newly cropped or rotated fields.

Krupkin *et al*. (1994) made an investigation using poultry manure, mixture of poultry manure plus hydrolysis lignin, and a compost of poultry manure plus hydrolysis lignin as organic fertilizers for potatoes, carrots, cabbage etc. with and without irrigation. The results showed that these organic fertilizers improved the yield and quality of the crop, especially on soil having a low content of nitrate N, but had only little effect on soils well supplied with nitrate N. The lignin based fertilizers i.e. mixture of poultry manure and hydrolysis lignin and a compost of poultry manure plus hydrolysis lignin were similar in their effect to poultry manure.

Flynn *et al*. (1995) carried out an experiment to evaluate the suitability of composted broiler chicken manure as a potting substrate using lettuce plants.

They mentioned that the broiler manure containing peanut hulls as breeding material was composted and then combined with a commercially available potting substrate. Highest fresh weight yield was obtained when broiler chicken litter compost was mixed with commercially available potting substrate at 3:1 ratio. There was no evidence of physiological disorders resulting from excessive nutrient concentrations.

Lu and Edwards (1994) suggested that application of 26 to 106 g Pm/kg soil resulted the maximum DM yield in cabbage grown in a green house pot study in USA.

Roe (1998) carried out an experiment by using compost, obtained from dairy manure and municipal solid waste to find out the beneficial effects on broccoli. He found beneficial effects on growth, yields and nutrient contents with compost application in the broccoli production.

Vidigal *et al*. (1997) performed an experiment in Brazil with lettuce using various organic compounds viz. crushed sugarcane, napier grass and coffee straw mixed with pig slurry in various combinations with or without gypsum or triple superphosphate. They found that napier grass + coffee straw + pig slurry was the best mixture, increasing yields by 10.8% and 17.6% than those produced by NPK in first and second crops, respectively.

An experiment was carried out by Zarate *et al*. (1997) in Brazil to evaluate the rates and methods of application of poultry manures on lettuce. The soil was supplied with 0, 7 or 14 t semi-rotted poultry manure incorporated into the soil and 0, 7 or 14 t semi-rotted poultry manure applied to the soil surface. They found in the absence on incorporated manure, surface application of 14 t ha^{-1} manure gave significantly higher yield (17.8 t fresh matter ha^{-1}) than other nutrients. When 7 t ha^{-1} was incorporated, the rate of surface application had no significant effect on yields (13.3 - 17 t ha^{-1}), where as when 14 t ha^{-1} was incorporated, surface application of 7 t ha^{-1} manure gave the significantly highest yields (20 t ha^{-1} Fresh matter).

Devliegher and Rooster (1997a) conducted an experiment on lettuce and Chinese cabbage by using pre-plant compost, obtained from different sources. The composts were comprised of (i) GFT, derived from vegetable, fruit and small garden waste; (ii) Humolex, derived from GFT compost, and (iii) green compost, derived from vegetable waste. They applied the composts at 25 t dry matter/ha. They found that average plant weight was increased by GFT and Humolex but green compost had no effect.

Devliegher and Rooster (1997b) carried out another experiment in Belgium on cauliflower, using standard peat-based compost alone or supplemented with green compost or a GFT- compost. They observed that plant growth was the greatest for plants raised in standard compost and harvest date was earlier.

Alam (2000) conducted an experiment to study the effect of different forms of mustard oil cake (MOC) and its different methods of application with growth and yield of potato (cv. Diamant). He reported that higher yield of tuber (33.31 t ha^{-1}) was obtained from decomposed form of MOC than powder form (32.18 t ha^{-1}).

2.2 Effect of plant spacing on growth and yield of cauliflower

Sharma and Rastogi (1992) were conducted at Horticultural Research Station, Kandaghat for two years (1988–90) to find out the response of cauliflower (PSB-1) to different levels of nitrogen (0, 50, 100, 150, 200 kglha) and plant spacing (60 x 30 cm, 60 x 45 cm and 60 x 60 cm). Maximum days to 50 per cent curd maturity, bolting and flowering were recorded when no nitrogen was applied for seed crop. However, maximum plant height and number of branches per plant were obtained at 200 kg N ha^{-1}. Maximum seed yield per plant as well as per hectare was obtained at 200 kg N ha^{-1}. It was noticed that plant spacing had no significant effect on days to 50 per cent curd maturity, bolting, flowering and plant height. However, highest number of branches per plant and maximum seed yield per plant was recorded at 60 x 60 cm, whereas maximum seed yield per hectare was recorded at 60 x30 cm. It was concluded that an application of 200 kg N ha^{-1} and a plant spacing of 60 x 30 cm is best for obtaining maximum seed yield per hectare of cauliflower cv. PSB-1.

Moniruzzaman (2011) carried out a field experiment on cabbage (*Brassica oleracea* var. *capitata*) comprising two plant spacings viz. 60 × 40 cm and 60 × 45 cm and ten hybrid cabbage varieties viz. Green Rich, Green-621, Green Coronet, Summer Warrior, Rare Ball, Atlas-70, Southern treasure, Laurels, KK Cross and K-S Cross was conducted during 15 October to 12 February of 2005-07 at the Agricultural Research Station, Raikhali, Rangamati Hill District to find out the optimum plant spacing and suitable cabbage variety(s). The wider spacing of 60 × 45 cm resulted in significantly maximum number of folded leaves and head weight (without unfolded leaves) in comparison to closer spacing of 60 × 30 cm. The variety Green Coronet took the highest duration (119 days), while Green-621 took the lowest duration for harvest (105 days). Although Green Coronet grew vigorously, it did not produce the highest head yield. All the varieties had good head compactness except Laurels and Green Coronet which had medium and less compactness, respectively. The combination of 60 × 30 cm spacing with variety Southern Treasure and K-S cross produced the highest head diameter, but wider spacing of 60 × 45 cm accompanied by Southern Treasure produced the highest head weight without unfolded leaves followed by K- K Cross in both the years. The pooled analysis showed the highest marketable head yield (73.32 t ha^{-1}) in the combination of 60 x 40 cm spacing with K-K Cross, which was closely followed by Southern Treasure (71.71 t ha^{-1}) and Laurels (71.56 t ha^{-1}). The variety Green-621 was found suitable for early harvest with reasonable yield (67.82 t ha^{-1}).

Amreesh, (2002) conducted a field experiment at village Pemasar, in Bikaner district (Rajasthan, India) during the rabi season 2001-2002 to find out the economics of cabbage (*Brassica oleracea* var. *capitata*) production. The wider spacing recorded the maximum yield and highest net return in the crops. In cabbage, the highest net return was obtained in treatment combination of 60 cm × 60 cm spacing + 150 kg N ha^{-1}.

Parmar *et al*., (1999) conducted a field experiment in 1999 in Gujarat to study the response of cabbage cv. Golden Acre to irrigation levels, plant spacing (30cm×30 cm or 40 cm ×30 cm) N application (150-250 kg ha^{-1} in clay soil. Mean marketable head yield was highest with 250 kg N (20.6 t), but was not significantly different at 2 spacings, but the yields were consistently higher at the narrow spacing.

A field experiment was conducted in Mymensingh, Bangladesh, from October 1996 to March 1997 to study the effects of irrigation regime and spacing (50 cm×60 cm, 50 cm×50 and 50 cm×40 cm) on cabbage cv. Atlas-70. A spacing of 50 cm×40 cm resulted in the highest gross yield (118.72 t ha^{-1}). The widest spacing gave the highest fresh weight of individual head (2.376 kg). The highest marketable yield (79.69 t ha^{-1}) and harvest index (80.17) were obtained with a spacing of 50 cm × 50 cm. Net return (Tk. 128.026 t ha^{-1}) and benefit cost ratio (2.63) were highest with a spacing of 50 cm × 50 cm (Mannan *et al*., 2001).

An experiment was carried out by Khatun (2008) at the farm of Sher-e-Bangla Agricultural University, Dhaka-1207 during the period from October 2007 to February 2008 to study theeffect of plant spacing and potassium on the growth and yield of cabbage. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications and includes of Factor A: three different plant spacing; S1 (60 cm x 30 cm), S2 (60 cm x 40 cm) and S3 (60 cm x 60 cm) and Factor B: four levels of potassium; K0 (control), K1 (90 kg ha^{-1}), K2 (120 kg ha^{-1}) and K3 (150 kg). At 60 DAT the highest plant height (37.70 cm), maximum diameter of head (19.05 cm), fresh weight head (1.87 kg), gross yield (71.20 t ha^{-1}) and marketable yield (53.97 t ha^{-1}) was recorded from 60 cm x 40 cm spacing.

An experiment was carried out by Ullah (2011) at the farm of Sher-e-Bangla Agricultural University, Dhaka-1207 during the period from October 2010 to March 2011 to study theeffect of planting time and spacing on the growth and yield of cabbage. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications and includes of Factor A: three different planting times; T1 (7 November), T2 (21 November) and T3 (5 December) in 2010, and Factor B: three different plant spacing; S1 (60 cm x 40 cm), S2 (60 cm x 45 cm) and S3 (60 cm x 50 cm). At 80 DAT the highest plant height (31.5 cm), maximum diameter of head (19.4 cm) and the highest fresh weight (1.00 kg) were found from S3 and the lowest weight (0.86 kg) from S1. On the other hand, at 80 DAT the tallest plant height (35.9 cm), maximum diameter of head (20.4 cm) and highest weight of head (1.28 kg) were found from T1 and the lowest weight (0.53 kg) from T3 treatment. The highest fresh weight of head (1.36 kg) was recorded from T1S1 and the lowest fresh weight of head (0.4 kg) from T3S3. He concluded that, the spacing (60 cm x 40 cm) and 21 November planting time were found suitable for growth and yield of cabbage.

An experiment was carried out to study the effects of N (0,50,75 or 100 kg ha^{-1}) and spacing (30 cm×60 cm, 45 cm×60 cm or 60 cm×60 cm) on the growth and yield of cabbages (cv. Golden Acre), at K.V.K. Badgaon, Udaipur, India. Growth (number of leaves, height of plant and weight of head) increased with increasing rates of N. The highest yield (254.85 q ha^{-1}) was observed at 100 kg N/ha compared with 168.73 q ha^{-1} in control. Yield decreased with increasing plant density, from 245.22 q/ha at a spacing of 30 cm × 60 cm to 184.71 q ha^{-1} at a spacing of 60 cm×60 cm (Gopal, 1996).

Ferreira *et al*. (2002) carried out a study on *Brassica* crop due to their importance as food for human consumption, especially in relation to their nutritional value. Both yield and consumption were high. *Brassica chinensis* var. *Parachinensis* was introduced in Uberlandia, Minas Gerais, Brazil, in 1992, surpassing other Brassica due to its high content of vitamins A and C, calcium and iron, and for becoming ready for consumption in about 30 days. The yield of this variety was analyzed under three kinds of fertilizers and three spacings with a view to its production on a commercial scale. The leaf area, dry matter mass, and absolute growth rate were higher with mineral than organic fertilizer. High values for relative growth rate and net assimilation rate were recorded in plants growing in greater spacings (30 cm × 20 cm and 30 cm × 30 cm). The highest value of agronomic yield (21.5 t/ha) was reached in the smallest spacing (30 cm × 10 cm), with mineral fertilizer application. This value is near to that registered in Malaysia and China where this vegetable was cultivated on a large scale.

Freyman *et al*. (1992) carried out study on the effects of intra-row competition by C. bursa-pastoris, grown either 10 of 25 cm apart, with cabbages cv. Tucana grown on well-drained soil in single rows and spaced 20 or 50 cm apart within the rows. At 50 cm spacing, cabbage head weight was reduced by C. bursapastoris grown at either spacing. However, at 20 cm spacing, cabbage head weight was unaffected by C. bursa-pastoris grown 25 cm apart but was reduced in 1 of 2 years when the weed was grown 10 cm apart. When cabbages were grown weed-free in 3 rows at either 20 cm×100 cm or 50 cm×40 cm spacing, no differences in yield were found. The results indicate that cabbages grown in wide rows with close within-row spacing should experience minimal intra-row weed competition.

Fujiwara *et al*. (2000) conducted an experiment to study the effects of planting densities of cabbage plant transplants in the field on the uniformity of their initial growth and head size at harvest. Head size uniformity decreased with small within-row spacing (WRS) from the beginning of head formation. Unevenness of initial-growth of high-density transplants resulted in a decrease of uniform head size at harvest. This lack of uniformity is attributed to the initial differences in growth which increased with time. Retarding harvest time did not improve growth uniformity. Gaps within the row and the slow growth of some plants promoted the growth of adjacent plants. This tendency was strong under high densities. Hence, growth uniformity was decreased with time. Head size uniformity at harvest decreased when WRS was small. The degree of the decrease was controlled by the initial-growth uniformity of transplants.

Fujiwara *et al*. (2003) carried out an experiment where a high uniformity of cabbage weight was obtained using a small-spreading and early-ripening cultivar despite high density planting because of shorter period of competition between plants and higher head weight/top weight ratio. A high uniformity of cabbage head weight in winter sowing-early summer harvesting cropping type (cropping type for rising temperatures) was successfully maintained despite the high density condition compared with summer sowing-winter harvesting cropping type (cropping type for decreasing temperatures) because of suppressed spreading of the initial growth.

Guzman (1990) monitored the effect of 12,13,14 and 15 inch(30.5, 33.0,35.6 and 38.0cm) plant spacing in the row to maximize yield and quality of transplanted crisphead lettuce. Spacing did not have a significant influence on fresh mass and the number and percentage of marketable heads. This suggested that 12 to 15 inch (30.5to38.0cm) plant spacing gave similar productivity. Nevertheless, it was evident that 12 or 13 inch (30.5or33.0cm) spacing would probably maximize yields more than with wider spacings. All plant spacings under study provided good head mass and quality.

Hill (1990) studied in an experiment at Manjimup Research Station on a sandy loam over clay at 60 cm, Chinese cabbage cv. Early Jade Pagoda was grown at spacing of 25 cm×25 cm, 30 cm×30 cm, 35 cm×35 cm, or 40 cm×40 cm and given 0,50, 100, 200, 300 or 400 kg N/ha. The highest marketable yields were 126.6 and 123.6 t ha^{-1}, respectively. Marketable yield for this spacing increased as N rate increased from 0 to 200 kg ha^{-1}, remained constant from 200 to 300 kg/ha and decreased when N rate was increased to 400 kg ha^{-1}. Soft rot damage was severe at the highest N rate and contributed to the reduced yield. The yield potential of Chinese cabbage was higher at wider spacing than at the close spacing. Plant height was not affected by any treatment, but plant width increased at the higher N rates.

Jaiswal *et al*. (1992) conducted an experiment on cabbage cv. Pride of India on 4 September1985 and transplanted on 10 October 1985 at a spacing of 30 cm×30 cm or 30 cm×20 cm. N was applied at 125, 250 or 375 kg ha^{-1}. Half of the N was applied as a basal dose and as top dressing 2 weeks after transplanting (WAT).The remaining ¼ of the N was applied as a top dressing 4 WAT (M1) or as a foliar application at 4,5,6 or 7 WAT (M2). Plant growth and productivity increased with increasing level of N application and was highest under M2. Plant growth was highest at the wider spacing but productivity (yield ha^{-1}) was highest at the smaller spacing. Highest yield (770.77 q ha^{-1}) was obtained with 375 kg N ha^{-1} applied under M2 at 30 cm×20 cm.

Kumar and Rawat (2002) conducted a study during 1997-98 at the Horticulture Farm, Rajasthan College of Agriculture, Udaipur, to determine the effects of nitrogen and spacing on the quality and yield of cabbage (*Brassica oleracea*L.var. *capitata*). It was observed that spacing had no effect on dry matter percentage. Maximum head diameter and head mass were recorded at wider spacing. It was believed that wider spacing provided more sufficient space and less competition between available nutrients for plants. Therefore, there was increase in the head diameter and head mass.

Mallik (1996) determined the response of cabbage cv. Pusa Drum Head to N fertilizer application rate (0, 40, 80 or 120 kg ha^{-1}) and spacing (60 cm × 45 cm or 60 cm × 60 cm) in field trials conducted on a sandy loam soil during the winter season of 1989-90. Yield increased with increasing rate of N application (57.76 and 331.46 q ha^{-1} with 0 and 120 kg ha^{-1}, respectively) and was higher at the closer spacing than at the wider spacing (229.53 and 207.37 q ha^{-1}, respectively). Highest net profit and cost benefit ratio were obtained at 120 kg N/ha and at the closer spacing.

Mannana *et al.* (1999) set up an experiment on six water regime treatments (40, 60, 80 or 100% of field capacity, or switching between 40 and 100% capacity at different growth stages) applied to cabbages grown at 50 cm×60 cm, 50 cm×50 cm or 50 cm×40 cm spacing. Among the water regime treatments, 80% field capacity gave the highest growth and dry matter of stem, leaf and head and total DM, and highest marketable yield per hectare. Severe stress produced the highest (19.19 g) dry matter of roots per plant and root shoot ratio. Growth, dry matter accumulation and yield were higher when stress was applied in vegetative growth than at heading. The maximum growth and dry matter of leaves, head, stem and root were obtained from the widest spacing (60 cm×50cm) and the lowest from the closest spacing (50 cm×40 cm). Maximum marketable yield was obtained from the moderate spacing of 50 cm×50 cm.

Meena (2003) conducted an experiment in Rajasthan, India, during the rabi season of 1997-98. Three levels of spacing, (30 cm × 45 cm) (45 cm × 45 cm) and (60 cm × 45 cm) had 72, 48, 36 plants respectively. Plant height was not significantly affected by increasing levels of spacing at all crop growth stages. Leaf number per plant significantly increased with increasing levels of spacing at 30 and 60 days after transplanting (DAT). The percent increase in leaf number per plant was 8.3 at 30 DAT, and 9.9 at 60 DAT. Stem diameter significantly increased with increasing levels of spacing. Stem diameter was the highest 1.28cm compared with 1.15cm and 1.00cm diameters were recorded respectively. Leaf area was the highest with 315.41 cm2 and lowest with 310.83 cm2 at harvest. The average head weight was the highest 831.3 g and the lowest 766.3 g. The percent increase in head weight was 8.5. A significant increase in biological and economical yield was observed. The percent harvest index was the highest 71.3 and the lowest 70.3. Closer spacings resulted in higher biological and economic yield.

Orowski (1991) studied in 3-year trials with the cultivar Amager; the seeds were sown at 6 or 0.6 g/m superscript 2 in rows 10, 15, 20 or 25 cm apart. The sowing treatments had no marked effect on transplant quality but the highest total 3-year marketable yield of head cabbage viz. 156.2 t ha^{-1}, were obtained by sowing weight 0.6 g/m row with rows 20 cm apart. The transplant raising treatment had generally no adverse effect on crop quality.

Prabhakar and Srinivas (1990) recorded higher cabbage head yield(11t ha^{-1}) with closer spacing(50x30cm) than wider spacings(50x40cmand50x50cm). Parmar *et al.*,(1999)noted higher head yield(16to43%) in30x30cm over45x30cm during individual years of conducting experiments.

Puiatti *et al*. (2005) studied the effects of three spacings (80 cm × 30 cm, 60 cm × 30 cm and 40 cm × 30 cm) and five rates of N (0, 75, 150, 225 and 300 kg/ha-1) on the qualitative aspects of cabbage cv. Kenzan in Minas Gerais, Brazil. The seedlings were produced in trays of 128 cells, under polyethylene cover greenhouse and transplanted after 28 days. The rates of N were divided as follows: 20% of the total rate at transplantation and at 20 DAT, and 30% at 35 and 50 DAT. Plants were harvested from 65 to 83 DAT. The average fresh head weight, transverse and longitudinal diameters, volume of head and total protein content were evaluated, aside from the post harvest losses during storage.

Sandhu *et al.* (1999) conducted a trial on plant growth characters in cabbage, variety. Golden Acre in Punjab, India during 1989-90 and 1990-91 under the influence of twelve combinations of spacing (30,45,60 and 75 cm row to row and 15,30 and 45 cm plant to plant) and six levels of nitrogen (0, 62.5, 125, 187.5, 250 and 312.5 kg N ha^{-1}). The application of 187.5 and 125 kg N ha^{-1} with wider spacing of 75 cm×45 cm and 75 cm×30 cm produced maximum plant spread. However, the application of 125 kg N ha^{-1} with closer spacing of 45 cm× 45 cm and 30 cm×45 cm produced the highest total yield of cabbage heads with good head compactness, which may be due to more number of plants per unit area. Total yield and head compactness were reduced considerably with the increase in nitrogen level beyond 187.5 kg N ha^{-1}.

Shaker (1999) carried out two field experiments during two successive winter seasons (1996-97 and 1997-98) in Egypt to evaluate the effects of planting date (first week of November, December or January) and spacing (40, 50 and 60 cm between plants) on cabbage cv. Balady. Data were recorded for plant height, number of branches per plant, number of inflorescence per plant, inflorescence length, number of pods per inflorescence, pod length and seed yield. Early planting and wide spacing significantly enhanced the growth of cabbage. However, early planting and narrow spacing recorded the highest seed yield per feddan.

Singh (1996) tested nitrogen, phosphorus and spacing for their impact on cabbage (cv. Pusa Drumhead) under Chotanagpur conditions. It was observed that with the increase in plant spacing from 30to60cm, there was a significant reduction in the number of marketable heads per unit area. The reductions were associated with higher plant densities in the closer spacings. Spacing did not have any significant in fluence on the head index, butan increasing trend was observed as spacing increased. Significant improvements in head volume were attained with an increase in spacing. Similar behavior was again observed with head mass a ssignificantly higher mass was recorded at 60cm spacing compared to 30 and 40cm inter-row spacings. This behavior was attributable to availability of enough space and more nutrients at the widest spacings, which encouraged the growth and development of plants.

Singh *et al*. (2007) conducted an experiment in Allahabad, Uttar Pradesh, India during winter season of 2000-2001 to evaluate the effects of N (0, 40, 80 and 120 kg/ha) and spacing (30 cm × 45 cm and 30 cm × 60 cm) on the growth and yield of cabbage [B *pekinensis*]. Yield and yield components increased with increasing N levels. Maximum curd weight/plant (1.68 kg) was obtained with

N at 120 kg/ha. Spacing at 30 cm × 60 cm resulted in maximum values (38.20, 12.20, 12.20 15.9 and 34.35 cm) for plant height, leaf number, leaf width, midrib length, and plant spread, respectively.

Stepanovic *et al.*(2000) reported highest cabbage head diameter values in the case of lowest crop density .It was observed that head diameter decreased in parallel with increasing crop density. In the contrary, higher cabbageyields per hectare were recorded in the case of higher plant densities. The higher crop densities were as a result recommended for cabbage production. It is, however, important to compare the issue of profitability of such a production with the high costs of transplants and manual labour. The most suitable crop density is that which ensures high yields, good quality and low production costs.

Tendaj and Kuzyk (2001) carried out a research to check whether greater plant density in cultivation of late red cabbage cultivars influence the size, yield and the weight of heads. Seedlings of three cabbage cultivars-Langenkijker Pol, Rodima and Roxy were planted at 30 × 45 cm, 40 cm×45cm, 50 cm×45 cm and 60 cm×45 cm spacing, what equaled the density of 7.4, 5.5, and 3.7 plants m^{-2}. It was demonstrated that various plant density had no significant effect on the size of the marketable yield of heads but it was significant for their weight. The largest marketable yield was obtained at 4.4 and 5.5 plants m-2 density, i.e. at the spacing 40 cm × 45cm and 50 cm × 45 cm, (on average 61.9-63.9 t ha^{-1}). Such plant density was advantageous for forming heads of rather low weight on average (1017-1250 g).

Tendaj and Kuzyk (2001) initiated a study to investigate the influence of greater plant density on the yield and head mass of red cabbage cultivars. They reported highest yield of marketable heads from 50x45cm spacing. There was no significant difference between 50x45cm spacing and the lower spacings (30x45cm and 40x45cm). As spacing was increased to 60x45 cm each cultivar used gave lower yields.

CHAPTER III

MATERIALS AND METHODS

This chapter deals with the materials and methods that were used in carrying out the experiment. It includes a short description of location of the experimental plot, characteristics of soil, climate and materials used for the experiment. The details of the materials and methods are described below.

3.1 Experimental site

The field experiment was carried out at the Horticulture Farm, Sher-e-Bangla Agricultural University (SAU), Dhaka during the period from April, 2013 to August, 2013. The experimental field was located at 90° 22′ E longitudes and 23°41′ N latitude at an altitude of 8.6 meters above the sea level (UNDP, 1988). The land was in Agro-Ecological Zone of Madhupur tract (AEZ No-28). It was deep red brown terrace soil and belonged to “Nodda” cultivated series. The soil was sandy loam in texture having pH 6.06. Physical and chemical characteristics of the soil have been presented in Appendix I.

3.2 Climate and weather

The experimental area was under the sub-tropical monsoon climate, which is characterized by heavy rainfall during kharif season (April to September) and scant or no rainfall during the rest of the year. Plenty of sunshine and moderately low temperature prevails during rabi season (October to March), which are suitable for growing cauliflower in Bangladesh. Monthly total rainfall, relative humidity and temperature during the study period have been presented in Appendix II.

3.3 Materials used for the experiment

The varieties of cauliflower selected for the experiment were ‘White beauty’. The seeds of this variety were collected from Siddique Bazar, Dhaka.

3.4 Raising of Seed bed

Seed bed was made on 20 April for raising cauliflower seedlings. The size of the seed bed was 3 m × 1 m. For making seed bed the soil was well ploughed and converted into loose friable and dried masses to obtain good tilth. Weed stubbles and dead roots were removed from the seed bed. The surface of the bed was made smooth and well leveled. Well decomposed FYM@ 2-3 kg/m^2 was added at the time of bed preparation. Raised beds are necessary to avoid problem of water logging in heavy soils.

3.5 Seed Treatment

Seeds were treated by Vitavax 200 WP@ 2.5 g/kg of seed to protect some seed borne diseases such as damping off and leaf spot.

3.6 Seed Sowing

Seeds were sown on seed bed on 20 April. The soil of the seed bed was well prepared and made into loose friable mass by spading. The bed was covered with dry straw to maintain required temperature and moisture. Sowing was done thinly spaced at 5 cm distance and the seeds were sown at a depth of 2 cm and covered with a fine layer of soil followed by light watering with a water can. The cover of dry straw was removed immediately after emergence of seedlings.

3.7 Raising of Seedling

Light watering and weeding were done as and when needed. No chemical fertilizer was applied for raising of seedlings. Seedlings were not attacked by any kind of insect or disease. Healthy seedlings were transplanted.

3.8 Design of experiment

The experiment was conducted in Randomized Complete Block Design (RCBD) with three replications. Two factors were used in this experiment is three levels of fertilizer and three types of spacing.

Factor A

Three levels of fertilizer: denoted as (F)

F_0 : Control (No fertilizer)

F_1 : Cowdung 30 t/ha

F_2 : Vermicompost 20 t/ha

Factor B

Three different spacing: denoted as (S)

S_1: 60 cm × 30 cm

S_2: 60 cm × 40 cm

S_3: 60 cm × 50 cm

Therefore, the treatment combinations are F_0S_1, F_0S_2, F_0S_3, F_1S_1, F_1S_2, F_1S_3, F_2S_1, F_2S_2, F_2S_3.

3.9Layout of the field experiment

The experiment area was first divided into 3 blocks. Each block was divided into 9 plots for the treatment combination. Therefore, the total numbers of plots were 27 and 9 treatment combinations were assigned to each block as per design of the experiment. The size of the unit plot was 1.8 m×2 m. A distance of 50 cm was maintained between the plot and 1m between the block. The layout has been presented in fig.1.

3.10 Land preparation

The experimental plot was first opened on 18 May, 2013 with a power tiller and then it was exposed to the sun for five days. It was thoroughly ploughed several times with a power tiller to bring about a good tilth, suitable for growing cauliflower. Weeds and stubbles were removes as far as possible from the field and big clods were broken through laddering into tiny pieces. The experimental plot was partitioned into the unit plots in accordance with the experimental design Vermicompost and cowdung as per treatments were mixed with the soil of each unit plot.

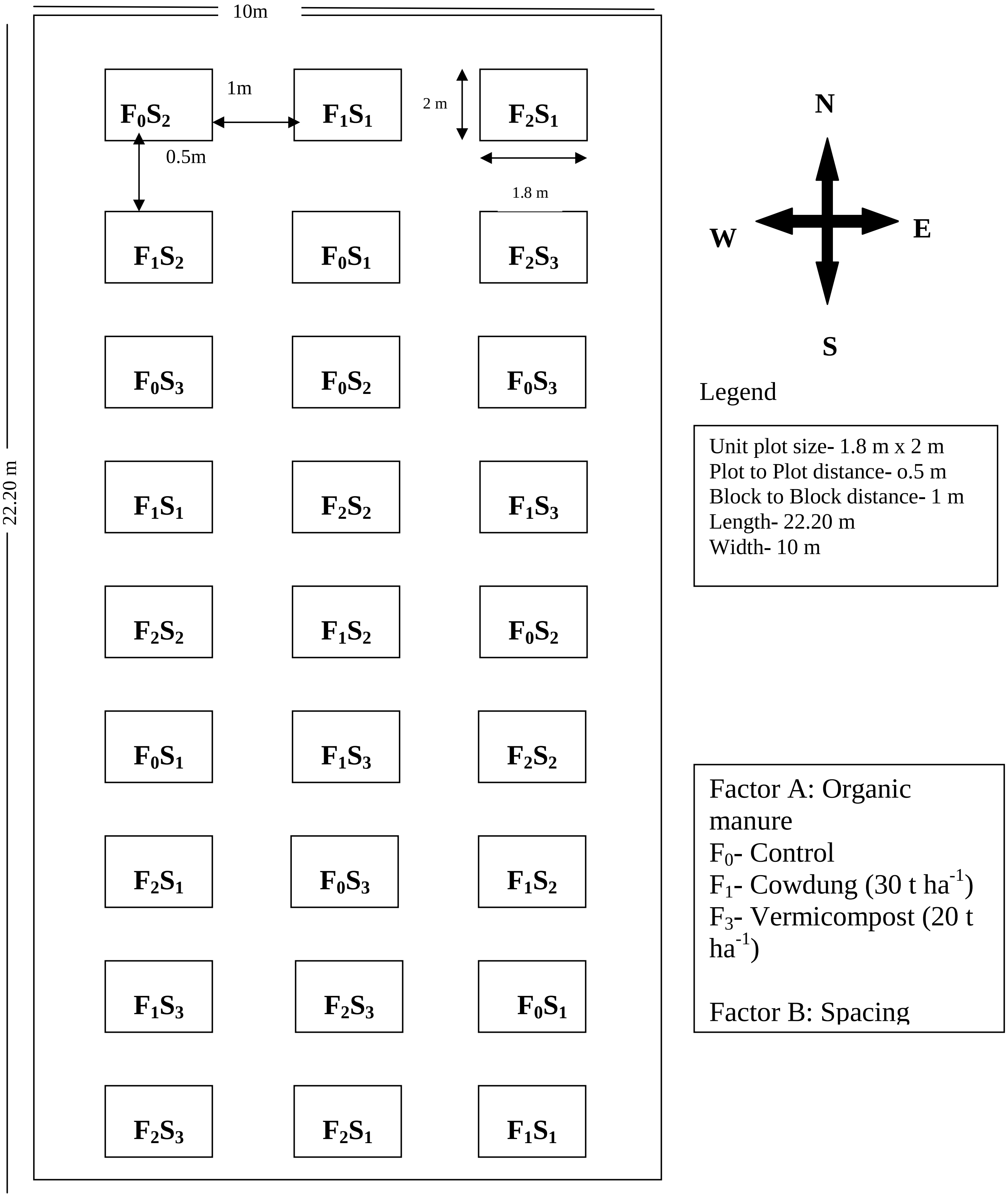


Fig. 1 Layout and design of the experimental plot

3.11 Manure and Fertilizers

The amount of different types of organic manures was applied in this experiment were given below:

Manures	Dose (t ha^{-1})	Dose (kg $plot^{-1}$)
Cowdung	30.00	11.00
Vermicompost	20.00	7.50

*plot size: 3.6 m^2

The total amount of cowdung, vermicompost and poultry manure was applied during land preparation.

3.12 Transplanting of Seedlings

The seed bed was watered before uprooting the seedling to minimize the root damage. Care was taken so that root damage was minimum and some soil should remain with the roots. Before transplanting, the root of the seedlings was dipped in solution of Bavistin (2g/l of water). The seedling having 5-6 true leaves were transplanted on 25 May at the spacing 60 cm × 50 cm, 60 cm × 40 cm and 60 cm × 30 cm in plots. Transplanting was done in the afternoon to the experimental plot and a light irrigation was given after transplanting. Banana leaf sheath pieces were used to protect the seedlings from scorching sunshine. Until the seedlings were established, shading and watering were continued. A number of seedlings were also planted in the border of the experimental plots.

3.13 Intercultural operations

3.13.1 Gap filling

Transplanted seedlings were kept under careful observation to minimize damage. Replacement of injured and dead seedlings was done with healthy seedlings through the border plants.

3.13.2 Weeding

Weeding was done at 15, 30 and 45 days after transplanting to keep the plots free from weeds during the entire growing period.

3.13.3 Earthing up

At the time of earthing up the plants were supported with soil to avoid toppling down of the plant during the head formation.

3.13.4 Irrigation and drainage

Irrigation was given as and when required after transplanting of seedlingfor proper growth and development. Care was taken to avoid water stress from the time of head formation to the head maturity period. During experimental period, there was heavy rainfall for several times. So it was essential to remove the excess water from the field.

3.13.5 Insects and Diseases Management

Few plants were damaged by mole crickets and caterpillars which fed on the leaf epidermis and later made holes just after transplanting. In the leaves spraying with Malathion 57 EC@ 2ml per litre was done to control them. Some time, adult Cauliflower borer female laid eggs on the growing point or on the older leaves. Some plants were infected by Alternaria leaf spot disease caused by *Alternaria brassicae*. To prevent the spread of Alternaria leaf spot disease, Rovral 50 WP @ 20 g/10 liter of water was sprayed.

3.14 Harvesting

Randomly selected ten plants were harvested from each plot for recording data to achieve the goal of experiment.

3.15 Methods of data collection

Data was recorded from 10 randomly selected plants from the middle rows of each unit plot during the course of experiment. The following parameters were recorded.

3.15.1 Plant height

Height of plant was recorded at 30, 50, and 70 days after transplanting (DAT) using meter scale. The height was measured from ground level to the tip of the largest leaf of an individual plant. Mean value of the ten selected plants per plot was considered as the height of the plant and was expressed in centimeter.

3.15.2 Number of leaves per plant

Number of leaves per plant was counted at 30, 50 and 70 DAT from 10 randomly selected plants. Fallen leaves were counted on the basis of scar marks on the stem introduced by the petiole of the leaves.

3.15.3 Length of leaf

Length of the largest leaf was measured at 30, 50 and 70 DAT from the base of the petiole to the tip of leaf with a meter scale and was recorded in centimeter.

3.15.4 Breadth of leaf

Breadth of the largest leaf was measured at 30, 50 and 70 DAT at the widest part of the lamina by a meter scale and was expressed in centimeter.

3.15.5 Fresh weight of leaves per plant

Fresh weight of leaves per plant was recorded at 30, 50 and 70 DAT in gram.

3.15.6 Dry weight of leaves per plant

At first the fresh weight of leaves per plant was recorded then all leaves was chopped and sun dried. Sun dried sample was then dried in an oven at 70^0C for 72 hours.

3.15.7 Diameter of stem

Stem diameter was measured at 30, 50 and 70 DAT with a measuring scale placing it vertically at the widest point of the stem. It was expressed in centimeter.

3.15.8 Length of root per plant

A distance between the bases to the tip of the root was measured in cm at 30, 50 and 70 DAT with the help of scale for determining the length of root.

3.15.9 Curd height

Curd height was measured with a measuring scale placing it horizontall. It was measured in centimeter.

3.15.10 Diameter of curd

Curd diameter without leaves was measured at 30, 50 and 70 DAT with a measuring scale placing it vertically at the widest point of the curd. It was expressed in centimeter.

3.15.11 Dry weight of curd per plant

A sample of curd was collected and was dried under direct sun for 72 hours and the sun dried sample was dried in an oven at 70^0C for 72 hours at 50, 60 and 70 DAT.

3.15.12 Curd weight with leaves

Curd weight with leaves per plant was recorded at 50, 60 and 70 DAT in gram with a beam balance from the average of ten randomly selected plants.

3.15.13 Curd weight

Curd weight per plant was recorded at 50, 60 and 70 DAT in gram with a beam balance from the average of ten randomly selected plants. It expressed in gram (gm).

3.15.14 Yield (tha^{-1})

It consisted of only quality curd of cauliflower and was also calculated in ton per hectare by converting the total yield of curd per plot.

3.16 Statistical analysis

Calculated data on various parameters under study were statistically analyzed by using MSTAT-C statistical package programme. Means for all the treatments were calculated and analyses of variances for all the characters under consideration were performed by 'F' variance test. Significance of differences between pairs of treatment means was evaluated by Duncan's Multiple Range Test (Gomez and Gomez, 1984).

3.17 Economic analysis

The cost of production was analyzed in order to find out the most economic treatment of organic manure and plant spacing. All input cost included the cost for lease of land and interests of running capital in computing the cost of production. The interests were calculated @ 15% in simple rate. The benefit cost ratio (BCR) was calculated as follows:

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

Chapter IV
RESULTS AND DISCUSSION

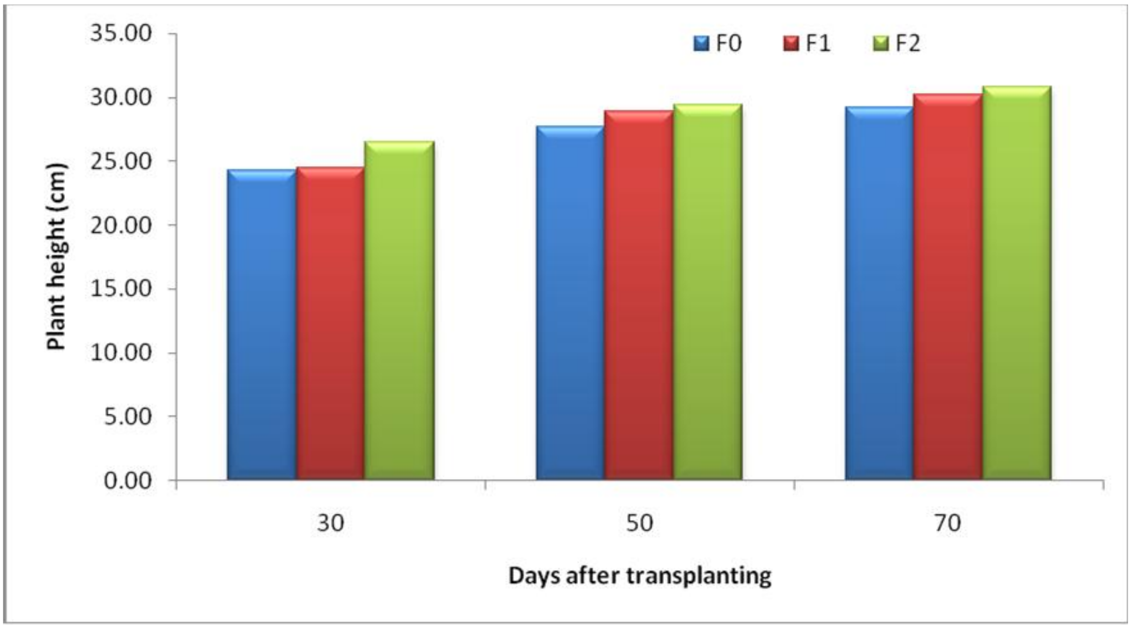
The experiment was conducted to investigate the potentiality of producing summer cauliflower as influenced by organic nutrient sources and spacing. Data of the different parameters analyzed statistically and the results have been presented in the Tables 1 to 14 and Figures 1 to 18. The results of the present study have been presented and discussed in this chapter under the following headings.

4.1 Plant height

The plant height was recorded at different stages of growth 30, 50 and 70 days after transplanting (DAT). The plant height varied significantly due to different organic manure (Fig.1). During the period of plant growth the maximum plant height (26.51, 29.34, and 30, 50.80 cm at 30, 50 and 70 DAT, respectively) was observed in F_2 (Vermicompost) treatment. On the other hand shortest plant height (24.24, 27.69 and 29.22 cm at 30, 50 and 70 DAT, respectively) was observed in F_0 (control) treatment. Organic manure ensure available essential nutrients for the plant for that organic manure gave the highest plant height compare to control. Among the different organic manure vermicompost was found more effective than other organic manure.

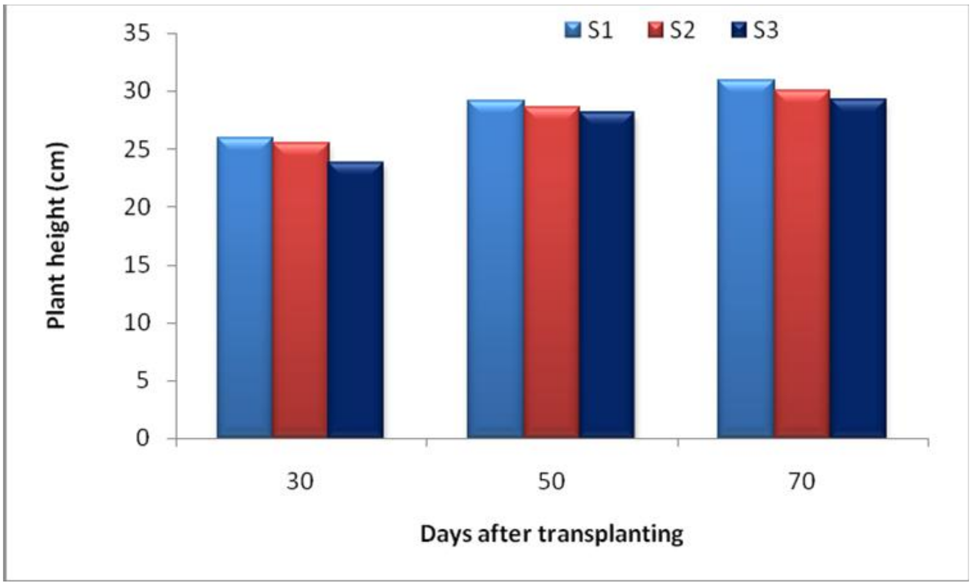
Significantly significant variation on plant height of cauliflower was shown due to different plant spacing at 30, 50 and 70 DAT. During the period of plant growth the tallest plant (25.93, 29.17 and 30.89 cm at 30, 50 and 70 DAT, respectively) was observed in S_1 (60×30 cm) treatment and minimum (23.83, 28.08 and 29.24 cm at 30, 50 and 70 DAT, respectively) in S_3 (60×50 cm) treatment (Fig.2). Results under the present experiment showed that closer spacing showed higher plant height where wider plant spacing showed lower plant height because of closer spacing plant compete for light which helps to elongate plant than the wider spacing. Moniruzzaman (2006) reported similar findings from the closest spacing.

The plant height was significantly influenced by the interaction effect of organic manure and spacing. The combined effect of organic manure and spacing at different days after transplanting was also statistically significant. The tallest plant (27.47, 30.47 and 33.13 cm at 30, 50 and 70 DAT, respectively) was found from the Vermicompost and 60×30 cm spacing treatment (F_2S_1) and the lowest (21.2, 26.47cm and 28.2 cm at 30, 50 and 70 DAT, respectively) from no organic manure and 60×50 cm spacing treatment (F_0S_3) combination (Table 1).



F_0=control, F_1=Cowdung, F_2 =Vermicompost

Fig. 1. Effect of organic manure on plant height of cauliflower at different days after transplanting



S_1=60×30 cm, S_2=60×40 cm, S_3=60×50 cm,

Fig. 2. Effect of spacing on plant height of cauliflower at different days after transplanting

Table 1. Combined effect of organic manure and spacing on plant height and number of leaf per plant of cauliflower

Treatment	Plant height (cm)			Number of leaf per plant		
	30 DAT	50 DAT	70 DAT	30 DAT	50 DAT	70 DAT
F_0S_1	25.20 a	27.87 cd	28.53 b	**10.80 d**	**10.27 f**	**12.90 f**
F_0S_2	26.33 a	28.73 bc	30.93 ab	11.53 cd	10.73 ef	13.87 e
F_0S_3	21.20 **b**	**26.47 d**	**28.20 b**	12.40 bc	11.00 ef	14.67 d
F_1S_1	25.13 a	29.70 ab	31.33 ab	13.20 ab	11.93 def	15.73 c
F_1S_2	26.20 a	26.73 d	28.67 b	12.13 bc	12.67 cde	14.70 d
F_1S_3	25.87 a	30.13 ab	30.60 ab	13.60 a	15.00 ab	14.67 d
F_2S_1	**27.47 a**	**30.47 a**	**33.13 a**	11.67 cd	13.40 bcd	17.13 ab
F_2S_2	23.87 ab	29.93 ab	30.67 ab	13.80 a	14.40 abc	16.67 b
F_2S_3	24.43 ab	27.63 cd	28.60 b	**13.87 a**	**15.67 a**	**17.73 a**
LSD $_{(0.05)}$	**3.51**	**1.40**	**3.98**	**1.08**	**1.79**	**0.75**
CV (%)	**8.09**	**10.67**	**7.83**	**8.48**	**11.55**	**10.32**

F_0= control, F_1= Cowdung, F_2 = Vermicompost

S_1= 60×30 cm, S_2= 60×40 cm, S3= 60×50 cm,

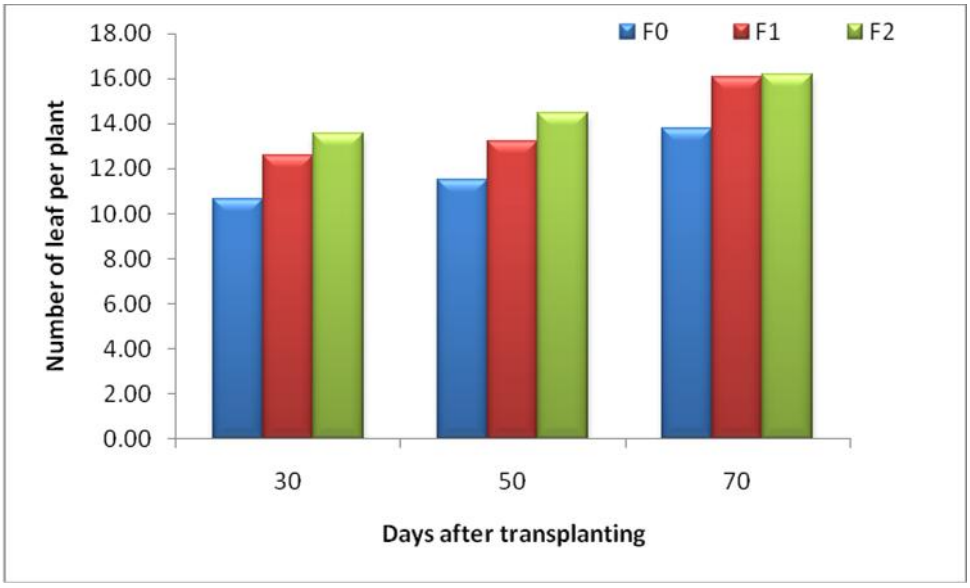
4. 2 Number of leaves per plant

Applications of organic manure significantly increase the production of leaves per plant (Fig.3) at 30, 50 and 70 DAT. The maximum number of leaves per plant (13.56, 14.49 and 16.16 at 30, 50 and 70 DAT, respectively) was produced by Vermicompost (F_2) treatment and the minimum (10.67, 11.53 and 13.81 at 30, 50 and 70 DAT, respectively) was produced by the control (F_0) treatment. Organic manure ensured available essential nutrients for the plant for that organic manure gave the highest number of leaves per plant compare to control condition and among the different organic manure vermicompost was more effective than other organic manure to increase the number of leaves per plant.

Significant variation was found in case of production of leaves per plant due to the effect of spacing (Fig.4). The maximum number of leaves (13.18, 13.18 and 15.69 at 30, 50 and 70 DAT, respectively) was obtained from S_3 (60× 50 cm) treatment. The S_1 (60×30 cm) treatment gave minimum number of leaves (11.84, 12.44 and 15.08) per plant showing significantly different result from other treatments. It was revealed that with the increases of spacing, number of leaves per plant also increased. Enough space for vertical and horizontal expansion in the optimum spacing that leads for production of maximum number of leaves per plant than the closer spacing. Steingrobe and Schenk (1994) also reported similar results earlier.

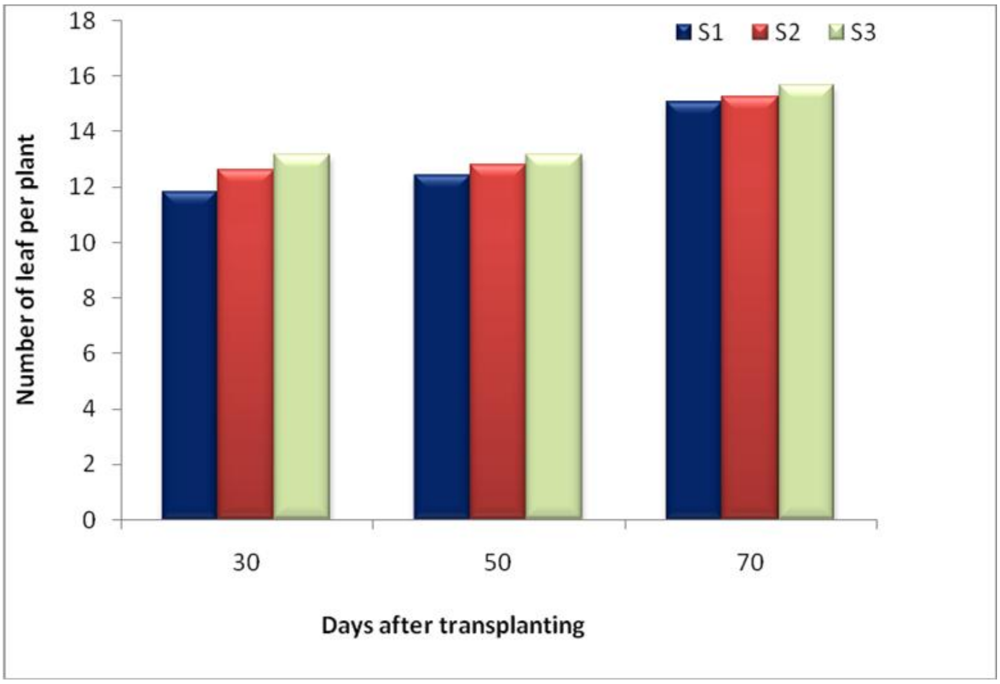
The number of leaves per plant was also significantly influenced by the interaction effect of organic manure and spacing. The number of leaves per plant was recorded to be the highest (13.87, 15.67 and 17.73 at 30, 50 and 70 DAT, respectively) from the treatment combination of Vermicompost with 60×50 cm (F_2S_3) treatment. The lowest number of leaves (10.80, 10.27 and

12.9 at 30, 50 and 70 DAT, respectively) was observed from the control with 60×20 cm (F_0S_1) treatment (Table 1).



F_0=control, F_1=Cowdung, F_2 =Vermicompost

Fig. 3. Effect of organic manure on number of leaves per plant of cauliflower at different days after transplanting



S_1=60×30 cm, S_2=60×40 cm, S_3=60×50 cm,

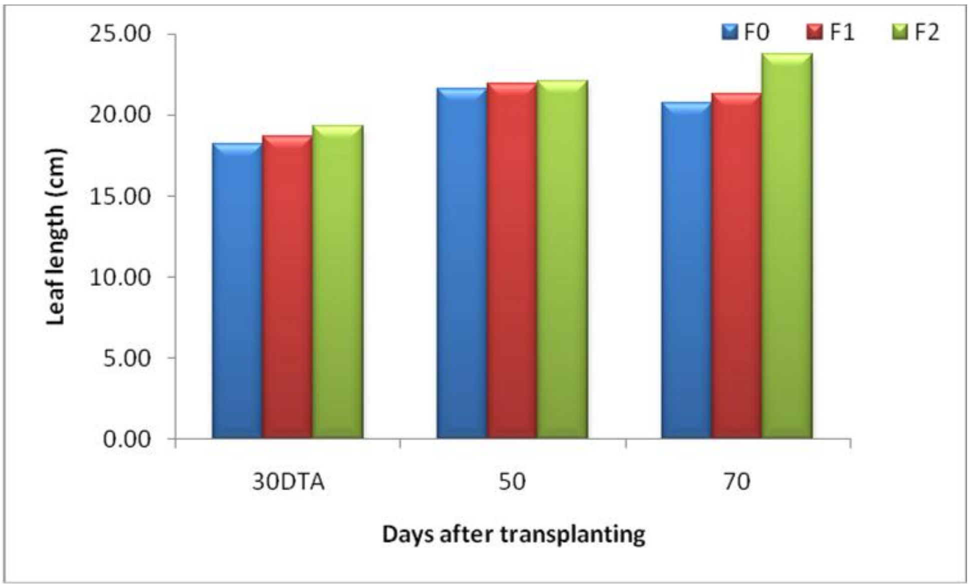
Fig. 4. Effect of spacing on number of leaves per plant of cauliflower at different days after transplanting

4.3 Length of leaf

The results on effects of organic manure showed that organic manure had significant effect on length of leaf at 30, 50 and 70 different days after transplanting. The Vermicompost gave the maximum length of leaf (19.3, 22.07 and 23.71 cm at 30, 50 and 70 DAT, respectively). The control treatment gave minimum (18.21, 21.59 and 20.76 cm at 30, 50 and 70 DAT, respectively) length of leaf (Fig.5).

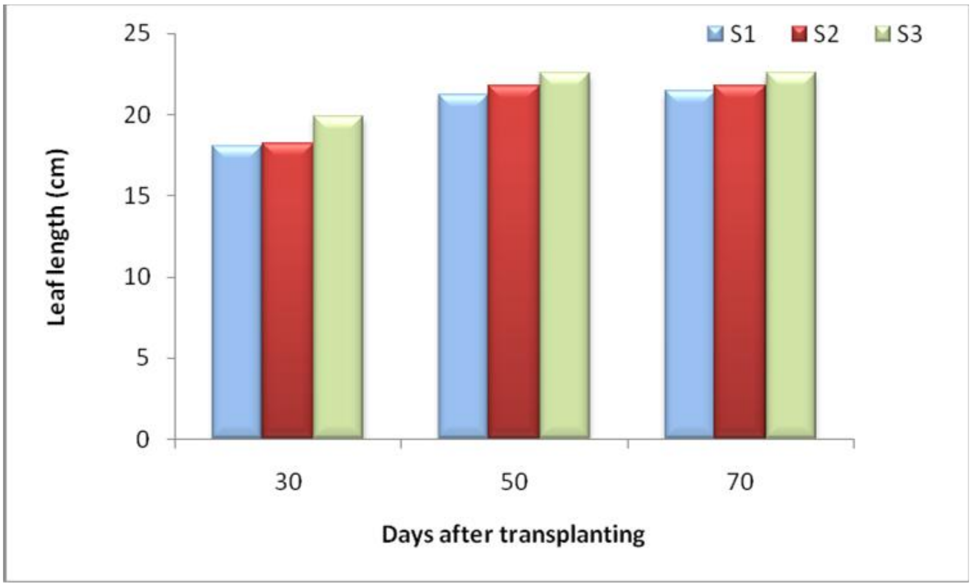
The length of leaf per plant counted at 30, 50 and 70 different days was significantly influenced by spacing. Treatment S_3 produced maximum length of leaf (19.9, 22.54 and 22.57 cm at 30, 50 and 70 DAT, respectively) and the minimum (18.08, 21.24 and 21.42 cm at 30, 50 and 70 DAT, respectively) length of leaf was recorded in S_1 treatment (Fig. 6). It was revealed that with the increases of spacing leaf length showed increasing trend. In case of closer spacing plant compete for light and with the time being leaf length decreases. Sodkowski and Rekowska (2003) reported longest leaf from closer spacing.

Interaction effect of organic manure and spacing had a significant variation on length of leaf. The maximum length of leaf (24.03, 24.13 and 25.67 cm at 30, 50 and 70 DAT, respectively) was obtained from F_2S_3 treatment while the minimum length of leaf (16.27, 19.8 and 20.03 cm at 30, 50 and 70 DAT, respectively) with F_0S_1 treatment (Table 2).



F_0=control, F_1=Cowdung, F_2 =Vermicompost

Fig. 5. Effect of organic manure on leaf length of cauliflower at different days after transplanting



S_1=60×30 cm, S_2=60×40 cm, S3=60×50 cm,

Fig. 6 Effect of spacing on length of leaf at different days after transplanting

Table 2. Combined effect of organic manure and spacing on leaf length and leaf breadth of cauliflower

Treatment	Leaf length (cm)						Leaf breadth (cm)					
	30 DAT		50 DAT		70 DAT		30 DAT		50 DAT		70 DAT	
F_0S_1	**16.27**	**c**	**19.80**	**e**	**20.03**	**c**	**9.27**	**b**	**10.57**	**c**	**10.73**	**c**
F_0S_2	18.93	bc	21.97	bc	21.17	bc	11.23	ab	11.50	ab	12.60	ab
F_0S_3	18.57	bc	23.00	ab	22.07	bc	10.47	ab	10.80	bc	12.30	abc
F_1S_1	18.43	bc	21.33	cd	20.60	c	9.50	b	11.37	abc	10.77	c
F_1S_2	18.30	bc	20.40	de	21.43	bc	9.80	ab	10.67	bc	10.93	bc
F_1S_3	19.40	b	20.60	de	20.80	bc	11.00	ab	12.13	a	12.37	abc
F_2S_1	17.13	bc	22.60	bc	21.40	bc	9.90	ab	11.43	abc	12.37	abc
F_2S_2	17.50	bc	23.00	ab	24.07	ab	10.50	ab	11.50	ab	12.77	a

F_2S_3	**24.03 a**	**24.13 a**	**25.67 a**	**11.57 a**	**12.17 a**	**13.73 a**
LSD $_{(0.05)}$	**2.56**	**1.27**	**3.06**	**1.82**	**0.82**	**1.58**
CV (%)	**10.91**	**8.05**	**10.80**	**10.49**	**9.17**	**9.11**

F_0= control, F_1= Cowdung, F_2 = Vermicompost

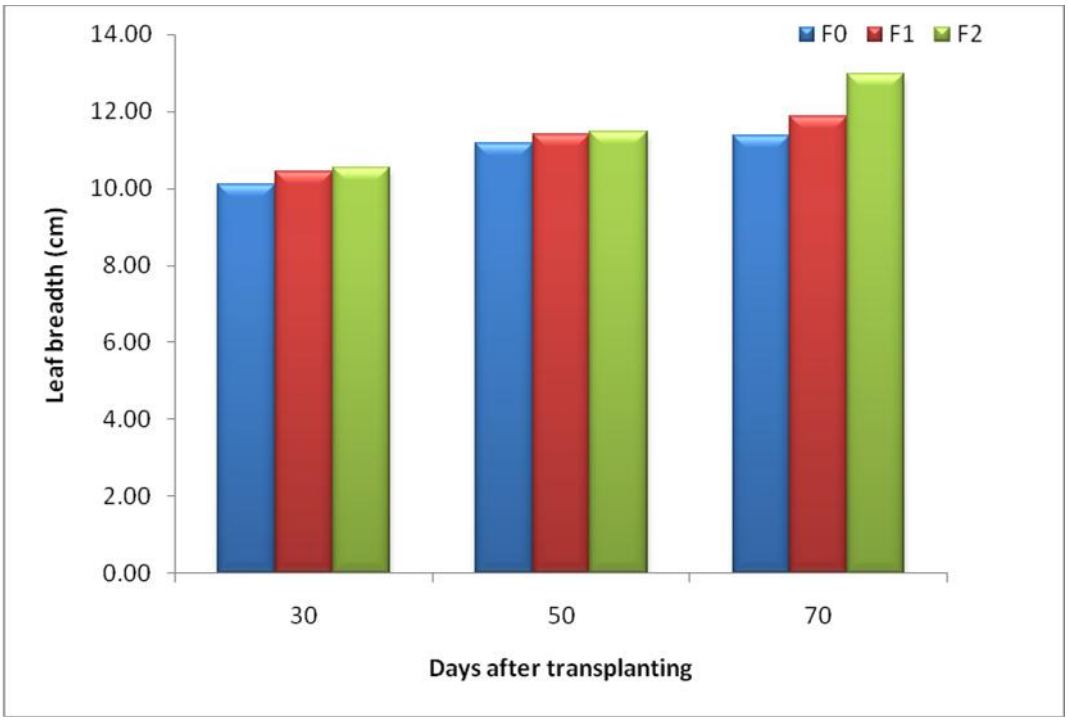
S_1= 60×30 cm, S_2= 60×40 cm, S3= 60×50 cm,

4.4 Breadth of leaf per plant

The effect of organic manure was significant in this regard. Vermicompost produced the widest (10.53, 11.48 and 12.96 cm at 30, 50 and 70 DAT, respectively) leaf and control treatment produced narrowest leaf (10.11, 11.16 and 11.36 cm at 30, 50 and 70 DAT, respectively) (Fig.7).

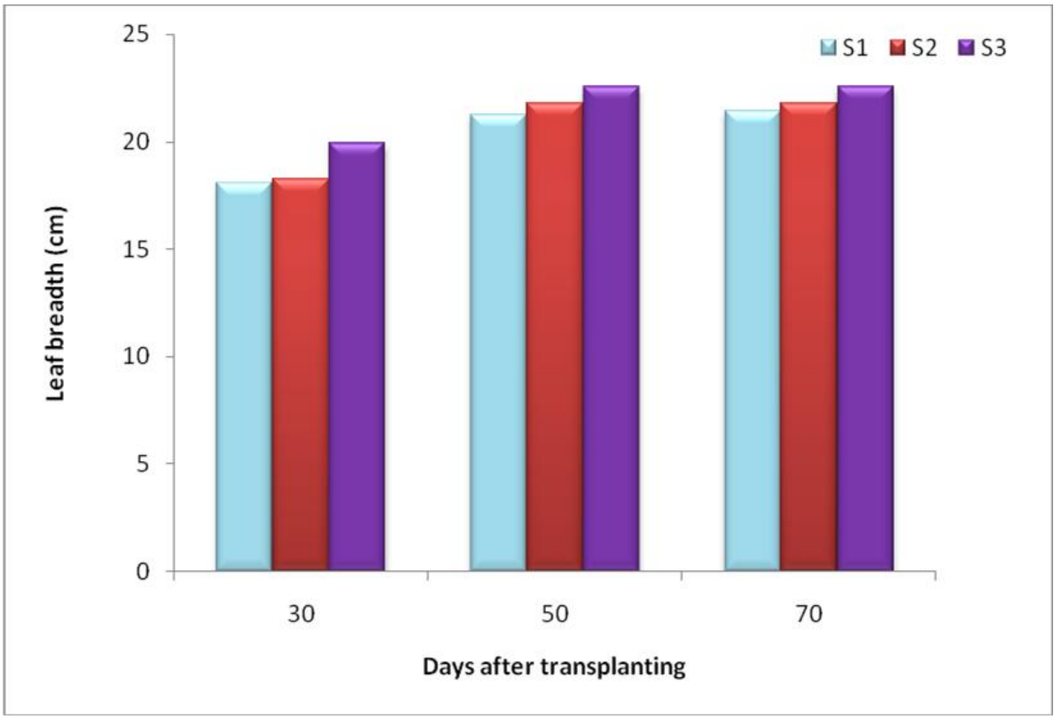
The Breadth of leaf counted at different days was significantly influenced by spacing. Treatment S_3 produced maximum Breadth of leaf (10.66, 11.89 cm and 12.34cm at 30, 50 and 70 DAT, respectively) and the minimum (10.18, 10.93 and 11.74 at 30, 50 and 70 DAT, respectively) Breadth of leaf was recorded in S_1 treatment (Fig. 8). It was revealed that with the increases of spacing leaf breath showed increasing trend. In case of closer spacing plant compete for light and with the time being leaf breath decreases.

The interaction effects of organic manure and spacing were found significant in respect of breadth of leaf. Numerically the highest breadth of leaf (11.57, 12.17 and 13.73 cm at 30, 50 and 70 DAT, respectively) was obtained from the treatment combination of F_2S_3 and the minimum breadth of leaf (9.267 , 10.57 and 10.73 cm at 30, 50 and 70 DAT, respectively) was found in the treatment combination of F_0S_1 treatment (Table-2).



F_0=control, F_1=Cowdung, F_2 =Vermicompost

Fig. 7. Effect of organic manure on breath of leaf of cauliflower at different days after transplanting



S_1=60×30 cm, S_2=60×40 cm, S3=60×50 cm,

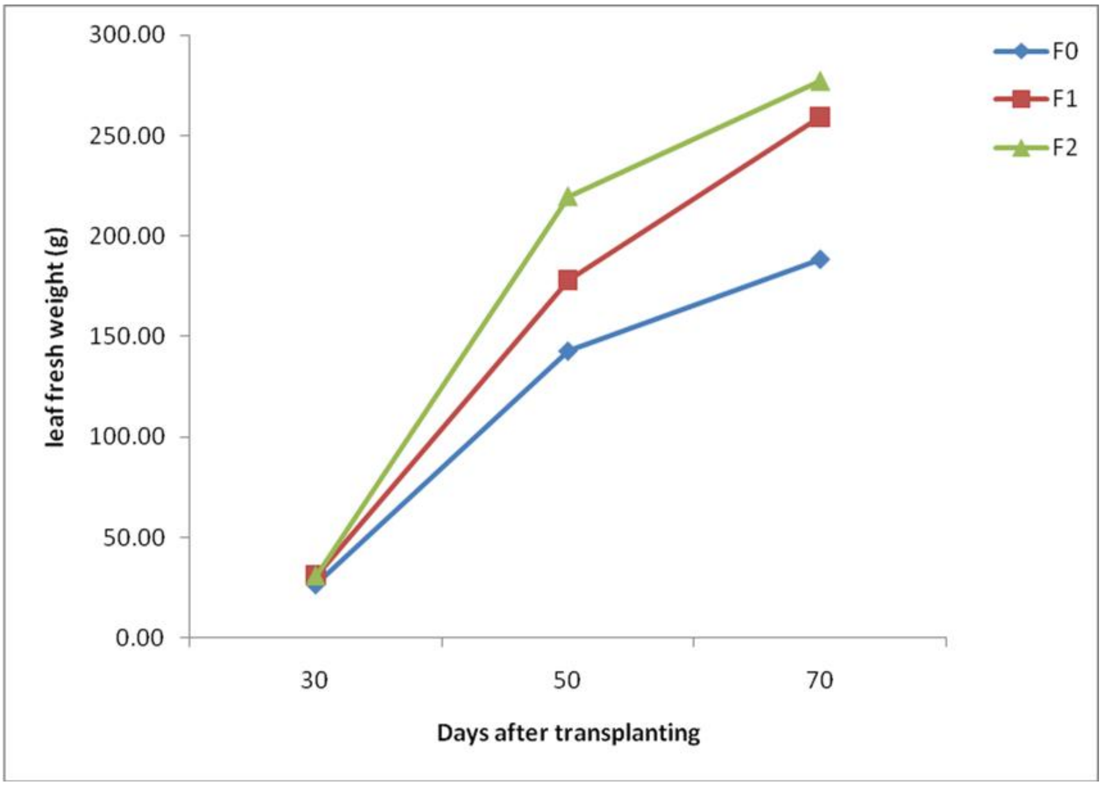
Fig. 8. Effect of spacing on breath of leaf of cauliflower at different days after transplanting

4.5 Fresh weight of leaves per plant (g)

Organic manure significantly influenced the fresh weight of leaves per plant at 30, 50 and 70 DAT. The maximum weight of fresh leaves per plant (30.92, 219.8 and 277.2 g at 30, 50 and 70 DAT, respectively) was observed in F_2 and the minimum weight (26.97, 142.8 and 188.3 g at 30, 50 and 70 DAT, respectively) was found in the F_0 (Fig 9). Among the different organic manure Vermicompost was more effective than other organic manure.

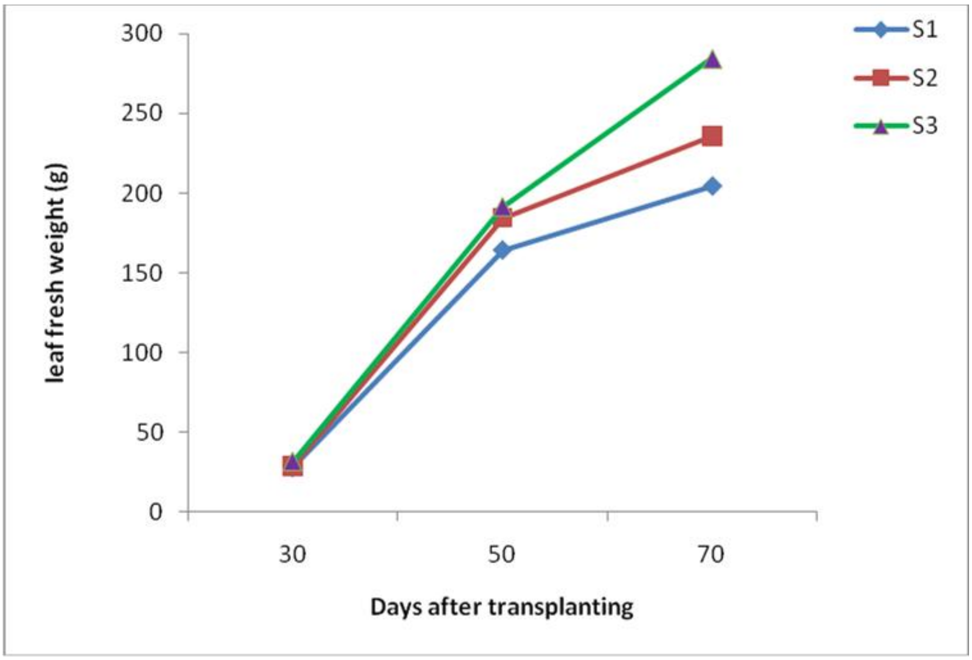
The fresh weight of leaves per plant was significantly influenced by plant spacing. Treatment S_3 produced maximum fresh weight of leaves per plant (31.53, 191.6 and 284.5 g at 30, 50 and 70 DAT, respectively) and the minimum (28.21, 184.4 and 204.4 g at 30, 50 and 70 DAT, respectively) fresh weight of leaves per plant was recorded in S_1 treatment (fig-10). It was revealed that with the increases of spacing fresh weight of leaves per plant showed increasing trend. In case of wider spacing plant receive enough light and nutrients which leads to attain maximum fresh weight of leaves per plant. Similar result was also observed by Sharma *et al*. (2001).

The interaction effects of organic manure and plant spacing were significant in respect of fresh weight of leaves per plant. The highest (33.37, 238.8 and 348.2 g at 30, 50 and 70 DAT, respectively) and lowest (24.73, 122.00 and 150.00 g at 30, 50 and 70 DAT, respectively) weight of fresh leaves per plant were observed in the treatment combination F_2S_3 and F_0S_1 (Table-3).



F_0=control, F_1=Cowdung, F_2 =Vermicompost

Fig.9 Effect of organic manure on fresh weight of leaf per plant of cauliflower



S_1=60×30cm, S_2=60×40 cm, S_3=60×50 cm,

Fig. 10. Effect of spacing on fresh weight of leaf per plant of cauliflower

Table 3. Combined effect of organic manure and spacing on fresh weight and dry weight of leaf per plant of cauliflower

Treatment	**24.244weight (g)**			**Dry weight of leaf (g)**		
	30 DAT	50 DAT	70 DAT	30 DAT	50 DAT	70 DAT
F_0S_1	**24.73 c**	**122.00 b**	**150.00 c**	**12.41 c**	**25.6 f**	**45.55 e**
F_0S_2	25.37 bc	131.80 ab	182.70 bc	12.95 bc	35.94 ef	59.97 d
F_0S_3	30.80 abc	174.60 ab	232.30 abc	16.34 a	60.43 cd	98.27 bc
F_1S_1	30.93 ab	182.70 ab	242.10 abc	15.70 ab	47.26 de	71.95 d
F_1S_2	31.17 ab	153.00 ab	196.30 abc	16.20 ab	63.89 c	86.49 c

F_1S_3	30.43 abc	198.40 ab	233.20 abc	15.71 ab	69.83 bc	89.84 c
F_2S_1	31.30 ab	202.00 ab	322.70 ab	16.01 ab	71.52 bc	110.5 b
F_2S_2	28.10 abc	218.70 ab	266.70 abc	14.19 abc	80.46 ab	135.6 a
F_2S_3	**33.37 a**	**238.80 a**	**348.20 a**	**17.33 a**	**91.07 a**	**146.6 a**
LSD $_{(0.05)}$	**5.53**	**95.92**	**145.00**	**2.98**	**14.58**	**14.43**
CV (%)	**10.75**	**14.68**	**11.31**	**11.89**	**14.45**	**11.31**

F_0= control, F_1= Cowdung, F_2 = Vermicompost

S_1= 60×30 cm, S_2= 60×40 cm, S3= 60×50 cm,

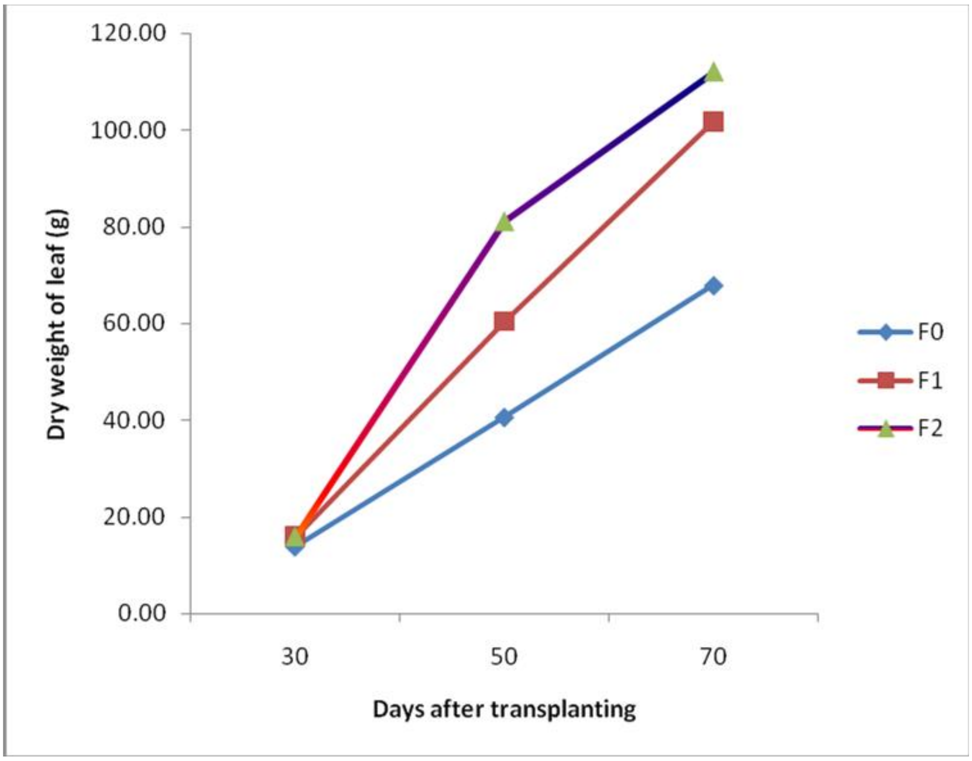
4.6 Dry weight of leaves per plant (g)

Organic manure significantly influenced the dry weight per plant at 30, 50 and 70 DAT. The maximum dry weight per plant (15.87, 81.00 and 112.00 g at 30, 50 and 70 DAT, respectively) was observed in F_2 and the minimum dry weight (13.9, 40.65 and 67.93 g at 30, 50 and 70 DAT, respectively) was found in the F_0 (Fig.11).

The dry weight per plant was significantly influenced by plant spacing. Treatment S_3 produced maximum dry weight per plant (16.46, 67.26 and 114 g at 30, 50 and 70 DAT, respectively) and the minimum (14.45, 51.33 and 75.99 g at 30, 50 and 70 DAT, respectively) dry weight per plant was recorded in S_1

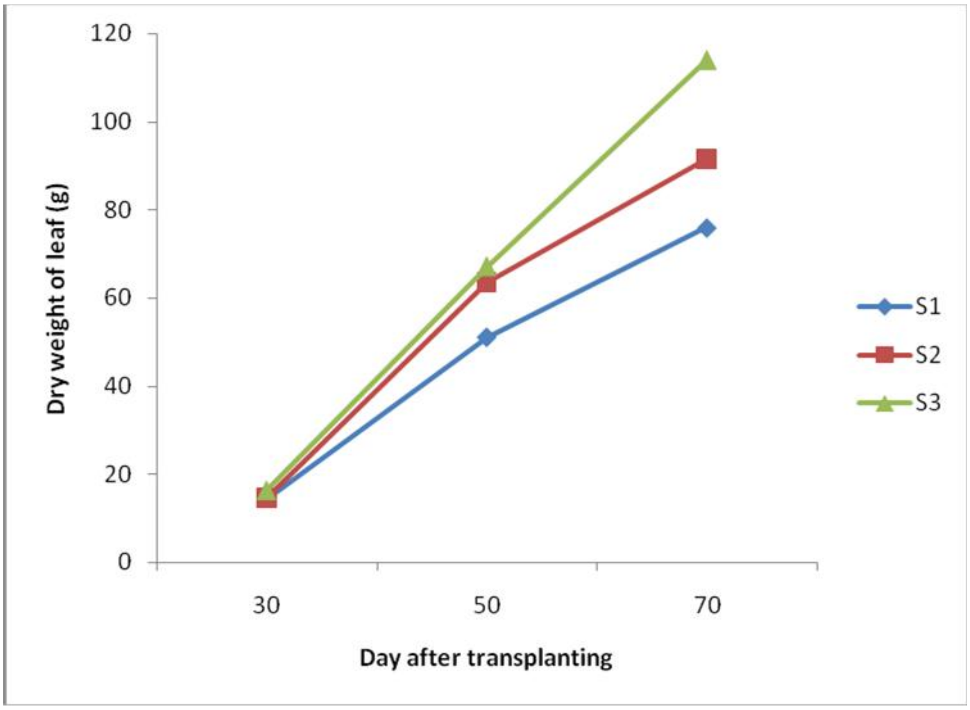
treatment (Fig. 12). It was revealed that with the increases of spacing dry weight per plant showed increasing trend because of less competition for nutrients among the plants during growth stages.

The interaction effects of organic manure and plant spacing were significant in respect of dry weight per plant. The highest (17.33, 91.07 and 146.6 g at 30, 50 and 70 DAT, respectively) and lowest (12.41, 25.60 and 45.55 g at 30, 50 and 70 DAT, respectively) weight of leaves per plant were observed in the treatment combination F_2S_3 and F_0S_1 (Table-3).



F_0=control, F_1=Cowdung, F_2 =Vermicompost

Fig.11 Effect of organic manure on dry weight of leaf per plant of cauliflower



S_1=60×30 cm, S_2=60×40 cm, S_3=60×50 cm,

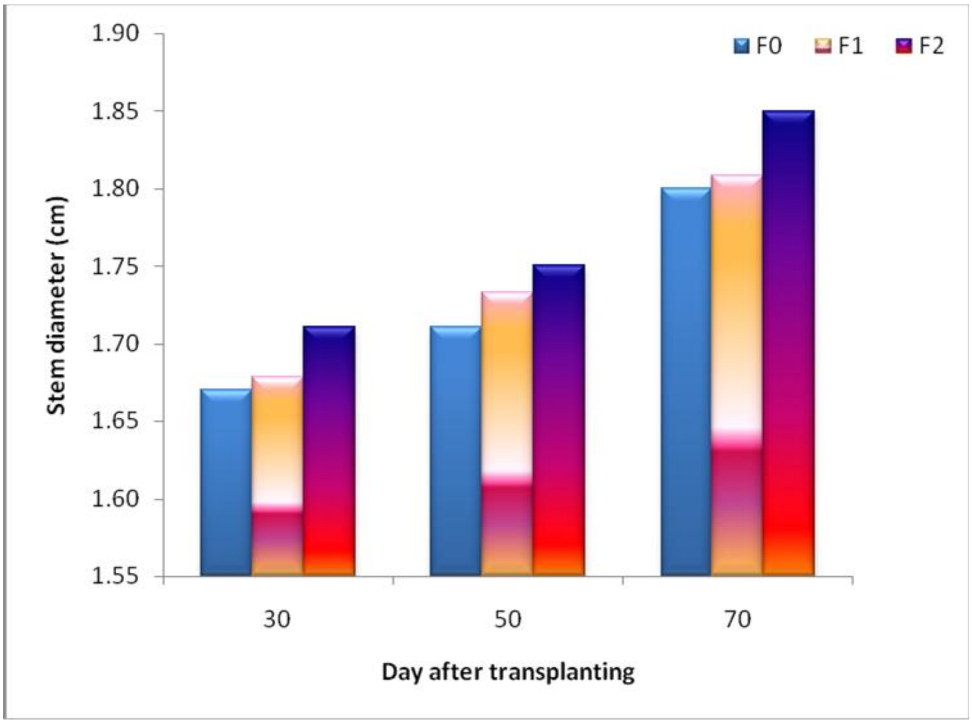
Fig. 12 Effect of spacing on dry weight of leaf per plant of cauliflower

4.7 Stem diameter

The effect of organic manure was significant in this regard. Vermicompost produced the highest stem diameter (1.71, 1.75 and 1.85 cm at 30, 50 and 70 DAT, respectively) and control treatment produced lowest stem diameter (1.67, 1.71and 1.8 cm at 30, 50 and 70 DAT, respectively) (Fig.13).

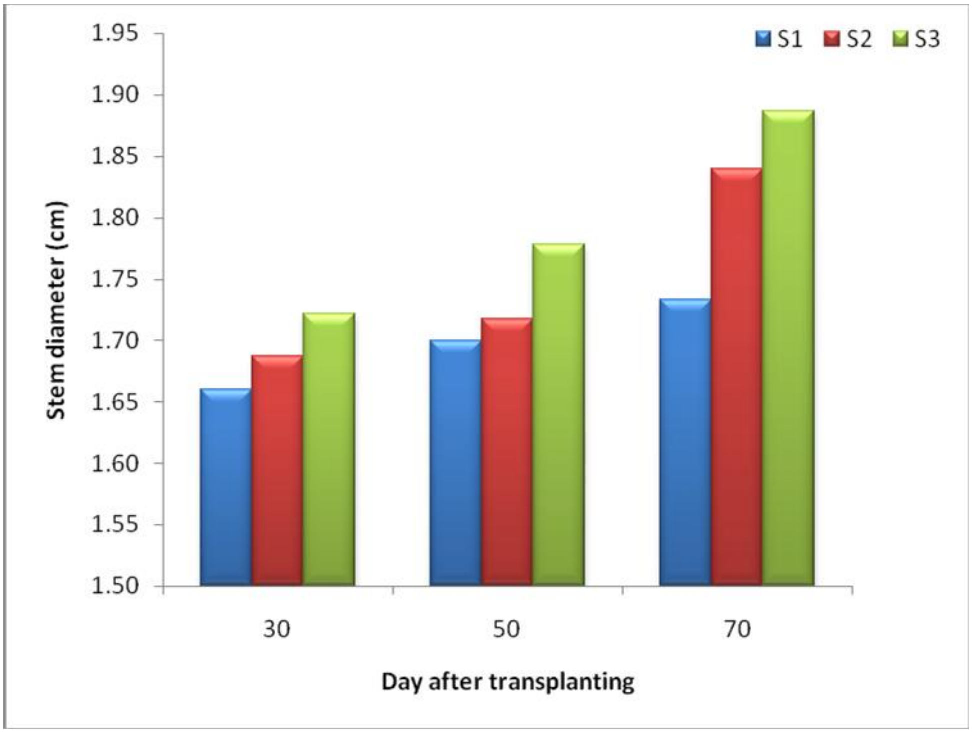
The Stem diameter counted at different days was significantly influenced by spacing. Treatment S_3 produced maximum Diameter of stem (1.72, 1.78 cm and 1.89 cm at 30, 50 and 70 DAT, respectively) and the minimum (1.66, 1.70 and 1.73 at 30, 50 and 70 DAT, respectively) diameter of stem was recorded in S_1 treatment (Fig. 14).

The interaction effects of organic manure and spacing were found significant in respect of diameter of stem. Numerically the highest diameter of stem (1.80, 1.83 and 1.93 cm at 30, 50 and 70 DAT, respectively) was obtained from the treatment combination of F_2S_3 and the minimum diameter of stem (1.62, 1.67 and 1.72 cm at 30, 50 and 70 DAT, respectively) was found in the treatment combination of F_0S_1 treatment (Table 4).



F_0=control, F_1=Cowdung, F_2 =Vermicompost

Fig.13 Effect of organic manure on stem diameter of cauliflower



S_1=60×30 cm, S_2=60×40 cm, S_3=60×50 cm,

Fig. 14 Effect of spacing on stem diameter of cauliflower

Table 4. Combined effect of organic manure and spacing stem diameter and root length of cauliflower

Treatment	Stem Diameter (cm)			Root length (cm)		
	30 DAT	50 DAT	70 DAT	30 DAT	50 DAT	70 DAT
F_0S_1	**1.62 bc**	**1.67 bc**	**1.72 c**	**21.50 bc**	**22.17 b**	**23.17 ab**
F_0S_2	1.70 b	1.70 bc	1.83 ab	23.00 ab	24.37 ab	24.00 ab
F_0S_3	1.70 b	1.80 ab	1.86 ab	22.00 bc	22.67 ab	24.33 ab
F_1S_1	1.63 c	1.70 bc	1.73 cd	21.40 bc	23.22 ab	23.33 b
F_1S_2	1.70 b	1.75 b	1.80 bc	21.33 bc	22.44 ab	24.83 ab
F_1S_3	1.67 bc	1.70 bc	1.88 ab	21.17 c	22.28 ab	24.33 ab
F_2S_1	1.70 b	1.73 bc	1.73 cd	21.87 bc	22.50 ab	26.10 ab

F_2S_2	1.67 bc	1.70 bc	1.87 ab	21.50 bc	22.43 ab	24.50 ab
F_2S_3	**1.80 a**	**1.83 a**	**1.93 a**	**23.90 a**	**24.80 a**	**27.78 a**
LSD $_{(0.05)}$	**0.08**	**0.08**	**0.08**	**1.53**	**1.59**	**3.45**
CV (%)	**6.04**	**7.65**	**7.50**	**9.99**	**9.40**	**11.11**

F_0= control, F_1= Cowdung, F_2 = Vermicompost

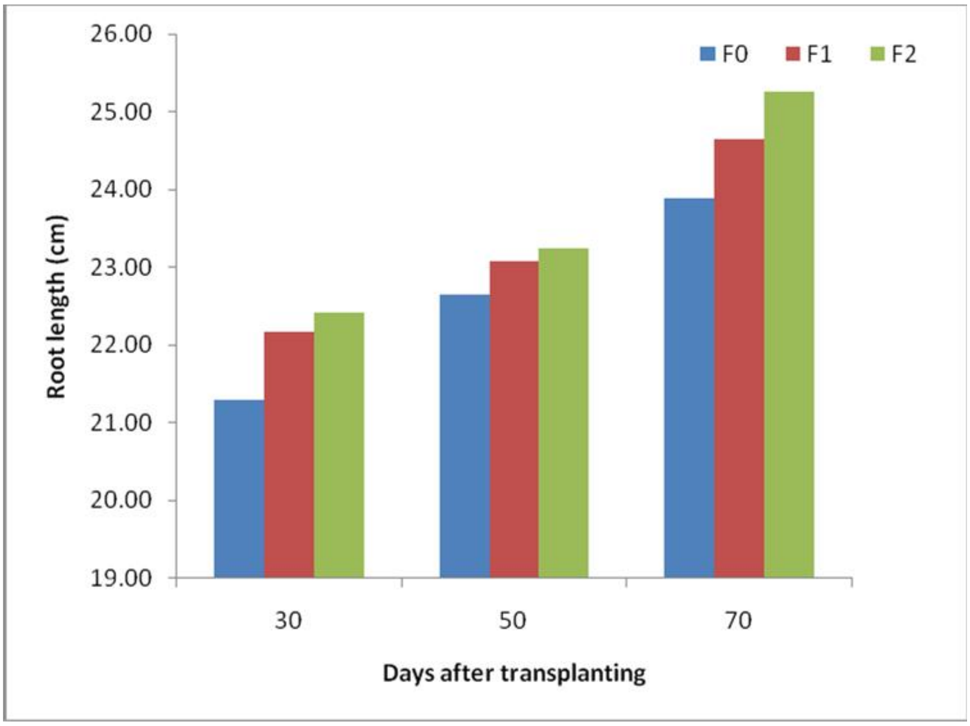
S_1= 60×30 cm, S_2= 60×40 cm, S3= 60×50 cm,

4.8 Root length

Organic manure significantly influenced the root length at 30, 50 and 70 DAT. Vermicompost produced the highest root length (22.42, 23.24 and 25.26 cm at 30, 50 and 70 DAT, respectively) and control treatment produced lowest root length (21.3, 22.65 and 23.89 cm at 30, 50 and 70 DAT, respectively) (Fig.15).

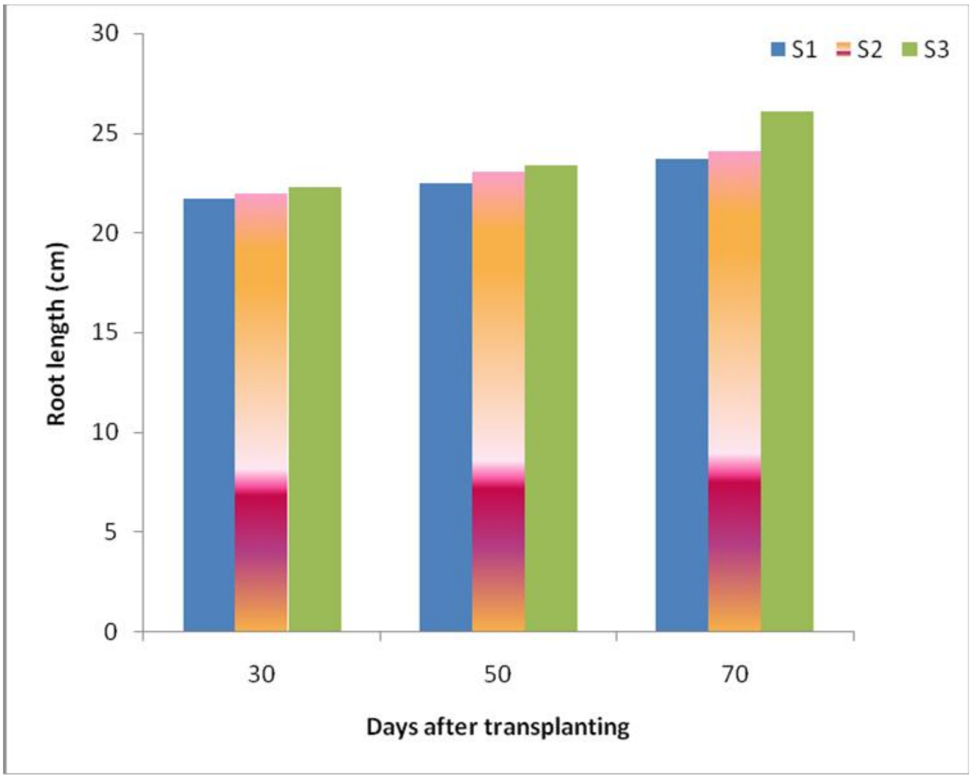
The root length counted at different days was significantly influenced by spacing. Treatment S_3 produced maximum root length (22.27, 23.4 cm and 26.07 cm at 30, 50 and 70 DAT, respectively) and the minimum (21.68, 22.48 and 23.67 at 30, 50 and 70 DAT, respectively) root length was recorded in S_1 treatment (Fig. 16).

The interaction effects of organic manure and spacing were found significant in respect of root length. Numerically the highest root length (23.9, 24.8 and 27.78 cm at 30, 50 and 70 DAT, respectively) was obtained from the treatment combination of F_2S_3 and the minimum root length (21.5, 22.17 and 23.17 cm at 30, 50 and 70 DAT, respectively) was found in the treatment combination of F_0S_1 treatment (Table 4).



F_0=control, F_1=Cowdung, F_2 =Vermicompost

Fig.15 Effect of organic manure on root length of cauliflower



S_1=60×30 cm, S_2=60×40 cm, S_3=60×50 cm,

Fig. 16 Effect of spacing on root length of cauliflower

4.9 Curd height

The pure curd height was recorded at different stages of growth 50, 60 and 70 days after transplanting (DAT). The pure curd height varied significantly due to different organic manure (table 5). During the period of plant growth the maximum pure curd height (8.11, 8.46, and 8.91 cm at 50, 60 and 70 DAT, respectively) was observed in F_2 (Vermicompost) treatment. On the other hand shortest pure curd height (7.56, 7.97 and 8.04 cm at 50, 60 and 70 DAT, respectively) was observed in F_0 (control) treatment. Organic manure ensure available essential nutrients for the plant for that organic manure gave the highest Pure curd height compare to control. Among the different organic manure vermicompost was found more effective than other organic manure.

No significant variation on pure curd height of cauliflower was shown due to different plant spacing at 50, 60 and 70 DAT. The highest pure curd height (7.94, 8.36 and 8.53 cm at 50, 60 and 70 DAT, respectively) was observed in S_3 (60×50 cm) treatment and minimum (7.72, 8.11 and 8.38 cm at 50, 60 and 70 DAT, respectively) in S_1 (60×30 cm) treatment (Table 6).

The pure curd height was significantly influenced by the interaction effect of organic manure and spacing. The combined effect of organic manure and spacing at different days after transplanting was also significant. The maximum pure curd height (8.34, 9.08 and 9.10 cm at 50, 60 and 70 DAT, respectively) was found from the Vermicompost and 60×50 cm spacing treatment (F_2S_1) and the lowest (7.17, 7.74 cm and 7.7 cm at 50, 60 and 70 DAT, respectively) from no organic manure and 60×50 cm spacing treatment (F_0S_1) treatment (Table 7).

4.10 Diameter of curd

The effect of organic manure was significant in this regard. Vermicompost produced the highest diameter of curd (7.83, 8.73 and 14.25 cm at 50, 60 and 70 DAT, respectively) and control treatment produced lowest diameter of curd (7.7, 8.27 and 13.02 cm at 50, 60 and 70 DAT, respectively) (Table 5).

The Diameter of curd counted at different days was significantly influenced by spacing. Treatment S_3 produced maximum Diameter of curd (7.83, 8.65 cm and 14.44 cm at 50, 60 and 70 DAT, respectively) and the minimum (7.69, 8.36 and 12.87 at 50, 60 and 70 DAT, respectively) diameter of curd was recorded in S_1 treatment (Table 6).

The interaction effects of organic manure and spacing were found significant in respect of diameter of curd. Numerically the highest diameter of stem (7.9, 8.99 and 15.17 cm at 50, 60 and 70 DAT, respectively) was obtained from the treatment combination of F_2S_3 and the minimum diameter of curd (7.57, 7.95 and 11.83 cm at 30, 50 and 70 DAT, respectively) was found in the treatment combination of F_0S_1 treatment (Table 7).

Table 5. Effect of organic manure on Curd height and curd diameter of Cauliflower

Treatment	Curd height (cm)			Curd diameter (cm)		
	50 DAT	60 DAT	70 DAT	50 DAT	60 DAT	70 DAT
F_0	**7.56 ab**	**7.97 b**	**8.04 b**	**7.70 b**	**8.27 b**	**13.02 c**
F_1	7.89 ab	8.16 ab	8.49 ab	7.72 b	8.43 b	13.67 b
F_2	**8.11 a**	**8.46 a**	**8.91 a**	**7.83 a**	**8.73 a**	**14.25 a**
LSD $_{(0.05)}$	**1.22**	**0.46**	**0.84**	**0.05**	**0.19**	**0.42**
CV (%)	**6.03**	**4.99**	**9.63**	**3.28**	**9.02**	**13.17**

Table 6. Effect of spacing on Curd height and curd diameter of cauliflower

Treatment	Curd height (cm)	Curd diameter (cm)

	50 DAT	60 DAT	70 DAT	50 DAT	60 DAT	70 DAT
S_1	**7.72 ab**	**8.11 ab**	**8.38 ab**	**7.69 ab**	**8.36 ab**	**12.87 ab**
S_2	7.89 ab	8.13 ab	8.53 a	7.73 ab	8.43 ab	13.62 ab
S_3	**7.94 a**	**8.36 a**	**8.53 a**	**7.83 a**	**8.65 a**	**14.44 a**
LSD $_{(0.05)}$	**1.67**	**0.38**	**0.91**	**0.272**	**0.248**	**1.19**
CV (%)	**6.03**	**4.99**	**9.63**	**3.28**	**9.02**	**13.17**

Table 7. Combined effects of organic manure and spacing on Curd height

Curd diameter of cauliflower

Treatment	Curd height (cm)			Curd diameter (cm)		
	50 DAT	60 DAT	70 DAT	50 DAT	60 DAT	70 DAT
F_0S_1	**7.17 bc**	**7.74 cd**	**7.70 d**	**7.57 d**	**7.95 d**	**11.83 g**
F_0S_2	7.67 ab	8.00 bc	8.27 bc	7.70 bcd	8.30 c	12.67 f
F_0S_3	7.67 ab	8.00 bc	8.47 bc	7.80 ab	8.57 b	13.11 ef
F_1S_1	7.67 ab	7.74 bc	8.17 c	7.83 ab	8.41 bc	14.89 ab
F_1S_2	7.67 ab	8.57 ab	8.72 ab	7.80 ab	8.40 bc	14.20 bc
F_1S_3	8.33 ab	8.73 ab	8.97 ab	7.87 ab	8.80 ab	13.67 cde
F_2S_1	7.83 ab	7.90 bc	8.72 ab	7.73 abc	8.57 b	13.28 def
F_2S_2	8.33 ab	8.00 bc	8.27 bc	7.60 cd	8.33 c	14.00 cd
F_2S_3	**8.34 a**	**9.08 a**	**9.10 a**	**7.90 a**	**8.99 a**	**15.17 a**

LSD $_{(0.05)}$	**0.82**	**0.58**	**0.45**	**0.13**	**0.21**	**0.80**
CV (%)	**6.03**	**4.99**	**9.63**	**3.28**	**9.02**	**13.17**

F_0= control, F_1= Cowdung, F_2 = Vermicompost

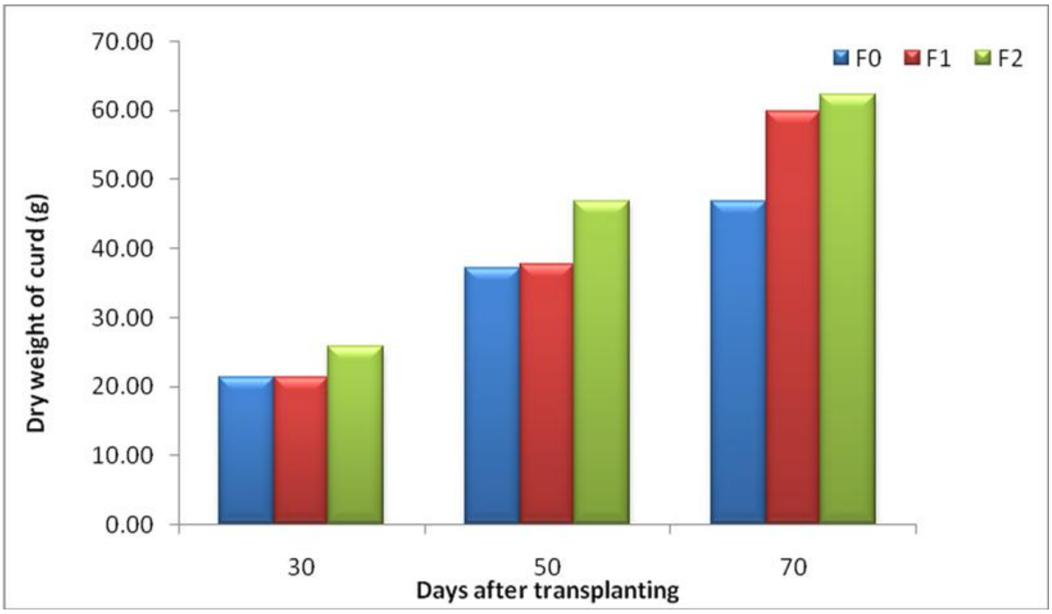
S_1= 60×30 cm, S_2= 60×40 cm, S3= 60×50 cm,

4.11 Dry weight of curd per plant (g)

Organic manure significantly influenced the dry weight of curd per plant at 50, 60 and 70 DAT. The maximum dry weight of curd per plant (25.85, 46.8 and 62.3 g at 50, 60 and 70 DAT, respectively) was observed in F_2 and the minimum dry weight of curd (21.27, 37.21 and 46.8 g at 50, 60 and 70 DAT, respectively) was found in the F_0 (Fig 17).

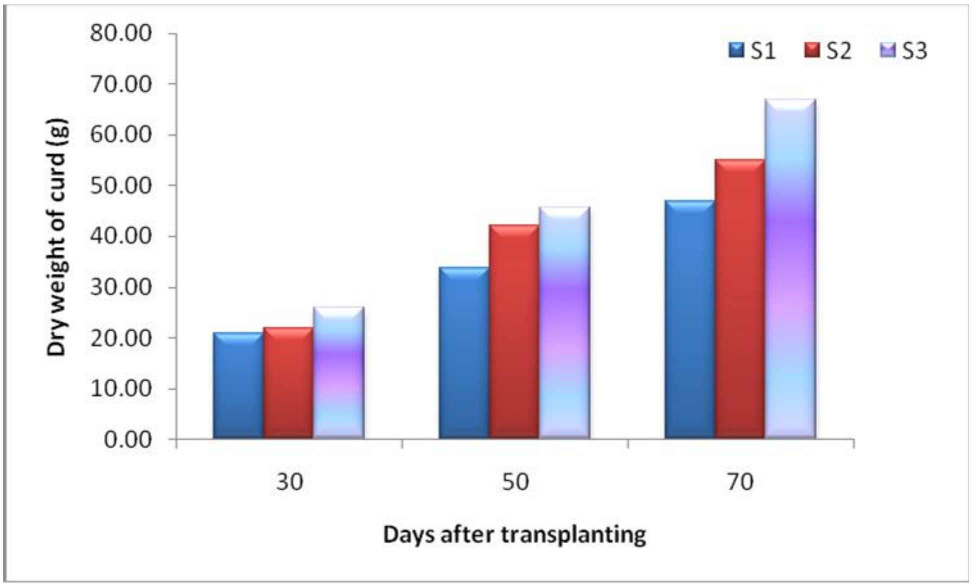
The dry weight of curd per plant was significantly influenced by plant spacing. Treatment S_3 produced maximum dry weight of curd per plant (25.88, 45.76 and 66.93 g at 50, 60 and 70 DAT, respectively) and the minimum (20.77, 33.86 and 47.00 g at 50, 60 and 70 DAT, respectively) dry weight of curd per plant was recorded in S_1 treatment (Fig 18).

The interaction effects of organic manure and plant spacing were significant in respect of dry weight of curd per plant. The highest dry weight of curd was observed (34.68, 57.53 and 73.41 g at 50, 60 and 70 DAT, respectively) and lowest dry weight of curd was observed (19.88, 30.29 and 37.83 g at 50, 60 and 70 DAT, respectively) in the treatment combination F_2S_3 and F_0S_1 (Table 8).



F_0=control, F_1=Cowdung, F_2 =Vermicompost

Fig.17 Effect of organic manure on dry weight of curd of cauliflower



S_1=60×30 cm, S_2=60×40 cm, S_3=60×50 cm,

Fig. 18 Effect of spacing on dry weight of curd of cauliflower

Table 8. Combined effect of organic manure and spacing on dry weight of curd of cauliflower

Treatment	Dry weight of curd (g)					
	50 DAT		60 DAT		70 DAT	
F_0S_1	**19.88**	**c**	**30.29**	**d**	**37.83**	**d**
F_0S_2	19.93	c	39.55	bc	47.56	c
F_0S_3	21.58	bc	43.27	b	54.99	b
F_1S_1	19.98	c	36.48	c	48.78	c
F_1S_2	20.83	bc	30.89	d	60.13	b
F_1S_3	23.01	b	44.26	b	72.38	a

F_2S_1	22.98 b	40.39 bc	54.37 b
F_2S_2	22.61 bc	42.48 b	57.20 b
F_2S_3	**34.68 a**	**57.53 a**	**73.41 a**
LSD $_{(0.05)}$	**2.58**	**5.08**	**5.49**
CV (%)	**10.03**	**11.12**	**9.55**

F_0= control, F_1= Cowdung, F_2 = Vermicompost

S_1= 60×30 cm, S_2= 60×40 cm, S3= 60×50 cm,

4.12 Curd weight with leaves

A significant variation was observed on curd weight with leaves due to the use of organic manure. The maximum curd weight with leaves (71.99, 312 and 397.4 gm at 50, 60 and 70 DAT, respectively) was recorded from F_2 (Vermicompost) treatment, While the minimum (69.26, 216.3 and 281.3 g at 50, 60 and 70 DAT, respectively) was from the control (F_0) treatment (Table 9).

The curd weight with leaves was also found to differ significantly by spacing treatment (Table. 10). The maximum curd weight with leaves (72.46, 274.6 and 412.6 g at 50, 60 and 70 DAT, respectively) was obtained from S_3 (60×50 cm) treatment. The S_1 treatment showed the minimum curd weight with leaves

(68.77, 272.4 and 296.9 g at 50, 60 and 70 DAT, respectively). It was revealed that with the increases of spacing individual weight per plant increased.

The interaction effects of organic manure and plant spacing were significant in respect of curd weight with leaves per plant. The highest (75.60, 350.5 and 487.6 g at 50, 60 and 70 DAT, respectively) and lowest (67.07, 180.1 and 224.3 g at 50, 60 and 70 DAT, respectively) curd weight with leaves was observed in the treatment combination F_2S_3 and F_0S_1 (Table 11).

Table 9. Effect of organic manure on Curd weight with leaves and Curd weight of cauliflower

Treatment	Curd weight with leaves (g)			Curd weight (g)		
	50 DAT	**60 DAT**	**70 DAT**	**50 DAT**	**60 DAT**	**70 DAT**
F_0	69.26 b	216.30 b	281.30 c	105.7 b	183.3 c	231.9 d
F_1	71.69 a	250.40 ab	374.60 b	122.3 ab	217.1 cb	346.20 ab
F_2	**71.99 a**	**312.00 a**	**397.40 a**	**123.4 a**	**276.5 a**	**360.3 a**
LSD $_{(0.05)}$	1.41	61.98	19.62	1.52	29.29	27.4
CV (%)	7.63	8.08	7.67	10.16	10.89	8.40

F_0= control, F_1= Cowdung, F_2 = Vermicompost

Table 10. Effect of spacing on Curd weight with leaves and pure curd weight of cauliflower

Treatment	Curd weight with leaves (g)			Pure curd weight (g)		
	50 DAT	60 DAT	70 DAT	50 DAT	60 DAT	70 DAT
S_1	**68.77 b**	**272.4 ab**	**296.9 c**	**114.7 b**	**191.7 b**	**265.1 c**
S_2	71.71 ab	231.7 b	343.9 b	115.9 ab	249.8 ab	307.8 b
S_3	**72.46 a**	**274.6 a**	**412.6 a**	**120.8 a**	**235.4 a**	**365.4 a**
LSD $_{(0.05)}$	**2.634**	**11.23**	**20.84**	**1.036**	**7.548**	**27.63**
CV (%)	**7.63**	**8.08**	**7.67**	**10.16**	**10.89**	**8.40**

S_1= 60×30 cm, S_2= 60×40 cm, S3= 60×50 cm,

Table 11. Combined effect of organic manure and spacing on Curd weight with leaves and Curd weight of cauliflower

Treatment	Curd weight with leaves (g)			Curd weight (g)		
	50 DAT	60 DAT	70 DAT	50 DAT	60 DAT	70 DAT
F_0S_1	**67.07 c**	**180.10 e**	**224.30 e**	**102.4 d**	**145.4 f**	**185.8 g**
F_0S_2	68.93 bc	216.60 d	291.30 d	104.3 cd	190.4 e	239.9 f
F_0S_3	71.77 abc	252.20 c	328.30 cd	110.5 bcd	212.2 d	269.9 e
F_1S_1	67.27 c	216.50 d	293.00 d	119 abcd	192.5 e	290 d
F_1S_2	71.97 abc	250.10 c	343.30 bc	122.4 abc	258.6 b	330.5 c
F_1S_3	73.40 ab	284.60 b	458.80 a	128.9 ab	202.1 de	418 a

F_2S_1	70.60 abc	287.00 b	360.10 bc	116.5 abcd	239.4 c	319.6 c
F_2S_2	72.20 abc	298.50 b	373.30 b	117.5 abcd	255.1 b	353 b
F_2S_3	**75.60 a**	**350.50 a**	**487.60 a**	**132.9 a**	**335.1 a**	**408.3 a**
LSD $_{(0.05)}$	**5.30**	**30.91**	**40.04**	**16.71**	**14.43**	**6.05**
CV (%)	**7.63**	**8.08**	**7.67**	**10.13**	**8.23**	**9.48**

F_0= control, F_1= Cowdung, F_2 = Vermicompost

S_1= 60×30 cm, S_2= 60×40 cm, S3= 60×50 cm,

4.13 Curd weight

A significant variation was observed on curd weight due to the use of organic manure. The maximum curd weight (123.4, 276.5 and 360.3 g at 50, 60 and 70 DAT, respectively) was recorded from (F_2) vermicompost treatment, While the minimum (105.7, 183.3 and 231.9 g at 50, 60 and 70 DAT, respectively) was from the control (F_0) treatment (Table 9).

The curd weight was also found to differ significantly by spacing treatment (Table 10). The maximum curd weight (120.8, 235.4 and 365.4 g at 50, 60 and 70 DAT, respectively) was obtained from S_3 (60×50 cm) treatment. The S_1 treatment showed the minimum curd weight (114.7, 191.7 and 265.1 g at 50, 60 and 70 DAT, respectively). It was revealed that with the increases of spacing individual weight per plant increased (Plate 1).

The interaction effects of organic manure and plant spacing were significant in respect of curd weight per plant. The highest (132.9, 335.1 and 408.3 g at 50, 60 and 70 DAT, respectively) and lowest (102.4, 145.4 and 185.8 g at 50, 60 and 70 DAT, respectively) curd weight was observed in the treatment combination of F_2S_3 and F_0S_1 (Tableb 11).

A

B

C

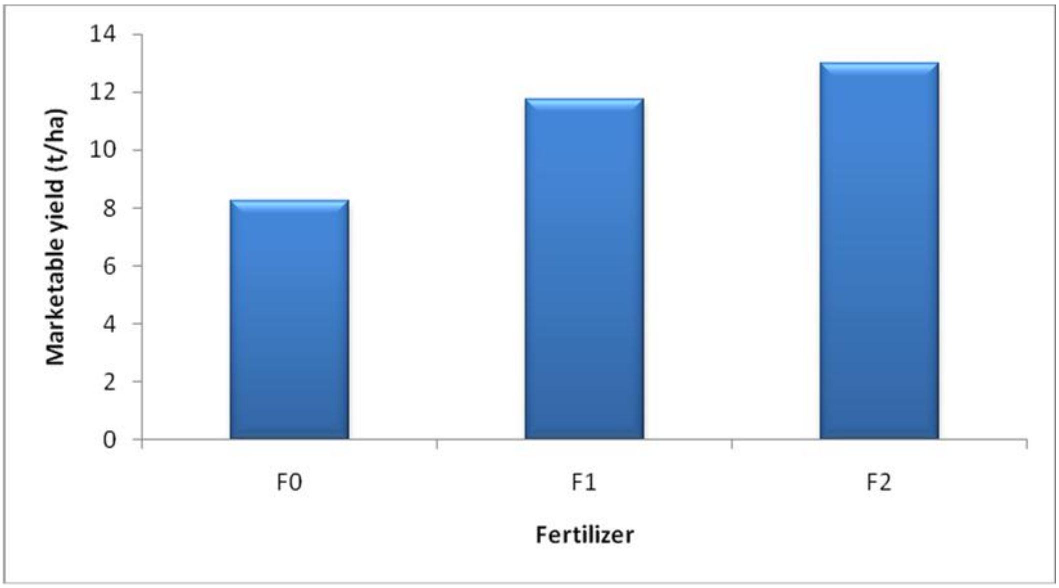
Plate 1: Picture showing curd of Cauliflower with
A) Controlled Organic manure with 60 cm×30 cm Spacing which resulted small curd size
B) Cowdung with 60 cm ×40 cm Spacing which resulted medium size curd
C) Vermicompost with 60 cm×50 cm spacing which resulted best size curd

4.11 Yield (t ha^{-1}) of Cauliflower per hectare

Yields of cauliflower varied significantly due to different organic manure. The maximum yield (12.98 t ha^{-1}) was found from (F_2) treatment. The minimum yield (8.24 t ha^{-1}) in this respect was found from control treatment (Fig 19).

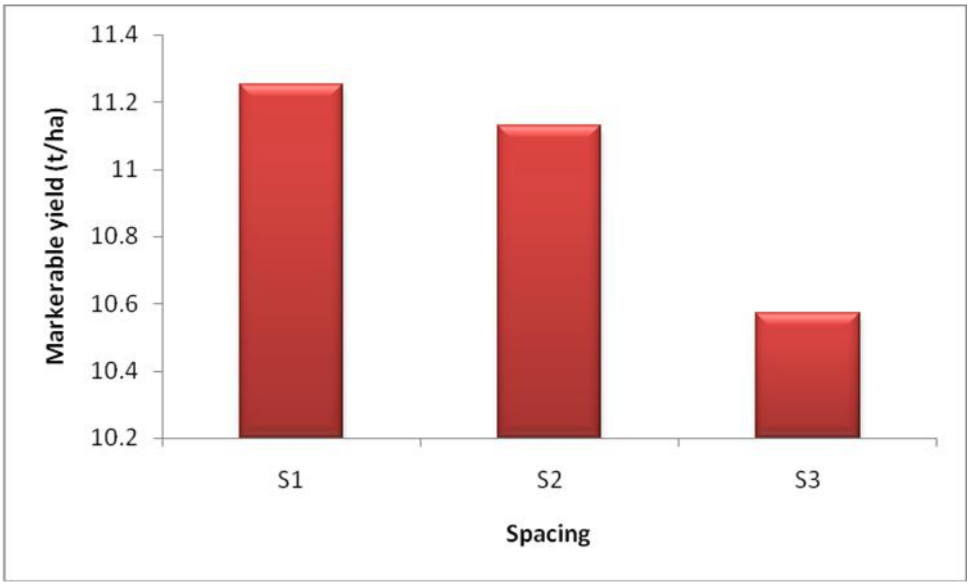
The yield of cauliflower per hectare was found to be statistically significant due to spacing (Fig.20). The highest yield (11.25 t ha^{-1}) was obtained from S_1 treatment and the lowest (10.57 t ha^{-1}) in this regard was obtained from S_3 treatment. It was revealed that with the increases of spacing individual weight per plant increased. So, in spite of less population, total yield per plot may higher due to higher individual plant weight and optimum spacing ensured the highest yield with maximum vegetative growth.

A significant combined effect of organic manure and spacing was also observed on yield of cauliflower per hectare. Though there is almost similar results are found from the treatment of controlled manure and cowdung manure. Because nitrogenous fertilizer is given repeatedly in field where cauliflower has been grown. The highest yield of cauliflower (13.33 t ha^{-1}) was obtained from vermicompost with 60×30cm spacing (F_2S_1) treatment which is statistically similar to F_2S_2 treatment and the lowest (7.91 t ha^{-1}) was found in the no organic manure with 60×50cm spacing (F_0S_3) treatment (Table 12).



F_0=control, F_1=Cowdung, F_2 =Vermicompost

Fig. 19 Effect of organic manure on yield of cauliflower



S_1=60×30 cm, S_2=60×40 cm, S_3=60×50 cm,

Fig. 20 Effect of spacing on yield of cauliflower

Table 14. Combined effect of organic manure and spacing on yield of cauliflower

Treatment	Yield (t/ha)	
F_0S_1	8.42	ef
F_0S_2	8.38	e
F_0S_3	**7.91**	**f**
F_1S_1	11.99	c
F_1S_2	11.79	cd
F_1S_3	11.4	d
F_2S_1	**13.33**	**a**
F_2S_2	13.21	ab
F_2S_3	12.4	b
LSD $_{(0.05)}$	**0.395**	
CV (%)	**17.52**	

F_0= control, F_1= Cowdung, F_2 = Vermicompost

S_1= 60×30 cm, S_2= 60×40 cm, S3= 60×50 cm,

4.12 Cost and return analysis

The cost and return analysis were done and have been presented in table 13. Materials (1A), non materials (1B) and over head costs were recorded for all the treatments of unit plot and calculated on per hectare basis the price of cauliflower at the local market rate were considered.

The total cost of production ranges between Tk. 88725 and 105600 per hectare among the different treatment combinations. The variation was due to different cost of different types of manure. The highest cost of production Tk. 105600 per ha was involved in the treatment combination of vermicompost (F_2S_1), while the lowest cost of production Tk. 88725 per ha was involved in the combination of no fertilizer and manure (F_0S_3) . Gross return from the different treatment combinations range between Tk 399900 and 237300 per ha.

Among the different treatment combinations vermicompost with 60×30 cm spacing (F_2S_1) gave the highest return Tk. 294300 per ha while the lowest net return Tk. 148575was obtained from the treatment combination of control with 60×50cm spacing (F_0S_3).

The benefit cost ratio (BCR) was found to be the highest (3.79) in the treatment combination of vermicompost with 60×30 cm spacing (F_2S_1). Thus it was apparent that although vermicompost with 60×30cm spacing (F_2S_1) treatment gave the highest yield (13.33 t ha^{-1}) and the highest gross return (Tk. 399900.00).

Table 15. Cost and return of cauliflower due to fertilizer management and spacing treatments

Treatment combinations	Marketable yield (t/ha) 70 DAT	Gross return (Tk/ha)	Total cost of production (Tk/ha)	Net return (Tk/ha)	Benefit cost ratio (BCR)
F_0S_1	8.42	252600	88725	163875	2.85
F_0S_2	8.38	251400	88725	162675	2.83
F_0S_3	**7.91**	**237300**	**88725**	**148575**	**2.67**
F_1S_1	11.99	359700	111225	248475	3.23
F_1S_2	11.79	353700	111225	242475	3.18
F_1S_3	11.4	342000	111225	230775	3.07
F_2S_1	**13.33**	**399900**	**105600**	**294300**	**3.79**
F_2S_2	13.21	396300	105600	290700	3.75
F_2S_3	12.4	372000	105600	266400	3.52

Price of cauliflower 30000 tk ha^{-1}

F_0= control, F_1= Cowdung, F_2 = Vermicompost

S_1= 60×30 cm, S_2= 60×40 cm, S3= 60×50 cm,

CHAPTER V

SUMMARY AND CONCLUSION

The field experiment was conducted at the Horticulture Farm, Sher-e-Bangla Agricultural University (SAU), Dhaka during the period from April 2013 to August 2013 to study the potentiality of producing summer cauliflower as influenced by different organic nutrient sources and spacing. In experiment, the treatment consisted of three organic manures viz. F_0: No organic manure, F_1: Cowdung, F_2: Vermicompost and three spacing viz. S_1 (60 cm × 30 cm), S_2 (60 cm × 40 cm), S_3 (60 cm × 50 cm).

Two factorial experiments were laid out in the Randomized Complete Block Design (RCBD) with three replications. Whole experimental area was first divided into three blocks. Then each block was divided into 9 unit plots that are total 27 (1.8 m × 2 m) unit plots. Seedlings were transplanted in the experimental plots on 25 th May, 2013. Healthy and uniform sized 30 days old seedlings were used as transplanting materials. Necessary intercultural operations were done as and when necessary. Data on different growth parameters and yield were recorded.

Results showed that a significant variation was observed among the treatments in respect majority of the observed parameters. The collected data were statistically analyzed for evaluation of the treatment effect. Using MSTAT statistical package programmed. Difference between treatment means were determined by Duncan`s new Multiple Range Test (DMRT).

The effect of organic manure demonstrated that, the Vermicompost produced the tallest plant (26.51, 29.34, and 30, 50.80 cm at 30, 50 and 70 DAT, respectively). Significant variation in number of leaves was observed due to organic manure. The maximum number of leaf (13.56, 14.49 and 16.16 at 30, 50 and 70 DAT, respectively) was obtained from the organic manure of Vermicompost. The results on effects of organic manure showed that different organic manure had significant effect on length of leaf at different days after transplanting. The Vermicompost gave the maximum length of leaf (19.3, 22.07 and 23.71 cm at 30, 50 and 70 DAT, respectively).

Vermicompost produced the widest (10.53, 11.48 and 12.96 cm at 30, 50 and 70 DAT, respectively) leaf. Organic manure significantly influenced the fresh weight of leaves per plant. The maximum weight of fresh leaves per plant (30.92, 219.8 and 277.2 g at 30, 50 and 70 DAT, respectively) was observed in F_2. The maximum dry weight per plant (15.87, 111.00 and 142.00 g at 30, 50 and 70 DAT, respectively) was observed in F_2. Vermicompost produced the highest stem diameter (1.71, 1.75 and 1.85 cm at 30, 50 and 70 DAT, respectively). Vermicompost produced the highest root length (22.42, 23.24 and 25.26 cm at 30, 50 and 70 DAT, respectively). the maximum pure curd height (8.11, 8.46, and 8.91 cm at 50, 60 and 70 DAT, respectively) was observed in F_2 (Vermicompost) treatment. Vermicompost produced the highest diameter of curd (7.83, 8.73 and 14.25 cm at 50, 60 and 70 DAT, respectively). The maximum dry weight of curd per plant (25.85, 46.8 and 62.3 g at 50, 60 and 70 DAT, respectively) was observed in F_2. The maximum curd weight with leaves (71.99, 312 and 397.4 gm at 50, 60 and 70 DAT, respectively) was recorded from F_2 (Vermicompost) treatment. The maximum pure curd weight (105.7, 183.3 and 231.9 g at 50, 60 and 70 DAT, respectively) was recorded from F_2 (Vermicompost) treatment. The maximum marketable yield (12.98 t/ha) was found from Vermicompost treatment.

The tallest (25.93, 29.17 and 30.89 cm at 30, 50 and 70 DAT, respectively) was observed in S_1 (60×30 cm). The maximum number of leaves per (13.18, 13.18 and 15.69 at 30, 50 and 70 DAT, respectively) was obtained from S_3 (60× 50 cm) treatment. Treatment S_3 produced maximum length of leaf (19.9, 22.54 and 22.57 cm at 30, 50 and 70 DAT, respectively). Treatment S_3 produced maximum breadth of leaf (10.66, 11.89 cm and 12.34cm at 30, 50 and 70 DAT, respectively). Treatment S_3 produced maximum fresh weight of leaves per plant (31.53, 191.6 and 284.5 g at 30, 50 and 70 DAT, respectively). Treatment S_3 produced maximum dry weight per plant (16.46, 97.26 and 144 g at 30, 50 and 70 DAT, respectively). Treatment S_3 produced maximum Diameter of stem (1.72, 1.78 cm and 1.89 cm at 30, 50 and 70 DAT, respectively). Treatment S_3 produced maximum root (22.27, 23.4 cm and 26.07 cm at 30, 50 and 70 DAT, respectively). The highest pure curd height (7.94, 8.36 and 8.53 cm at 50, 60 and 70 DAT, respectively) was observed in S_3 (60×50 cm) treatment. Treatment S_3 produced maximum Diameter of curd (7.83, 8.65 cm and 14.44 cm at 50, 60 and 70 DAT, respectively). Treatment S_3 produced maximum dry weight of curd per plant (25.88, 45.76 and 66.93 g at 50, 60 and 70 DAT, respectively). The maximum curd weight with leaves (72.46, 274.6 and 412.6 g at 50, 60 and 70 DAT, respectively) was obtained from S_3 (60×50 cm) treatment. The maximum pure curd weight (120.8, 235.4 and 365.4 g at 50, 60 and 70 DAT, respectively) was obtained from S_3 (60×50 cm) treatment. The highest marketable yield (11.25 t/ha) was obtained from S_1 treatment

Interaction effect of different organic manure and spacing had a significant variation on all parameter. The tallest plant (27.47, 30.47 and 33.13 cm at 30, 50 and 70 DAT, respectively) was found from the Vermicompost and 60×30 cm spacing treatment (F_2S_1). The maximum number of leaves(13.87, 15.67 and 17.73 at 30, 50 and 70 DAT, respectively), length of leaf (24.03, 24.13 and 25.67 cm at 30, 50 and 70 DAT, respectively), breadth of leaf (11.57, 12.17 and 13.73 cm at 30, 50 and 70 DAT, respectively), fresh weight of leaves per plant (33.37, 238.8 and 348.2 g at 30, 50 and 70 DAT, respectively), dry weight per plant (17.33, 121.1 and 176.6 g at 30, 50 and 70 DAT, respectively) were obtained from Vermicompost with 60×50 cm (F_2S_3) treatment. The highest diameter of stem (1.80, 1.83 and 1.93 cm at 30, 50 and 70 DAT, respectively), root length (23.9, 24.8 and 27.78 cm at 30, 50 and 70 DAT, respectively), pure curd height (8.34, 9.08 and 9.10 cm at 50, 60 and 70 DAT, respectively) and diameter of curd (7.83, 8.73 and 14.25 cm at 50, 60 and 70 DAT, respectively) was obtained from the treatment combination of F_2S_3 The highest (34.68, 57.53 and 73.41 g at 50, 60 and 70 DAT, respectively) dry weight of curd was observed in the treatment combination F_2S_3. The highest (75.60, 350.5 and 487.6 g at 50, 60 and 70 DAT, respectively) curd weight with leaves was observed in the treatment combination F_2S_3. The interaction effects of organic manure and plant spacing were significant in respect of pure curd weight per plant. The highest pure curd weight (132.9, 335.1 and 408.3 g at 50, 60 and 70 DAT, respectively) was observed in the treatment combination F_2S_3 (Vermicompost with 60×50 cm). The highest yield of cauliflower (13.33 t/ha) was obtained from vermicompost with 60×30cm spacing (F_2S_1) treatment.

The benefit cost ratio (BCR) was found to be the highest (3.79) in the treatment combination of vermicompost with 60×30 cm spacing (F_2S_1).

Considering the stated findings, it may be concluded that yield and yield contributing parameters are positively correlated with orananic manure and spacing. However, white beauty planted and use of vermicompost with 60×50 cm spacing would be beneficial for the farmers.

Conclusion

Considering the situation of the present study, further studies in the following areas may be suggested-

i. Other combination of spacings may also use to optimize spacing for higher yield of cauliflower in summer season.

ii. Available other organic manure with different amounts and their combination may be used for further study especially in summer season.

iii. Doses of organic fertilizer may be rearranged for specification.

iv. Further investigation may carry out in different agro ecological zones of Bangladesh before giving final recommendation.

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