# EFFICACY OF VERMICOMPOST AND CONVENTIONAL COMPOST ON THE GROWTH AND YIELD OF CAULIFLOWER

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## *CERTIFICATE*

This is to certify that the thesis entitled, "EFFICACY OF VERMICOMPOST AND CONVENTIONAL COMPOST ON THE GROWTH AND YIELD OF CAULIFLOWER" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE IN SOIL SCIENCE, embodies the result of a piece of *bona fide* research work carried out by FATEMA NASRIN JAHAN, Registration No. 04-01452 under my supervision and 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 been duly acknowledged by her.

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*DEDICATED*

*TO*

*MY*

*BELOVED*

*PARENTS*

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## ABSTRACT

A field experiment was conducted with cauliflower "Snow white" during the rabi season (2008-2009) in Grey Terrace Soil (Inceptisol) of Joydebpur, Agro Ecological Zone (AEZ-28). To find out the efficacy of vermicompost (VC) and conventional compost (CC) on cauliflower (*Barssica oleracea* var. botrytis) yield, uptake, optimum rate of vermicompost and conventional compost for cauliflower cultivation. Minimize the use of chemical fertilizer in presence of vermicompost or conventional compost. The experiment was laid out in RCBD design with twelve treatments replicated three times. The treatments were: $T_1$= 100% Recommended Dose of Chemical Fertilizer (RDCF),$T_2$= 80% RDCF,$T_3$= 60% RDCF,$T_4$= 100% RDCF+ VC @ 1.5 t $ha^{-1}$,$T_5$= 80% RDCF+ VC @ 3 t $ha^{-1}$, $T_6$= 60% RDCF+ VC @ 6 t $ha^{-1}$,$T_7$= VC @ 6 t $ha^{-1}$, $T_8$= 100% RDCF+ CC @ 1.5 t $ha^{-1}$,$T_9$= 80% RDCF+ CC @ 3 t $ha^{-1}$,$T_{10}$= 60% RDCF+ CC @ 6 t $ha^{-1}$, $T_{11}$= CC @ 6 t $ha^{-1}$,$T_{12}$= Absolute control. The doses of 100% RDCF was $N_{250}$ $P_{35}K_{65}S_{40}$ $Zn_5B_1$kg $ha^{-1}$. The sources of vermicompost were cowdung and kitchen wastes (3:1) processed by epigeic earthworm *Eisenia fetida*. Different nutrient packages significantly influenced the yield and yield components of cauliflower. It was observed that 100% RDCF+ 1.5 t $ha^{-1}$ vermicompost produced the highest curd yield (37.63 t $ha^{-1}$) of cauliflower. This yield was statistically identical with 100% RDCF + 1.5 t $ha^{-1}$ conventional compost (34.67 t $ha^{-1}$) and 80% RDCF + 3.0 t $ha^{-1}$ vermicompost (34.07 t $ha^{-1}$). Vermicompost exhibited better performance than conventional compost alone or in combination with chemical fertilizer. The enhanced yield of cauliflower in this study can be partially explained by the elevated levels of NPKS contents in the vermicompost. It is suggested that vermicompost (1.5 t $ha^{-1}$) + NPKSZnB (100%) is more favorable for higher curd yield of cauliflower and suitable for soil environment but vermicompost (3 t $ha^{-1}$) + NPKSZnB (80%) can be more environmentally suitable. In this fertilizer package, 20% chemical fertilizer is reduced in presence of vermicompost. Use of vermicompost can play a vital role in minimizing the fertilizer crisis. All the treatments showed a negative balance for N and K and those for P and S was positive balance except the control treatment at Joydebpur. Residual effect of vermicompost showed increased plant available nutrients in post harvest soil; to improve and sustain soil health as well as to improve crop production; chemical fertilizer rate needs to be reduced.

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# LIST OF ABBRIVIATIONS

| ABBREVIATION | FULL WORD |
|---|---|
| AEZ | Agro-Ecological Zone |
| @ | At the rate |
| CEC | Cation Exchange Capacity |
| cm | Centimeter |
| $CuSO_4.5H_2O$ | Green vitriol |
| cv. | Cultivar(s) |
| CV% | Percentage of Coefficient of Variance |
| DMRT | Duncan's Multiple Range Test |
| e.g. | example |
| *et al* | and others |
| FYM | Farm Yard Manure |
| g | Gram |
| $H_3BO_3$ | Boric acid |
| $HClO_4$ | Perchloric acid |
| $HNO_3$ | Nitric acid |
| $H_2O_2$ | Hydrogen per oxide |
| $H_2SO_4$ | Sulfuric acid |
| i.e | that is |
| K | Potassium |
| kg | Kilogram |
| kg $ha^{-1}$ | Kg per hectare |
| $K_2SO_4$ | Potassium Sulfate |
| LSD | Least Significant Difference |
| S | Sulphur |
| TSP | Triple Super Phosphate |
| m | Meter |
| Mg | Megagram |
| mL | Milliliter |
| mm | Millimeter |
| MP | Muriate of Potash |
| N | Nitrogen |
| NaOH | Sodium Hydroxide |
| NPKS | Nitrogen, Phosphorus, Potassium and Sulphur |
| OM | Organic matter |
| pH | Hydrogen ion concentration |
| $^0C$ | Degree Celsius |
| % | Percent |
| RCBD | Randomized Complete Block Design |
| SAU | Sher-e-Bangla Agricultural University |
| t $ha^{-1}$ | Ton per hectare |

# CHAPTER 1

# INTRODUCTION

# CHAPTER I

## INTRODUCTION



Cauliflower (*Brassica oleracea* L. var. botrytis sub var cauliflora cv) is a cole crop and belongs to the family cruciferae. It commonly grow in the vegetable producing countries like USA, UK, New Zealand, Italy, China, India, Egypt, Israel, Thailand, Bangladesh etc. Cauliflower is one of the popular vegetables grown in winter season of Bangladesh. It is low in fat, high in dietary fibre, folate, water and vit C. It possesses a very high nutritional density which can help to protect a range of diseases from cancer to cataract (Kirsh *et al.,* 2007). Cauliflower is also a very tasty and much popular vegetable in Bangladesh as well as all over the world being cultivated in large area in the growing period. It contains 8.0 g carbohydrate, 2.3 g protein, 40 IU carotene, 0.13 mg $B_1$, 0.11 mg $B_2$, 50 mg Vit C, 30 mg Ca and 0.8 mg iron per 100g edible curd (Rashid, 1999). The demand as well as the price of cauliflower is also higher, both in the national and international market.

In Bangladesh, the yield of vegetable crops declined due to depleted soil fertility. Soil organic matter plays a crucial role in soil fertility of horticultural crops. However, the continuous use of large quantities of chemical fertilizers has led to reduce levels of organic matter in most agricultural soils. It leads to loss of soil fertility due to imbalanced use of fertilizers that has adversely impacted agricultural productivity and causes soil degradation. The continuous use of chemical fertilizers badly affects the texture and structure, reduces organic matter content and decreases microbial activities of soil (Alam *et al.* 2007a). Now there is a growing realization that the adoption of ecofriendly and sustainable farming practices can resolve the declining trend in the global productivity and environment protection.

The application of organic matter to soil is the prime need for the maintenance of soil fertility status and crop productivity in agricultural systems (Karmegam and Daniel, 2000). Application of different doses of organic manure with or without inorganic fertilizer significantly increased organic matter content in soil, but application of inorganic fertilizer alone had no positive effect on soil. Imbalanced use of chemical fertilizer in vegetables and other crops production is a common practice in Bangladesh. The farmers are using the chemical fertilizers continuously without knowing the actual dose and their residual effects on soil properties as well as quality and production of crops. In Bangladesh, most of the cultivated soils have less than 1.5% organic matter while a good agricultural soil should contain at least 2% organic matter. Under these imbalanced conditions various beneficial soil microorganisms are being adversely affected. The soil is losing the fertility as well as productivity day by day. If this trend continues, crop production will be seriously affected in the long run. On the contrary, organic manure can play a vital role in sustaining soil fertility and crop production. Therefore, integrated nutrient management in which both organic manures and inorganic fertilizers are used simultaneously is probably the most effective method to maintain healthy sustainable soil system with increasing crop productivity. So, combined applications of both organic and inorganic fertilizers need to be applied for the improvement of soil physical properties and requisite supply of essential plant nutrients.

Several methods have been developed to convert bio-wastes into organic manure as an alternate source of farm yard manure and a substitute for chemical fertilizers. Among the various methods of waste management, vermicomposting is an important aspect as it converts organic wastes into potential organic manure within a short period by using epigeic earthworms as biological agent. The compost prepared by the action of earthworm of non-toxic biodegradable waste is called 'vermicompost' and is considered as a very important aspect in the organic farming practices. However, the first reports in academic literature documenting the use of earthworms for vermicomposting appeared after the Second World War (Barrett, 1949). Vermicompost, especially earthworms' casts is the final product of vermicomposting. In Bangladesh, epigeic earthworm *Eisenia fetida* is widely used for vermicomposting as it is easily available and well adapted. Earthworm vermicompost is proved to be highly nutritive 'organic fertilizer' and more powerful 'growth promoter' over the conventional compost and a 'protective' farm input (increasing the physical, chemical & biological properties of soil, restoring and improving its natural fertility) against the 'destructive' chemical fertilizers which has destroyed the soil properties and decreased its natural fertility over the years. Vermicompost is rich in NPK (nitrogen 2-3%, phosphorus 1.55-2.25% and potassium 1.85-2.25%), micronutrients and beneficial soil microbes and also contain 'plant growth hormones and enzymes'. It is scientifically proving as 'miracle growth promoter and also plant protector' from pests and diseases.

Use of vermicompost for vegetable production in large scale can solve the problem for disposal of wastes and also solve the lack of organic matter in soil (Alam *et al.*, 2007b). On the other hand, a judicious combination of organic and inorganic sources of nutrients might be helpful to obtain a good economic return with good soil health for the subsequent crop. Vermicompost is rich in organic matter, which plays a key role in soil fertility, and contains all essential plant nutrients in appropriate proportions which can be a complete and balanced plant food. Prospect of vermicompost in Bangladesh is bright. Huge amount of cowdung and other animal dung, water hyacinth, kitchen waste, municipal waste and other decomposable substances are available in Bangladesh. About 2.5 crore rural house holds generate 25 lakh M ton kitchen wastes per day. (Dainik Sangbad, 2009). Approximately 60% or more of household waste is of organic type that could be recycled using vermiculture (Tripathi *et al.*, 2005). Beside these, compost worms are sold to households for recycling of organic waste and have the potential to be used in vermitechnology waste conversion systems for industrial or municipal applications.

Information on the use of organic manure like vermicompost and conventional compost for vegetable production alone or in combination with chemical fertilizer is not adequate in our country. So, it is necessary to carry out such studies by using fertilizers and manures in an integrated way in order to obtain sustainable crop yield without affecting soil fertility.

Keeping these in mind, the preset investigation was undertaken to study the effects of vermicompost and conventional compost on the nutrient concentration, uptake and yield of cauliflower in Grey Terrace Soil of Bangladesh (AEZ-28). Considering the above facts the present study has been undertaken with the following objectives.

**Objectives:**

- To study the effect of vermicopost and conventional compost on the growth and yield of cauliflower.
- To determine the optimum rate of vermicopost and conventional compost for cauliflower cultivation.
- To minimize the use of chemical fertilizer with the replacement of vermicompost and conventional compost in vegetable production.

# CHAPTER 2

# REVIEW OF LITERATURE

# CHAPTER II

# REVIEW OF LITERATURE

A large variety of organic materials is available in the country that can be used as potential supplement to improve soil organic matter. These are cow dung, poultry manure, rice straw, wheat straw, water hyacinth, leaf litter, household wastes, biogas slurry, vermicompost, sugarcane trash, oil cakes, molasses, rice husk, bran, saw dust etc. Effect of different inorganic fertilizer on the growth and yield of cole crops have been investigated by many investigators in various part of the world. So there are most available information on the effect of inorganic fertilizer on the growth and yield of these crops. But very little information about organic fertilizer and combined effect of organic and inorganic fertilizer on the yield of cauliflower is available elsewhere. Among the cole crops the method of cultivation of cauliflower, broccoli and cabbage are almost similar. Therefore, a brief review of the available literature on cauliflower along with some pertinent information on cabbage, broccoli etc. has been furnished in this chapter.

## 2.1 Effect of compost and inorganic fertilizer on soil organic matter content of soil

Soil organic matter is a key factor for sustainable soil fertility and crop productivity. Organic matter undergoes mineralization with the release of substantial quantities of N, P, and S and smaller amounts of micronutrients. The organic matter content of Bangladesh soils has been depleted by 5 to 36% during the period of 1967-1995 (Ali *et al.*, 1997) which is an indicator of its productivity. A good soil should have at least 2.5% organic matter, but in Bangladesh most of the soils have less than 1.5%, and some soils even less than 1% ranging between 0.05 and 0.9% in most cases. It is believed that the declining productivity of the country's soil is the result of depletion of organic matter due to increasing cropping intensity, higher rates of decomposition of organic matter under the prevailing hot and humid climate, use of lesser quantities of organic manure, little or no use of green manure practices etc. (BARC, 2005). More than 60% of the soils contain less than 2% organic matter and N percentage is very low in our country (Zaman, 1986).

If the present rate of degradation is continued, in near-future the soil would become barren. Moreover, the organic matter content of our soil is declining with time due to poor attention to its improvement and maintenance. The addition of organic materials to soil through farmyard manures, composts, and organic residues has been reduced considerably because a major portion of these residues is used up as fuel or livestock feed by the rural population. Owing to increasing cost of fertilizers and their short supply, it is felt essential to reduce the dependence of chemical fertilizers (Ahmed *et al.*, 1998). Soil degradation, mainly the decline in soil organic matter both in quality and quantity, is one of the major reasons linked to stagnation and decline in yields in most chemical intensive agriculture areas in Bangladesh (Gopikrishna, 2011).

Soil organic matter, living or dead plant and animal residue, is a very active and important portion of the soil. It is the N reservoir, furnishes large portion of the soil P and S; it protects soils against erosion and supplies the cementing substances for desirable aggregate formation and loosens up the soil to provide better aeration and water movement. For maximum benefit, organic matter must be readily decomposable and continuously replenished with fresh residues such as roots, tops, and manures (Donahue *et al.*, 1983).

**2.2 Effect of inorganic fertilizer on cole crops**

Jana and Mukhopadhyay (2002) reported that the application of 150 kg N $ha^{-1}$ and 80 kg $P_20_5ha^{-1}$ exhibited the highest value with respect to leaves per plant, curd diameter, curd height, net curd weight and marketable curd yield of cauliflower.

Bjelic *et al.* (2000) conducted a field trial in the Lazarevac region of Yugoslavia. Cauliflower cv. Lawyna was grown from seedlings on a Pseudogley soil and given N fertilizer at 80, 120, 160 or 200 kg N $ha^{-1}$ in addition to 120 kg P $ha^{-1}$ and 90 kg K $ha^{-1}$, at the time of transplanting (all P, all K, half N dose) and as top dressing (half N dose). Curd diameter was measured every 10 days and yields were recorded at maturity. Nitrogen application increased curd diameter and significantly increased cauliflower yields (average10.68 t $ha^{-1}$ increased over control). However, nitrogen fertilizer rates greater than 160 kg $ha^{-1}$ did not significantly increase cauliflower yields.

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Anwar *et al.* (2001) mentioned that application of NPKS to soils significantly increased leaf length of broccoli.

Kishan *et al.* (1999) obtained the maximum curd weight (408.5 g), diameter (12.84 cm) and curd yield (64.85 q $ha^{-1}$) of cauliflower from 90 kg N per hectare and 80 kg $P_2O_5$ $ha^{-1}$. In a two season trial on cauliflower plants of the cultivars Soltany and Amsheey was supplying 0-120 kg N per feddan (1 feddan = 0.42 ha), applied a, ammonium nitrate 30 and 60 days after planting. In addition plants were sprayed with B (2.5 kg borax per feddan) or Mo (500 g ammonium molybdate per feddan) 45 days after planting. They found that all fertilize, treatments enhanced curd yield and quality in both cultivars. Plant fresh weight, curd weigh, curd diameter, ratio of curd weight, to plant weight, total curd yield and leaf N content increased with increasing N application rate, but date of curd formation was delayed. Microelement treatments did not affect curd formation date or curd weight and plant weight ratio. Interactions between N rates and microelements treatments were significant for most traits studied.

Rather *et al.* (1999) investigated the response of yield and quality of cauliflower varieties (*Brassica oleracea* var. botrytis) to nitrogen supply at University of Hannover, Germany. Field trials were conducted in 1993 and 1994 with the cauliflower Fl-hybrids Marine, Lindurian and Linford at Ruthe (Germany) and Schermer (the Netherlands) sites. Optimum N supply was 250 kg $ha^{-1}$ as the sum of the inorganic N content of the soil (Nmin) at planting and fertilizer N. Limiting N supply consisted of Nmin at planting and mineralization of N during cultivation. The Nmin at planting was 116 and 66 kg $ha^{-1}$ at Ruthe and 84 and 20 kg $ha^{-1}$ at Schermer in 1993 and 1994, respectively. The yield in terms of total dry-matter and quality was highest in hybrid cauliflower (Marine) both at limiting and optimum N supply. Linford could be considered as N inefficient in quality, whereas Lindurian generally performed inconsistently. The reduction in quality with N shortage was due to an increase in loose curds, indicating that limiting N supply promoted the process of bolting. It was concluded that the improved efficiency of hybrid cauliflower in terms of total dry matter and quality might have been achieved either through a higher N uptake capacity of the root system or through a greater utilization of N by the plant.

In an experiment conducted by Mohanty and Hossain (1998) at Regional Research Station, Orissa, India in 1987-88 and 1988-89 with cabbage cv. Pride of India were given N @ 40, 80 or 120 kg $ha^{-1}$ and P @ 30 or 60 kg $P_2O_5$ $ha^{-1}$ as well as FYM at 50 q $ha^{-1}$. Yields increased as N and P rates increased and were higher in 1988-89 than in 1987-88. The highest yield of 242.80 q $ha^{-1}$ followed application of 120 kg N + 60 kg $P_2O_5$ $ha^{-1}$ in 1988-89. There was a significant interaction between N and P for head weight and diameter. The treatment with the best return on cost of fertilizer application was 120 kg N + 30 kg $P_2O_5$ $ha^{-1}$.

The effects of amount and timing of nitrogen fertilization on growth parameters of cauliflower and soil nitrogen depletion were studied at a site in Denmark by Boogaard and Thorup (1997). A higher nitrogen supply, calculated as the sum of fertilizer nitrogen and mineral nitrogen at transplanting, increased the nitrogen uptake by the crop and the crop fresh weight. Curd fresh or dry weight and looseness of the curd were not affected. It was shown that total nitrogen supply can be reduced to 250 kg $ha^{-1}$ without negative effects on yield. An increase in nitrogen supply of 100 kg $ha^{-1}$ resulted in 17 kg $ha^{-1}$ more residual soil nitrogen, 52 kg $ha^{-1}$ more nitrogen in crop residues, 37 kg $ha^{-1}$ more mineralizable N and 15 kg $ha^{-1}$ more nitrogen in harvested curds. Changing the timing of nitrogen application, by reducing the application at planting and increasing the second application instead, resulted in a higher curd biomass, a large amount of nitrogen in the curd and less residual soil nitrogen after harvest. Thus, the efficiency of nitrogen use was increased when more nitrogen was supplied at the time of a higher absolute growth and nitrogen demand.

Baghel and Singh (1995) conducted a field trial in the winter seasons of 1988/89 and 1989/90. Cauliflower cv. Pusa Katki transplanted on 15 September or 1 October, were given 0-80 kg N and 0-100 kg $K_2O$ $ha^{-1}$. Transplanting in September and October gave curd yields of 23.04 and 19.97 t $ha^{-1}$, respectively. Yields increased 19.53 t $ha^{-1}$ with no fertilizer to 24.98 t $ha^{-1}$ with 80 kg N and 21.31 t $ha^{-1}$ with 100 kg $K_2O$.

In field trials on the effects of 5 rates of N application (80, 120, 160, 200 and 240 kg $h^{-1}$), 4 rates of P application (100, 150, 200 and 250 kg $P_2O_5$ $ha^{-1}$) and 2 rates of Borax application (0 and 20 kg $ha^{-1}$) on cauliflower cv. Pusa Snowball-1 were studied by Thakur *et al.* (1991), increasing rate of N delayed curd maturity and increased curd diameter , gross Plant weight, number of leaves plant$^{-1}$, leaf area, curd yield (507.09 and 705.05 g plant$^{-1}$ with 80 and 240 kg h$^{-1}$, respectively). Increasing the rate of P hastened curd maturity, leaf size and increased gross plant weight, number of leaves plant$^{-1}$, diameter of curd and curd yield. Application of boron increased the number of leaves plan$^{-1}$, diameter and curd yields, and reduced leaf area.

Response of cauliflower to plant density (45 x 30, 45 x 45 and 45 x 60 cm spacing), Nitrogen (50, 100, 150 and 200 kg ha$^{-1}$) and P levels (50, 100 and 150 kg ha$^{-1}$) were studied by Singh and Naik (1990), They found that the highest of marketable curd and total yield. Application of nitrogen was at 200 kg ha$^{-1}$ resulted the highest curd size, weigh, and yield. The rate of phosphorus application had no significant effect on yield.

Balyan *et al.* (1988) conducted an experiment on the yield of cauliflower a. Harvnna Agricultural University, Hiser, India, during winter seasons of 1984-85. Nitrogen application improved number of leaves, per plant and leaf size index over control but delayed of cauliflower curd initiation. Curd compactness and marketable yield were increased. Significantly up to 120 kg N ha$^{-1}$ without further improvement at 160 kg ha$^{-1}$ but unmarketable yield decreased with the increase of nitrogen. Phosphorus application had no effect on number of leaves per plant and leaf size index. Curd compactness and marketable yield were improved significantly up to 20 kg $ZnSO_4$ ha$^{-1}$, 149 kg N ha$^{-1}$ and 20 kg $ZnSO_4$ ha$^{-1}$ as economic optimum dose for the crop. Interaction effect of these nutrients was found on marketable yield.

Lawande *et al.* (1987) in their experiment with cauliflower noted maximum yield by adding 240 kg ha$^{-1}$ N + 80 kg $P_2O_5$ ha$^{-1}$ but the application of $K_2O$ at 0-80 kg ha$^{-1}$ was not significant.

Khurana *et al.* (1987) reported that N application at the rate of 60 kg ha$^{-1}$ gave the highest average curd weight and economically profitable for cauliflower.

Panday *et al.* (1982) conducted an experiment on nitrogen fertilization and its methods of application on cauliflower (cv. Snow ball-16). They observed that highest yield was obtained in plots receiving 60 kg N ha$^{-1}$ at transplanting plus 60 kg N ha$^{-1}$ as top dressing (30 days after transplanting). However, the highest average yield (277.8 q ha$^{-1}$) and maximum plants were obtained by applying 40 kg N ha$^{-1}$ at transplanting plus 40 kg N ha$^{-1}$ as top dressing at 60 days after transplanting.

Rajput and Singh (1975) reported by conducting an experiment at Banaras Hindu University, Varanasi during 1971-73 to determine the dose of nitrogen for cauliflower cultivar snowball-16. The maximum growth and yield of cauliflower were recorded when nitrogen was applied at the rate of 120 kg $ha^{-1}$.

Saimbhi *et al.* (1969) reported that a combination of 112 kg N + 56 kg $P_2O_5$ resulted in marked increase in yield and was the most economic dose of nutrients for the production of late cauliflower cultivars snowball in Punjab, India.

Deshi *et al.* (1964) found that application of 224 kg N $ha^{-1}$ significantly increased the yield of cauliflower. The response to P (50 kg $ha^{-1}$) and K (112 kg $ha^{-1}$) was however, not significant.

**2.3 Effect of organic fertilizer on cole crops**

Lavelle (1992) demonstrated that earthworms inoculated organic manure in the soil increased plant growth and yield of crops.

Hochmuth *et al.* (1993a) observed the responses of cabbage yields, head quality, and leaf nutrient status, and of second-crop squash, to poultry manure fertilization. The responses of cabbages (cultivars Gourmet and Copenhagen) and double-cropped summer squashes (cv. Lemondrop) to different rates (high, medium and low based on estimated available N) of poultry manure and conventional 13:1.7:10.8 NPK fertilizers (controls) were evaluated in the springs of 1990 and 1991, on a Lakeland fine sand soil. Analyze for major and minor nutrients were tabulated for the manures. In respect of marketable yield the first- crop cabbage responded to increasing rates of poultry manure during 1990, with the maximum yield (28.4 t $ha^{-1}$) being obtained with 18.8 t $ha^{-1}$. Yields obtained with 1.0 or 1.4 t of conventional NPK fertilizer $ha^{-1}$ were the same as those with the highest rate of manure. The results showed that manuring efficiency was initially higher with commercial fertilizer than poultry manure; since lower amounts of total nutrients were applied using commercial fertilizer.

The use of organic compost was evaluated for cabbage (*Brassica oleracea* var. capitata) production in Santa Catarina, Brazil. Six treatments were applied: 100 t compost at planting, 50 t at planting, 50 t compost after 30 days of planting, 50 t compost at planting plus 25 after 30 days and 25 after 45 days; chemical fertilizer plus chicken manure; recommended levels of chemical fertilizer and no fertilizer or compost. There were no significant differences in yield between plots with one compost application and those with chemical fertilizer or fertilizer plus chicken manure (41.0, 47.0 and 46.4 t $ha^{-1}$, respectively). Plots with 2 or 3 compost applications and the control had significantly lower yields than the other treatments. It was concluded that, application of one type compost with chemical fertilizer was as effective as chemical fertilizer (Schallenberger *et al.*, 2004)

Application of the highest dose of organic manure with highest dose of inorganic fertilizer induced the highest leaf chlorophyll content, while the lowest chlorophyll content obtained from control treatment. These results agreed with the previous findings obtained in other vegetable crops. A promotion effect of organic and inorganic fertilizers on chlorophyll contents might be attributed to the fact that N is a constituent of chlorophyll molecule (Al-Tarawneh, 2005).

**2.4 Effect of vermicompost and compost on soil properties**

Pattnaik and Reddy (2009) reported that the nutrients—N, P, K, Ca, and Mg increased from vermicompost and compost while the organic carbon, C: N and C: P ratios decreased as the composting process progressed from 0 to 15, 30, 45, and 60 days. The nutrient status of vermicompost of all earthworm species produced from both the wastes was more than that of the compost and that of their respective substrates. Vermicompost, another type of compost, which has attracted an increasing attention, is formed by earthworm activities from organic residues, mainly animal manures. Earthworms stabilize organic residues by producing earthworm casts which are soil conditioners that have a high nutrient bioavailability for plant growth.

Significantly, vermicompost works as a 'soil conditioner' and its continued application over the years lead to total improvement in the quality of soil and farmland, even the degraded and sodic soils. Experiments conducted in India at Shivri farm of 'U.P. Bhumi Sudhar Nigam' to reclaim 'sodic soils' gave very good results. Application of vermicompost @ 6 tons/ha resulted in reduction of 73.68 in sodicity (ESP) and increase of 829.33 kg/ha of available nitrogen (N) leading to significant improvement in soil quality (Sinha *et al.* 2008).

Suhane (2007) showed that exchangeable potassium (K) was over 95% higher in vermicompost than compost. There are also good amount of calcium (Ca), magnesium (Mg), zinc (Zn) and manganese (Mn). Additionally, vermicompost contain enzymes like amylase, lipase, cellulase and chitinase, which continue to break down organic matter in the soil (to release the nutrients and make it available to the plant roots) even after they have been excreted. Annual application of adequate amount of vermicompost also lead to significant increase in soil enzyme activities such as 'urease', 'phosphomonoesterase', 'arylsulphatase' and 'phosphodiesterase'. The soil treated with vermicompost has significantly more electrical conductivity (EC) and near neutral pH. . Vermicompost has very 'high porosity', 'aeration', 'drainage' and 'water holding capacity'. They have a vast surface area, providing strong absorbability and retention of nutrients. They appear to retain more nutrients for longer period of time. Study showed that soil amended with vermicompost had significantly greater 'soil bulk density' and hence porous and lighter and never compacted. Increase in porosity has been attributed to increased number of pores in the 30-50 μm and 50-500 size ranges and decrease in number of pores greater than 500 μm.

In an experiment conducted at Kerala, India, Mathew and Nair (2007) opined that cattle manure applied alone or in combination with NPK fertilizers increased the soil organic matter content and hence, balanced application of organic manures in combination with chemical fertilizer was important for maintaining soil health and productivity.

Vermicomposts have much 'finer structure' than ordinary compost and contain nutrients in forms that are readily available for plant uptake. Vermicomposts have outstanding chemical and biological properties with 'plant growth regulators' (lacking in other composts) and significantly larger and 'diverse microbial populations' than the conventional thermophilic composts (Edwards *et al.* 2004).

Dao and Cavigelli (2003) reported that animal manure had long been used as an organic source of plant nutrients and organic matter to improve the physical and fertility condition of agricultural lands.

Eghball (1999) found that application of beef cattle feedlot manure or compost increased the soil surface (0-15 cm) pH while N application as $NH_4NO_3$ significantly reduced the pH (from 6.4 to 5.6). Manure and compost effects on soil pH depend on the initial soil pH level.

Conventional composting and vermicomposting are quite distinct processes particularly with respect to optimum temperatures for each process and the type of decomposer microbial communities that predominate during active processing. While 'thermophilic bacteria' predominate in conventional composting, 'mesophilic bacteria and fungi' predominate in vermicomposting. Although the conventional composting process is completed in about 8 weeks, but additional 4 weeks are required for 'curing'. Curing involves the further aerobic decomposition of some compounds, organic acids and large particles that remain after composting. Less oxygen and water is required during curing. Compost that has had insufficient curing may damage crops. Vermicomposting takes nearly half the time of conventional composting and vermicompost do not require any curing and can be used straightway after production (Dominguez *et al.*, 1997).

Karim *et al.* (1995) reported an increase in soil organic matter due to application of compost, green manure and rice straw application. Addition of plant residues can cause a significant increase in soil pH of acidic soils.

Kale and Bano (1986) reported that as high as 7.37% nitrogen (N) and 19.58% phosphorus as $P_2O_5$ in worms' vermicast.

## 2.5 Effect of organic and inorganic fertilizer on cole crops

Nakadli (2010) noticed no significant differences in the intensity of soil respiration test between treatments at first seasons for Cauliflower crop whereas the intensity of soil respiration increased in treatments amended with nitrogen fertilizer at the second season. The concentration of nitrate increased on the floral curd of Cauliflower in treatments amended with nitrogen fertilizers and treatment amended with cow manure at the first season, whereas the increasing of nitrate on the floral curd of Cauliflower at second season was in treatment amended with cow manure. The yield of Cauliflower increased in treatments amended with chicken manure at the first season, whereas the productivity of Cauliflower increased in treatments amended with cow manure at second season.

Uddin *et al.* (2009) conducted an experiment at Horticultural Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during October-December, 2007 to study the effect of different organic manures on growth and yield of kohlrabi plant. The maximum plant height (36.50 cm), plant canopy (63.50 cm), leaf length (30.42 cm), leaf breadth (14.25 cm), fresh leaves weight per plant (131.10g), diameter of knob (8.23cm), Knob weight (366.60 g), yield (22.90 t $ha^{-1}$) were found with poultry manure application. Only the maximum number of leaves (20.00) was found in control treatment. On the other hand the minimum plant height (32.25 cm), plant canopy (55.75 cm), leaf length (24.92 cm), leaf breadth (10.75 cm), fresh leaves weight per plant (86.97g), diameter of knob (7.95 cm), Knob weight (177.50 g), yield (15.40 t $ha^{-1}$) were found in control treatment. Minimum number of leaves (14.33) was found with cowdung application.

Different combinations of chemical fertilizers and organic manure were applied for sustainable crop productivity in the cauliflower-stem amaranth -jute cropping pattern. The experiment was conducted at farmer's field in Multilocation Testing (MLT) site of Pakshi, Pahna over three years (Ali *et al.*, 2009). There were five combinations of chemical fertilizers (CF) and poultry manure (PM) along with absolute control arranged in a randomized complete block design. The results revealed that all three crops showed significant yield for fertilizer and poultry manure use. Higher yields were obtained with 50% CF + 50% PM followed by 75% CF + 25% PM treatments where cauliflower equivalent yield was increased by 85% and 78%, respectively, over control. This indicates a positive residual effect of poultry manure on the subsequent crops. From the economic points of view, the highest marginal benefit cost ratio (MBCR) was attained in 100% chemical fertilizer due to its lower variable cost followed by 75% CF + 25% PM treated plots. However, gross margin was higher in 50% CF + 50% PM combination for its higher total yield.

Khan *et al*. (2008) reported that the use of organic and inorganic fertilizer has good impact on cabbage and broccoli production. A field experiment was conducted in the field at Bangladesh Agricultural Research Institute (BARI) with poultry manure (5-10 t $ha^{-1}$) in addition to 50-75 recommended dose of chemical fertilizers produced significantly higher yield of cabbage and broccoli. Moderate dose of poultry manure in combination with chemical fertilizer appeared as cost undominated providing higher economic return.

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

The effects of organic fertilizer (processed poultry manure) on the growth, yield and nutrient content of cabbage were determined in an experiment conducted in tunnel-shaped structures with plastic roof and netted sides in Serdang, Malaysia. Treatments consisted of varying rates of processed poultry manure (0, 15, 30, 45 and 60 t $ha^{-1}$). 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 $ha^{-1}$ and x=organic fertilizer in t $ha^{-1}$, 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 tha-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 (Vimala *et al.*, 2006).

Liu-JianLing *et al.*, (2006) conducted field experiments in China, to study the yield response of Chinese cabbage to phosphate fertilizer and animal manure applications and the effect of over-application of these fertilizers to the plant total phosphorus (P) content and P accumulation in the soil. The application of phosphate fertilizers at 150-600 mg $kg^{-1}$ resulted in a yield increase of 14.9-21.5 and the application of animal manure at 33.3-133.2 g $kg^{-1}$ resulted in a yield increase of 18.2-25.9. There was no significant difference in the yield response of Chinese cabbage when applied with phosphate fertilizer at 150, 300 and 600 mg $kg^{-1}$ and there was also no significant difference in the yield response of the crop when phosphate fertilizer was applied after the application of animal manure. The total P content of Chinese cabbage gradually increased with an increase in the rate of phosphate fertilizer and animal manure application. The total P, Olsen P, water soluble P and biologically available P in the soil also increased with an increase in the application rate of phosphate fertilizer and animal manure. Organic P in the soil increased with the application of animal manure. Olsen P had high correlations with water soluble P and biologically available P, but there was a poor relationship between Olsen P and organic P.

Noor *et al.* (2005) conducted an experiment with cabbage and found that 5 t poultry manure per hectare with 75 recommended dose, significantly increased the cabbage yield which may be recommended for the marginal farmers whereas resource rich farmers may use either (70% RDCF + 2.5 t oil cake $ha^{-1}$) or (70% RDCF + 10 t PM $ha^{-1}$) for maximum gross margin.

Choudhury *et al.* (2004) studied in a field experiment conducted during 2002-03 that the effect of integrated use of organic manure, biofertilizer and chemical fertilizer on the nutrient status of soil and the productivity of cauliflower in Jorhat, Assam, India, with various treatment combinations including farmyard manure (FYM), Phosphate Solubilizing Bacteria (PSB), rock phosphate, Azotobacter and inorganic fertilizers. The differences in organic carbon, available N, $P_2O_5$ and $K_2O$ were significantly influenced. The highest plant growth parameters and yield of cauliflower was recorded with Azotobacter, PSB and FYM along with inorganic fertilizers.

Cabbage cv. Vignesh plants were supplied with 100 and 75 recommended N rate, alone or in combination with biofertilizers (*Azospirillum brasilense* or *Azotobacter chroococcum*); 75 and 50 recommended N rate and/or cowdung manure, neem cake or poultry manure, alone or in combination with biofertilizers in a field experiment conducted in Mohanpur, West Bengal, India during the rabi season of 2000-01. Crop yield was highest (55.82 t $ha^{-1}$) with the application of 50% recommended N + 25% poultry manure +25% biofertilizers, whereas the highest benefit cost ratio (4.30) was recorded with the application of 75% N + biofertilizers (Devi *et al.*, 2003).

An experiment was conducted by Kadir (2002) at Jamalpur, in 1996-97 in Bangladesh to investigate the effects of nutrient applications on $F_1$, hybrids of cabbage cv. Atlas-70. The treatments included inorganic fertilizer applied according to the yield goal (HYG = high yield goal; MYG = medium yield goal and LYG = low yield goal) and organic manure (cowdung, poultry manure and compost). Individual treatment at full recommended rate and treatment combinations of inorganic + organic sources (each applied at half the recommended rates) was done. The most compact head (0.54 g/cc) was obtained with MYG + cowdung. Protein content was highest at HYG + poultry manure and ascorbic acid content was highest with HYG + cowdung. The treatment, HYG + poultry manure was the most profitable with a benefit:cost ratio of 2.21.

Noor *et al.* (2002) reported that addition of 10t/ha cow dung instead of 50% recommended dose of chemical fertilizer can able to produce satisfactory yield of cauliflower.

The growth and physio-morphological characters were positively and significantly influenced by cowdung and poultry manure in combination with NPK fertilizers. Occasionally poultry manure but in most of the cases $^1/_3$ NPK + $^1/_3$ poultry manure + $^1/_3$ cowdung combination performed better. Different combinations of cowdung, poultry manure and NPK fertilizers manifested significant variation in respect of yield attributes and yield of cabbage. All the source of nutrients increased the yield attributes and yield compared to control. However, the maximum marketable yield (80.59 t $h^{-1}$) was obtained from the plants, treated with the combination of $^1/_3$ NPK + $^1/_3$ poultry manure + $^1/_3$ cowdung and the lowest (38.90 t $ha^{-1}$) from the control (Uddin, 2002).

The Vegetable Section of Bangladesh Agricultural Research Institute (Anonymous, 1998) conducting an experiment on the effect of chemical fertilizer and manure on the yield of cabbage reported that the application of NPKS and cow dung increased the yield component and head yield significantly whereas the effect of Zn and Mo was beneficial. The highest head yield, 75 t $ha^{-1}$ was recorded in treatment $N_{120}$ $P_{100}$ $K_{120}$ $S_{30}$ $Zn_5$ $Mo_1$ kg $ha^{-1}$ along with cow dung 5 t $ha^{-1}$.

Jakse *et al.* (1998) conducted a trial at Ljubljana, Slovenia where conventional NPK fertilizer, compost from chicken manure and bark and farmyard manure were compared on the medium early cultivars Hermes. In all treatments, 200 kg N $ha^{-1}$ was used. Plants grown with mineral fertilizers (with one or two applications) were taller (21.2 cm), heavier (1492 g) and larger (13.2 cm x 13.6 cm) than organically grown plants. The average weight of cabbage heads obtained in the treatment with farmyard manure was 987 g compared with 663 g with compost and 595 g in control.

Zahangir (1994) carried out an experiment during the period from October, 1993 to January. 1994 at BSMRAU, Salna, Gazipur, to determine the optimum fertilizer need for desirable yield of cauliflower (*Brassica oleracea* var. Botrytis). The highest cauliflower yield (13.73 t $ha^{-1}$) was obtained with the application of 120 kg N, 120 kg $P_2O_5$, 100 kg $K_2O$, 20 kg S, 1 kg B, 0.5 kg Mo and 5 ton organic compost $ha^{-1}$ followed by 120 kg N, 180 kg $P_2O_5$, 100 kg $K_2O$, 20 kg S, 1 kg B, 0.2kg Mo and 10 ton cowdung $ha^{-1}$ and 120 kg N, 100 kg $K_20$, 20 kg S, 1 kg B, 0.2 kg Mo and 10 ton cowdung $ha^{-1}$.

It was reported that the cabbage yield (76.6 t $ha^{-1}$) was found from the combined effect 180 kg N $ha^{-1}$, 60 kg P $ha^{-1}$, 180 kg K $ha^{-1}$ and cow dung at the rate of 5 t $ha^{-1}$ (Anonymous, 1988) and it was also stated that a combination of organic and inorganic fertilizer was better than a single fertilizer for cabbage production.

Lu and Bai (1989) conducted a trial in Beijing suburbs where processed chicken manure were applied at 0.26 g N, 0.195 g P and 0.26 g K $kg^{-1}$ soil to pots planted with cauliflower and rape. The result showed that yield increased to 21.8-153.4 compared with those with no manure, but the yields were significantly different from those with the same quantity of NPK fertilizer.

The vegetable section of Bangladesh Agricultural Research Institute conducted an experiment on the effect of chemical fertilizer and manure on the yield of cabbage, with the findings that the application of NPKS and cow dung increased the yield component and head yield significantly, whereas the effect of Zn and Mo was beneficial. The highest head yield of 75 t $ha^{-1}$ was recorded in treatment $N_{120}$ $P_{100}$ $K_{120}$ $Zn_5$ $Mo_1$, kg $ha^{-1}$ along with cow dung 5 t $ha^{-1}$ (Anonymous, 1988).

## 2.6 Influence of vermicompost and inorganic manure on cauliflower

A two year experiment was conducted by BARI (2008-2009) showed that 100% RD+1.5t $ha^{-1}$ vermicopost produced the highest yield (56 t $ha^{-1}$) of cauliflower. Vermicompost exhibited better response than compost. The nutrient uptake was higher in the treatment ($T_4$ 100% RD+1.5t $ha^{-1}$ vermicopost) as the curd yield and biomass production was higher in this treatment.

Vigardt (2008) observed that increase in broccoli growth is usually seen with the addition of vermicompost. Broccoli grown in 75% to 100% vermicompost established better. Root development decline above 75% vermicompost, possibly due to initially high salt contents but this did not affect their overall establishment in the field. Fertilized plants had the highest number of leaves with 25% vermicompost.

Ghuge *et al.* (2007) carried out a field experiment during 2003-04 at the Department of Horticulture, Marathwada Agricultural University, Parbhani, Maharashtra, India, to evaluate the response of inorganic fertilizers and organic manures singly and in combination on dry matter, uptake and also nutrient availability of soil after harvest of cabbage. Results revealed that application of 50% RDF along with 50% vermicompost at 2.5 t $ha^{-1}$ gave the highest yield (379.87 q $ha^{-1}$), maximum uptake of N, P and K nutrients (66.17, 13.22 and 34.22 kg $ha^{-1}$) and more availability of N, P and K (259.45, 27.77 and 369.67 kg $ha^{-1}$) as compared to other treatments. Treatments where 50% RDF+50% Terrace at 1.25 t $ha^{-1}$ and 50% RDF+50% organic booster at 1.0 l $plant^{-1}$ after transplanting were used also found equally better.

Singh *et al.* (2005) conducted an experiment to assess the effect of vermicompost on cauliflower productivity and profitability considering soil health under small production systems. The farmers' reaction on the use of vermicompost was highly positive because of its simplicity and compatibility with the farming system components and with the household internal resources, as well as its cost effectiveness. Moreover, vermicompost was also accepted by the resource-rich farmers who preferred to use vermicompost in place of chemical fertilizers due to environmental considerations and to combat health hazards.

Alam (2005) who stated that combined application of vermicompost and chemical fertilizer performs the highest plant height of cabbage.

Alam (2006) reported that the largest leaf breadth of cabbage was found by 5 t $ha^{-1}$ vermicompost + 100% recommended doses of chemical fertilizers.

Azad (2002) and Kabir (1998) mentioned that the maximum number of leaves in cabbage plant was obtained when vermicompost and inorganic fertilizer were used in combination.

Kamla-Kanwar (2002) conducted a field experiment to determine the effect different NPK fertilizer rates (0, 50 and 100%) applied alone or in combination with different organic manures (no manure, vermicompost and farmyard manure (FYM) at 25 t $ha^{-1}$) on cauliflower cv, Pusa Snow Ball K-1 yield and on soil fertility in Dhaulakuan, Himachal Pradesh, India. With the application of NPK fertilizer (100%) alone, curd weight, diameter, plant height and curd yield increased. But when organic manure (vermicompost or FYM) was applied, significant increase in all these parameters was found at 50% NPK level. Soil organic carbon content increased when organic fertilizers were supplied alone compared to NPK fertilizer alone.

Morselli *et al.* (1999) showed that the vermicompost was more efficient for cauliflower and that for cabbage it is possible to replace chemical fertilizer by vermicompost.

## 2.7 Effect of vermicompost on nutrient status and crop production

Organic manure influences favorably on the plant growth and yield through augmentation of beneficial microbial population and their activities such as organic matter decomposition (Gaur *et al.*, 1971).

Harris (1990) reported that earthworm excreta is the excellent soil conditioning material with higher water holding capacity and less time for releasing nitrogen into the soil. The nutrient level of the vermicompost was about two times greater than natural compost and the use of vermicompost is important for the farmers to get better quality crop yields.

Atiyeh *et al.* (2000a) found that the conventional compost was higher in 'ammonium', while the vermicompost tended to be higher in 'nitrates', which is the more available form of nitrogen. They also found that vermicompost retains nutrients for long time and while the conventional compost fails to deliver the required amount of macro and micronutrients including the vital NKP (nitrogen, potassium & phosphorus) to plants in shorter time. They also observed that the greatest plant growth responses when vermicompost occupied 10 to 40 % of the total volume of plant growth medium.

Sohrab and Sarwar (2001) showed that vermicompost contains 2.29 folds more organic carbon, 1.76 times total nitrogen, 3.02 folds phosphorous and 1.60 times potassium than normal compost. Earthworms decrease the C: N ratio from 14.21 to 10.11 and an average 56.03% of organic waste can be converted into vermicompost by the activities of earthworms in short time.

Zahid (2001) said that vermicompost contain high organic matter, N, P, S, Ca and Mg. It was shown that worm-worked composts have better texture and soil enhancing properties, hold typically higher percentages of N, P, K and S.

Reddy *et al.* (2002) conducted a study in Hyderabad, Andhra Pradesh, India, during the rabi seasons of 1999-2002 to determine the effect of organic farming on tomato (cv. Marutham) production. Treatments comprised: 20 t farmyard manure (FYM)/ha ($T_1$); 5 t vermicompost/ha ($T_2$); 10 t FYM/ha + 2.5 t vermicompost/ha ($T_3$); 50% N through FYM + 50% N through urea

($T_4$); 50% N through vermicompost + 50% N through urea ($T_5$); and recommended NPK rate (120:60:60 kg/ha) ($T_6$). Treatment with $T_4$ recorded the highest plant height (55.6 cm), number of branches per plant (7.4), number of fruits per plant (16.6), fruit weight (66.7 g) and yield (30.47 t/ha), and these parameters were at par with those of T6 treatment. Compared to the crop yield obtained with $T_6$ treatment, reduced yields were observed with $T_1$, $T_2$ and $T_3$ treatments. A yield reduction of 7.76% was observed with $T_5$ treatment compared to the yields obtained with $T_6$ treatment. A yield increase of 4.7% was observed with $T_4$ treatment, indicating that the integrated application of organic manures along with inorganic fertilizers significantly increased the yield compared to organic or inorganic fertilizer applications alone. The cost-benefit ratio was high (1:3.01) with the application of $T_4$ treatment compared to all other treatments including T6 (1:2.93).

Kumari and Kumari (2002) from an experiment stated that vermicompost is a potential source of organic manure due to the presence of readily available plant nutrients, growth enhancing substances and number of beneficial microorganisms like N fixing, P solubilising and cellulose decomposing organisms.

Arancon *et al.* (2003) and Atiyeh *et al.* (2002) showed that the application of vermicompost to soil increases microbial biomass N and orthophosphate levels while improving seed germination, seedling growth and crop productivity in a variety of cereals, legumes, vegetables, fruits, ornamental and flowering plants grown in greenhouses and to a lesser extent in the field.

Kaviraj and Satyawati Sharma (2003) reported that municipal solid waste can be subjected to vermicompost, which can yield high nutritive value.

Sannigrahi (2004) conducted two experiments to determine the impact of variation of earthworm population as well as cowdung ratio on vermicomposting. He studied that the quality of compost in terms of total nutrient content such as N, P, K, Na and Ca was also found better with the addition of more earthworms. Vermicomposting of thatch grass was quicker (4 months) in 1:4 grasses: cow dung ratio while it was slower with the 1:1 ratio.

Tognetti *et al.* (2005) showed composts and vermicomposts from a municipal composting plant in northwestern Patagonia, both having undergone a thermophilic phase, (with the vermicompost being inoculated with earthworms after the thermophilic stage) and a nonthermophilic backyard vermicompost were studied. Between the two municipal products, the vermicompost had significantly larger nutrient concentrations than the compost; when mixed with the soil, the vermicompost also had higher microbial populations size and activity, and produced increased ryegrass yields. Compared to the municipal compost, the backyard vermicompost had similar or higher nutrient concentrations but its effects on soil microbial biomass, soil microbial activity and ryegrass yields were lower. Our results suggest that no generalization can be made regarding the higher quality of vermicomposts vs. composts, because the product quality depends both on the original materials and the technology employed.

Arancon *et al.* (2005) observed Agricultural Research and Development Center on soils under strawberries and grapes a larger population of fungivorous and bacterivorous nematodes in soils where vermicompost was applied than in soils with inorganic fertilizer treatments.

Payal *et al.* (2006) reported vermicomposting is a viable, cost effective and rapid technique for the efficient management of the solid wastes. Vermicomposting is a suitable technology for decomposition of different types of organic waste (domestic as well as industrial) into value added material.

Suhane *et al.* (2008) reported that better availability of essential micronutrients and useful microbes in vermicompost applied soils. Most remarkable observation was significantly less incidence of pests and disease attacks in vermicompost applied crops.

Manivannan *et al.* (2009) stated that the increased growth and yield of the beans, may be due to the application of vermicompost which indirectly influences the physical conditions of the soil and supported better aeration to the plant roots, absorption of water , induction of N, P and K exchange there by resulting better growth of the plants.

# CHAPTER 3

# MATERIALS AND MATHODS

# CHAPTER III

# MATERIALS AND METHODS

This chapter deals with the materials and methods including a brief description of the experimental site, soil, climate and materials used in the experiment. The details of research procedure are described in this section.

### 3.1 Experimental Location

The experimental site was located at the experimental field of the Soil Science Division, Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur having approximately 24.00° N latitude and 90.25° E longitudes and has a mean elevation of 8.4 m above mean sea level (Figure-1).

### 3.2 Soil Characteristics

The soil of the experimental site belongs to Grey Terrace Soil, which falls under Inceptisol in Soil Taxonomy (FAO, 1988). The soil lies in the Agro-Ecological Zone (AEZ) -28, Madhupur Tract. The soils are poorly drained with moderate slow permeability and slow runoff.

### 3.3 Climate

Gazipur belongs to sub-tropical climate with monsoon rainfall, and is characterized by three distinct seasons, pre-monsoon (March to May), rainy or monsoon (June to September), and winter (mid October to early March). The pre-monsoon or early kharif season is the hot spring with moderate humidity. The winter or the rabi season is a cool dry season with low humidity. Rainfall hardly occurs during this period. This season is favorable for growing a wide variety of crops, but lack of water restricts cropping area and crop production. Mean monthly temperatures range from 18-20°C in winters to 28-29°C in the pre-monsoon and monsoon seasons. The average period with minimum temperatures below 15°C is around 75 day, thus, climatically the area is very suitable for cole vegetables.

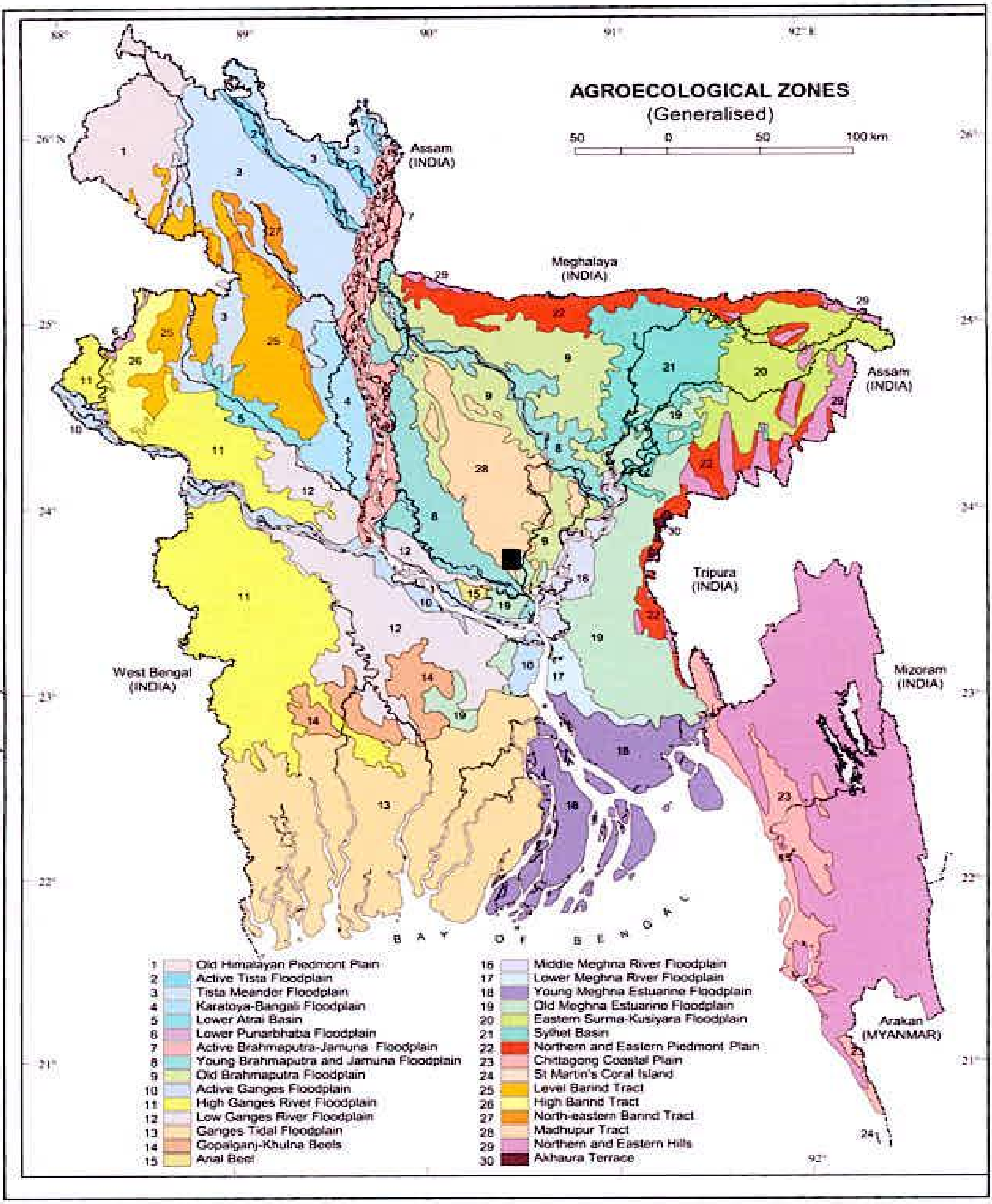





Figure-1. ■-Location of the experimental site

### 3.4 Cauliflower variety

A high yielding cauliflower (*Brassica oleracea* var. *botrytis*) variety 'Snow white' was used as the test crop in the study. The seeds of cauliflower were collected from the Vegetable Section, Horticulture Research Center (HRC), Bangladesh Agricultural Research Institute (BARI), Joydebpur. The seeds were healthy, well-matured and free from other seeds, weeds and extraneous materials. The germination percentage of the seeds was 96. This variety is matured within 60 to 70 days after transplantation of seedlings. This is a popular variety among the farmers in Bangladesh.

### 3.5 Design and layout of the experiment

The experiment was laid out in a Randomized Complete Block Design (RCBD) with twelve treatments replicated three times. The total number of plots was 36 and the unit plot size was 3.0 m x 2.7 m. Each replication consisted of twelve treatments. Treatments of the experiment were assigned at random into twelve plots of each at three replications. The distance between adjacent plots was 50 cm and one replication to another replication was 1m. The layout of the experiment is presented in Figure-2.

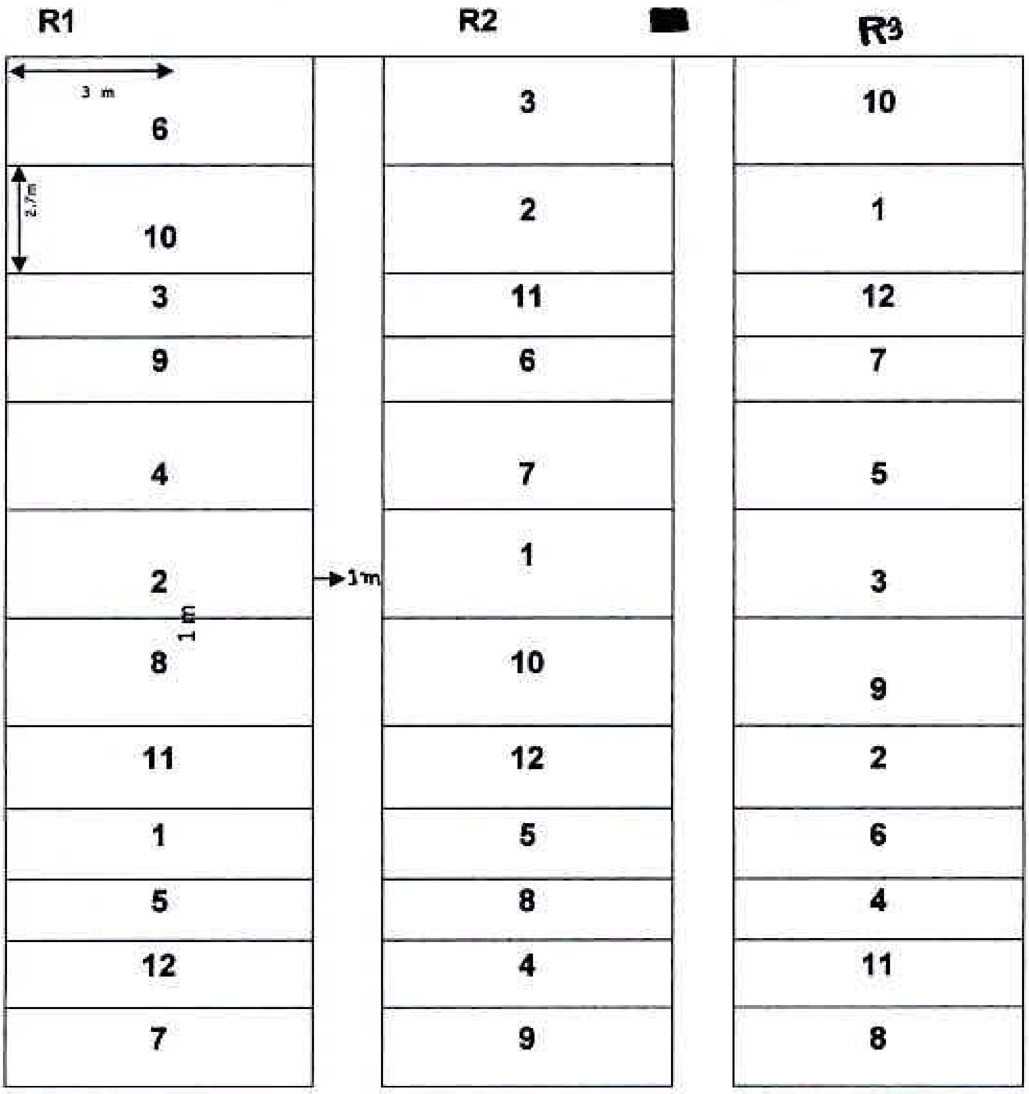
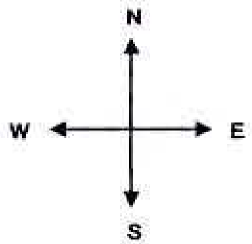



**Figure-2: Layout of the experiment**




Plot size : 3m x 2.7 m

Plot to plot distance : 50 cm

Block to block distance : 1.0 m

### 3.6 Treatments

The experiment comprised of twelve treatments which were as follows:

$T_1$ = 100% Recommended Dose of Chemical Fertilizer (RDCF)
$T_2$ = 80% RDCF
$T_3$ = 60% RDCF
$T_4$ = 100% RDCF+ Vermicompost @ 1.5 t $ha^{-1}$
$T_5$ = 80% RDCF+ Vermicompost @ 3 t $ha^{-1}$
$T_6$ = 60% RDCF+ Vermicompost @ 6 t $ha^{-1}$
$T_7$ = Vermicompost @ 6 t $ha^{-1}$
$T_8$ = 100% RDCF+ Conventional compost @ 1.5 t $ha^{-1}$
$T_9$ = 80% RDCF+ Conventional compost @ 3 t $ha^{-1}$
$T_{10}$ = 60% RDCF+ Conventional compost @ 6 t $ha^{-1}$
$T_{11}$ = Conventional compost @ 6 t $ha^{-1}$
$T_{12}$ = Absolute control

RDCF= $N_{250}$ $P_{35}K_{65}S_{40}$ $Zn_5B_1$ kg $ha^{-1}$

### 3.7 Land preparation

The plot selected for the experiment was opened by power tiller driven rotovator to a depth of 15 cm on the 20th November 2008. Afterwards the land was ploughed and cross-ploughed several times followed by laddering to obtain a good tilth. Weeds and stubbles were removed, and the large clods were broken into smaller pieces to obtain a desirable tilth of soil. Finally, the land was level by laddering and the experimental plot was partitioned into the unit plots in accordance with the experimental design mentioned above.

### 3.8 Seed Sowing for raising seedlings and transplanting of seedlings

Cauliflower seeds were sown in the seed bed on the 31st October 2008. Healthy and disease free uniform sized twenty five days old seedlings of cauliflower were uprooted from the seedbeds and transplanted in the main field on the 25th November, 2008 with a spacing of 60 cm from row to row and 45 cm from plant to plant. The seedbed was watered before uprooting the seedlings so as to minimize the damage of roots. The seedlings were watered immediately after transplanting. Some seedlings were also transplanted adjacent to the main field to be used for gap filling.

### 3.9 Fertilizer application

The doses of 100% N-P-K-S–Zn-B were 250-35-65-40-5-1 kg $ha^{-1}$, respectively and these were used in the form of urea, TSP (triple super phosphate), MP (muriate of potash), gypsum, zinc sulphate and boric acid, respectively. The whole amount of P, K, S, Zn, B, and $^{1}/_{3}$ N were broadcast and thoroughly incorporated into the soil at the time of final land preparation and the remaining $^{2}/_{3}$ N was top dressed in two equal installments at 25 and 45 days after transplanting. Vermicompost and conventional compost were applied in the pit before transplanting.

### 3.10 Production of vermicompost and conventional compost

The vermicompost and conventional compost were subjected to NPK analysis following standard procedures. In the present study, kitchen wastes especially vegetable wastes and cowdung was used as vermibed substrates due to their availability in large quantities in Bangladesh. Earthworms are chosen for their resistance to extreme conditions and feeding and reproductive rate. *Eisenia fetida* is the most efficient in waste processing in Bangladesh. Vermicompost was produced by using vermicomposting "chari" method. In this method, 75% cowdung and 25% kitchen wastes were subjected to produce vermicompost (Figure-3) by the decomposition of organic wastes facilitated through earthworm *E. fetida*. Conventional compost is a traditional mixed litters, crop residues and cow dung without earthworm activities in aerobic condition.

**Figure-3: Vermicompost**

### 3.11 Intercultural operations:

**Weeding:** Hand weeding was done as and when required to keep the plot free from weeds.

**Irrigation**: The experimental plots were irrigated as and when necessary.

**Pest management:** For controlling insect pest Ripcord 100 EC @ 1ml/ liter water was sprayed as and when required.

### 3.12 Gap filling

Damaged/dead seedlings were replaced by healthy plant within one week of transplantation.

### 3.13 Harvesting

The crop was harvested at full maturity of curd starting from on 1st February, 2009 to 15th February.

### 3.14 Collection of soil samples

Soil samples to a depth of 0-15 cm were collected before initiation of the experiment and after harvesting of crops. Before initiation and the completion of the experiments, composite soil samples were collected from each plot (three replications) at 0-15 cm depth. Three auger samples were taken from each plot and divided into two sets of sub-samples. The collected samples were then air-dried, and ground to pass through a 2 mm (10 meshes) sieve and stored in a clean plastic container for physical and chemical analysis.

### 3.15 Collection of plant samples

Plant samples were collected from each of the thirty-six plots for laboratory analysis at the harvesting stages of cauliflower. Ten plants were randomly collected from each plot, washed in distilled water and then dried in an oven at $70^{0}$ C for 48 hours. To obtain homogeneous powder, the samples were finely ground and passed through a 20-mesh sieve. The ground samples were preserved for analysis.

### 3.16 Collection of data

Data were recorded on the following parameters from the plant sample during the course of experiment. Ten plants were randomly selected from each plot to record data in such a way the border effect was avoided for the highest precision.

(i) Plant height (cm)
(ii) No. of leaves $plant^{-1}$
(iii) Circumference of curd (cm)
(iv) Curd height (cm)
(v) Weight of whole $plant^{-1}$ (kg)
(vi) Marketable weight $plant^{-1}$ (kg $plant^{-1}$ )
(vii) Curd yield (t $ha^{-1}$)
(viii) Stover yield (t $ha^{-1}$)

#### 3.16.1. Plant height:

Plant height was measured in centimeter (cm) by a meter scale at harvested from the ground level up to the tip of the longest leaf.

#### 3.16.2. No. of leaves:

Numbers of leaves per plant of ten randomly selected plants were counted at harvest. All the leaves of each plant were counted separately. Only the smallest young leaves at the growing point of the plant were excluded from counting.

#### 3.16.3. Circumference of curd:

Curd circumference in centimeter (cm) was recorded in several directions with a meter gauge following meter scale at matured stage from ten randomly selected plants.

#### 3.16.4. Curd height:

Height (cm) of the curd was also recorded from the junction of last upper leaves up to the tip of curd at mature stage from ten randomly selected plants in centimeter (cm).

### 3.16.5. Total weight of plant:

After harvest, ten randomly selected plants including all parts was weighted in kilogram (Kg) and recorded.

### 3.16.6. Marketable curd weight:

Marketable curd weight was recorded after harvesting of curd when the leaves around the curd were pruned. It was measured with a weighing balance and expressed in kilogram (kg).

### 3.16.7. Yield per unit plot:

The yield per unit plot was calculated by adding the weight of central curds and the weight of the secondary curds. The yield of all plants in each unit plot was recorded and was expressed in kilogram (kg).

### 3.16.8. Yield per hectare:

The yield per hectare was calculated by converting the per plot yield data to per hectare and was expressed in ton (t).

### 3.16.9. Stover yield:

Weight of stover was recorded by weighing the total leaves, stem of individual plants and expressed in gram (g). The yield per hectare was calculated by converting the per plot yield data to per hectare and was expressed in ton (t).

### 3.17 Analysis of soil samples, plant samples and vermicompost and conventional compost.

#### 3.17.1 Analysis of soil samples

Collected initial and post harvest soil samples were analyzed for both physical and chemical properties in the laboratory of the Soil Science Division, BARI, Joydebpur (Table-1). The properties studied included pH, organic C, total N, exchangeable K and available P, S, and Zn contents and some of the physical properties like texture, Bulk density, Particle density, Field capacity were also determined.

**Table 1. Initial soil characteristics of the experimental field**

**a) Chemical properties:**

| Soil Properties | pH | OM % | Ca | Mg | K | Total N % | P | S | B | Cu | Fe | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | meq100g$^{-1}$ | | | | ppm | | | | | ppm |
| Result | 6.4 | 0.94 | 8.1 | 2.7 | 0.15 | 0.06 | 12 | 10 | 0.19 | 8.2 | 109 | 1.2 |
| Critical level | - | - | 2.0 | 0.8 | 0.2 | - | 14 | 14 | 0.20 | 1.0 | 10 | 2.0 |

**b) Physical properties:**

| Soil depth (cm) | Particle size (%) | | | Textural class | Bulk density (gcm$^{-3}$) | Particle density (gcm$^{-3}$) | Field capacity (vol. %) |
|---|---|---|---|---|---|---|---|
| | Sand | Silt | Clay | | | | |
| 0-15 | 11.72 | 66.66 | 21.62 | Silt loam | 1.48 | 2.59 | 27.37 |

#### 3.17.1. a) Physical analysis of soil

**Particle-size analysis**

Particle size analysis of soil samples was done by hydrometer method as outlined by Day (1965) and the textural classes was ascertained using USDA textural triangle.

**Bulk density**

To determine the bulk density of 0-15 cm soil layer, undisturbed soil cores of 5 cm long and 5 cm diameters were collected from the midpoint of the layer (0-15cm) with the help of the manually operated core sampler. Precautions were taken to avoid compaction of the soil mass. The collected soil cores were trimmed to the exact volume of the cylinder and oven dried to constant weight at 105°C. The oven-dry weight divided by the volume of the core sampler is the bulk density usually expressed in g $cm^{-3}$ (Black, 1965).

### 3.17.1. b) Chemical analysis of soil

The soil chemical properties determined were pH, organic carbon, total nitrogen, available phosphorus, sulphur, zinc and potassium (Table-2). The following standard methods were followed for soil analysis as briefly described in the following page:

**Table-2. Chemical analysis of soil**

| Properties | Methods |
|---|---|
| pH | Using glass-electrode pH meter with 1: 2.5 soil-water ratio (Jackson, 1973) |
| Organic carbon | Organic carbon in soil was determined by wet oxidation method described by Black (1965). |
| Total N | Total N was determined by modified micro-Kjeldahl method following concentrated sulphuric acid digestion and distillation with 40% NaOH. The ammonia evolved was collected in boric acid indicator and was titrated against 0.02 N $H_2SO_4$ (Black, 1965). |
| Available P | Available P was extracted with 0.5M $NaHCO_3$ (pH 8.5) following the method mdescribed by Olsen *et al.* (1954). The P in the extract was then determined by developing blue colour using ascorbic acid. The absorbance of the molybdophosphate blue colour was measured at 660 ηm wave length by spectrophotometer. |
| Exchangeable K | Extracted by 1M $CH_3COONH_4$ and determined by flame photometer (Peterson, 2002) |
| Available S | Available S in the soil was extracted with 0.15% CaCl2 solution. The S content in the extract was determined turbidimetrically by spectrophotometer at 420 ηm wavelength. |

### 3.17.2 Plant Sample analysis

After harvest, plant samples from each plot were collected and divided into stover and curd. The plant samples were analyzed for N, P, K, S, and Zn contents. The samples were cleaned, dried and kept for chemical analysis. Plant samples were digested with $H_2SO_4$ for N and $HNO_3$-$HClO_4$ (3:1) for P, K, S and Zn. The follow-up methods of analysis have been outlined as below:

#### 3.17.2. a) Nitrogen

Plant samples were digested with 30% $H_2O_2$, conc. $H_2SO_4$ and a catalyst mixture ($K_2SO_4$ : $CuSO_4.5H_2O$ : Selenium powder in the ratio 100 : 10 : 1, respectively) for the determination of total nitrogen by Micro-Kjeldal method. Nitrogen in the digest was determined by distillation with 40% NaOH followed by titration of the distillate absorbed in $H_3BO_3$ with 0.01N $H_2SO_4$ (Jackson, 1973).

#### 3.17.2. b) Phosphorous

Phosphorus was digested from the plant sample with 0.5 M $NaHCO_3$ solutions, pH 8.5 (Olsen *et al.*, 1954). Phosphorus in the digest was determined by using 1 ml for sample from 100 ml extract was then determined by developing blue color with reduction of phosphomolybdate complex and the color intensity were measured colorimetrically at 660 nm wavelength and readings were calibrated with the standard P curve (Page *et al.*, 1982).

#### 3.17.2. c) Potassium

Five milli-liter of digest sample for the plant were taken and diluted to 50 ml volume to make desired concentration so that the absorbance of sample were measured within the range of standard solutions. The absorbances were measured by flame photometer.

#### 3.17.2. d) Sulphur

Sulphur content was determined from the digest of the plant samples with $CaCl_2$ (0.15%) solution as described by (Page *et al.*, 1982). The digested S was determined by developing turbidity by adding acid seed solution (20 ppm S as $K_2SO_4$ in 6N HCl) and $BaCl_2$ crystals. The intensity of turbidity was measured by spectrophotometer at 420 nm wavelengths (Hunter, 1984).

### 3.17.2. e) Zinc

Zinc content in the digest was determined directly by atomic absorption spectrophotometer (Page *et al.,* 1982).

### 3.17.3 Vermicompost and Conventional compost analysis

Before use in the field or setting the experiment, vermicompost and conventional compost were analyzed for pH, moisture content, organic matter, total N, P, K, S, and Zn contents. The samples were cleaned, air-dried and kept for chemical analysis. The vermicompost and conventional compost were digested with $H_2SO_4$ for N and $HNO_3$-$HClO_4$ (2:1) for P, K, S and Zn.

**Table-3. Nutrient composition of vermicompost and conventional compost**

| Organic manure | Content (%) | | | | | | | C:N ratio |
|---|---|---|---|---|---|---|---|---|
| | Moisture | Organic matter | N | P | K | S | Zn | |
| Vermicompost | 20.89 | 21.26 | 1.90 | 2.00 | 1.20 | 0.60 | 0.02 | 15.76 |
| Compost | 23.43 | 20.92 | 1.30 | 1.60 | 1.40 | 0.40 | 0.01 | 16.80 |

### 3.17.3.1 Sample preparation

The vermicompost and conventional compost was dried in air, mixed thoroughly and thereafter the samples were ground in a mortar to pass through a 20 mesh sieve and stored in brown paper bags into desiccators before analysis.

#### 3.17.3.2 Procedure

**Digestion of organic samples (vermicompost and conventional compost) with nitric-perchloric acid for nutrient content**

The sample weighing 1 g was transferred into a dry clean 100 ml beaker, 10 ml $HNO_3$ was added, boiled gently till the content became almost dry. After cooling the content, 5 ml $HClO_4$ was added, boiled gently until the solution became colorless or nearly so and dense white fumes fill the beaker. The contents of the flask were boiled until they became sufficiently clean and colorless. The contents were then transferred to a 100 ml volumetric flask by washing with distilled water through a Whatman filter paper no. 1. A blank was also digested without chemicals. The P, K, S and Zn contents were determined from this digest.

**Digestion of organic samples (vermicompost and conventional compost) with sulphuric acid for Nitrogen determination**

An amount of 1g vermicompost and conventional compost sample was taken into a 100 ml micro-Kjeldahl digestion flask. Into the flask, 10 ml $H_2O$ and 15 ml conc. $H_2SO_4$ were added and heated for 10 minutes. Then 5 g digestion mixture ($K_2SO_4$: $CuSO_4$: $H_2O$: Se = 100:10:5:1) was added in it after cooling The flask was swirled and allowed to stand for about 10 minutes, followed by continuous heating till the digest was clear and colorless. After cooling, the contents were transferred into a 100 ml volumetric flask and the volume was made with distilled water. A reagent blank was prepared in a similar manner. The digestion was performed for N determination.

### 3.18 Statistical analysis

Data recorded for different parameters were compiled and tabulated in proper form for statistical analysis. Analysis of variance was done with the help of computer package MSTAT. The mean differences among the treatments were done by Duncun's Multiple Range Test (DMRT) (Ressel, 1996) at 5% level of probability for the interpretation of results (Gomez and Gomez, 1984).

# CHAPTER 4

# RESULTS AND DISCUSSION

# CHAPTER IV

# RESULTS AND DISCUSSION

The results on different yield attributes, yield and nutrient content of cauliflower and availability of different nutrients in the soil after harvest of cauliflower are presented in this chapter.

## 4.1 Effect of vermicompost and compost on the growth parameters and yield of cauliflower

### 4.1.1 Plant height

The effects of vermicompost and conventional compost alone and in combination with inorganic fertilizer on the plant height of cauliflower are presented in Table-4. Significant variation was observed in plant height of cauliflower when vermicompost or conventional compost was incorporated in to soil. Among the treatments, $T_4$ (100% RDCF with 1.5 t $ha^{-1}$ vermicompost) treatment showed the highest plant height (49.40 cm) of cauliflower. On the other hand, the lowest plant height (28.87 cm) was observed in $T_{12}$ treatment where no organic or inorganic fertilizer was applied. Vermicompost might have improved the soil physical properties particularly soil porosity, structure, water holding capacity and supplied other plant growth promoting substances and for this reason increasing dose of vermicompost significantly increased plant height. Similar result was reported by Gorlitz (1987).

Statistically identical plant height was observed from $T_8$ treatment where 1.5 t $ha^{-1}$ conventional compost was used along with 100% RDCF (48.03 cm). The $T_8$ treatment was also statistically identical with $T_1$, $T_5$ and $T_9$. Similar trend was observed in $T_5$ (47.80 cm) and $T_9$ (47.73 cm) treatments. These two treatments composed of 80% RDCF with 3 t $ha^{-1}$ vermicompost and conventional compost respectively. Statistically identical plant height (46.20 cm) was also observed from $T_1$ treatment where only 100% recommended dose of chemical fertilizers was applied. Among the two organic manures, 6 t vermicompost $ha^{-1}$ obtains higher plant height (42.00 cm) in $T_7$ treatment than 6 t conventional compost $ha^{-1}$ in $T_{11}$ treatment (40.00 cm). The nutrient contents (NPK) were higher in vermicompost than those of conventional compost of the present study. The enhancement of plant height of cauliflower can be explainable, due to elevated levels of NPK in vermicompost. The N content in vermicompost was more which promoted the plant height of cauliflower than conventional compost treated plants. Nitrogen encourages vegetative growth and contributes to a dark green color. The improvement in plant growth could be due to large increases in soil microbial biomass after vermicompost application, leading to production of hormones or humates in the vermicompost acting as plant-growth regulators independent of nutrient supply (Norman *et al.*, 2003).

**Table-4. Plant height and number of leaves of cauliflower as influenced by chemical fertilizers and organic manure**

| Treatments | Plant height (cm) | No of leaves plant$^{-1}$ |
|---|---|---|
| $T_1$ | 46.20 abcd | 13.00 bc |
| $T_2$ | 43.10 de | 12.80 bc |
| $T_3$ | 42.90 de | 12.70 bc |
| $T_4$ | 49.40 a | 16.30 a |
| $T_5$ | 47.80 abc | 13.70 b |
| $T_6$ | 44.70 bcd | 12.90 bc |
| $T_7$ | 42.00 de | 12.40 bc |
| $T_8$ | 48.03 ab | 16.10 a |
| $T_9$ | 47.73 abc | 13.60 b |
| $T_{10}$ | 43.60 cde | 12.80 bc |
| $T_{11}$ | 40.00 e | 12.13 bc |
| $T_{12}$ | 28.87 f | 11.90 c |
| **$LSD_{0.05}$** | **3.801** | **1.476** |
| **CV%** | **5.14** | **6.53** |

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly as per DMRT

### 4.1.2 Number of leaves plant$^{-1}$

There was significant variation in the number of leaves plant$^{-1}$ due to application of different treatments. Here the highest (16.30) number of leaves was observed in $T_4$ treatment containing 100% chemical fertilizer along with 1.5 t ha$^{-1}$ vermicompost and the lowest (11.90) was recorded in control treatment ($T_{12}$). While comparing $T_1$ and $T_4$ (Table-4) it was observed that more number of leaves was obtained with $T_4$ treatment, on the other hand $T_1$ treatment (13.00) contained only 100 % RDCF. Treatment $T_5$ (80% RDCF) along with 3.0 t vermicompost ha$^{-1}$ produced significantly more leaves (13.70) than those having only 80% RDCF in $T_2$ treatment (12.80). Same trend was observed in case of $T_6$ (12.90) with $T_{10}$ (12.80) where 60% RDCF was applied with 6 t ha$^{-1}$ vermicompost and conventional compost respectively. From Table- 4, it was also revealed that the same amount of vermicompost produced more leaves with or without RDCF than same amount of conventional compost. However, sole application of 6 t vermicompost ha$^{-1}$ in $T_7$ (12.40) and 6 t conventional compost ha$^{-1}$ in $T_{11}$ (12.13) produced statistically similar number of leaves plant$^{-1}$. In every case vermicompost produced more leaves compared to conventional compost. But only vermicompost or conventional compost alone could not perform expected number of leaves. Organic manure should be incorporated with inorganic fertilizer for expected outcome.

### 4.1.3 Circumference of curd

Significant variation was observed in curd circumference of cauliflower as affected by different doses of vermicompost and conventional compost. The highest curd circumference (46.50 cm) was observed in $T_4$ treatment (Table-5). The lowest circumference (21.10 cm) was obtained from control treatment where no fertilizer was used. Among the treatments, $T_4$ (1.5 t $ha^{-1}$ vermicompost with 100% RDCF) showed highest curd circumference, this was statistically identical with $T_1$, $T_5$, $T_8$ and $T_9$ treatment.

**Table-5. Circumference and curd height of cauliflower as influenced by chemical fertilizers and organic manure**

| Treatments | Circumference (cm) | Curd height (cm) |
|---|---|---|
| $T_1$ | 40.50 abc | 14.60 cde |
| $T_2$ | 40.00 bc | 13.57 def |
| $T_3$ | 36.90 bc | 12.43 fg |
| $T_4$ | 46.50 a | 20.73 a |
| $T_5$ | 42.70 ab | 15.93 c |
| $T_6$ | 38.90 bc | 13.43 def |
| $T_7$ | 35.70 c | 10.87 gh |
| $T_8$ | 43.20 ab | 18.00 b |
| $T_9$ | 42.20 ab | 15.23 cd |
| $T_{10}$ | 37.97 bc | 12.77 feg |
| $T_{11}$ | 22.70 d | 10.00 h |
| $T_{12}$ | 21.10 d | 9.63 h |
| **$LSD_{0.05}$** | **5.585** | **1.960** |
| **CV%** | **8.83** | **8.32** |

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly as per DMRT

### 4.1.4 Curd height of cauliflower

Statistically significant variation was observed for curd height of cauliflower with the application of vermicompost and conventional compost. Combined application of different doses vermicompost and conventional compost along with RDCF exhibits significant influence on curd height of cauliflower. The highest curd height (20.73 cm) was observed from $T_4$ (100% RDCF with 1.5 t $ha^{-1}$ vermicompost) which was followed by $T_8$ (18.00 cm). The lowest curd height

(9.63cm) was obtained in $T_{12}$ (control) treatment (Table-5). Alam (2006) and Azad (2002) stated that combined application of manures and chemical fertilizers performed the highest plant height of cabbage.

Curd height was lower with compost than vermicompost. On the other hand, better curd height was obtained from $T_1$ (14.60 cm) where 100% RDCF was used without any organic manure which was statistically identical with $T_2$ (13.57 cm) and $T_6$ (13.43 cm). But use of only chemical fertilizer is harmful for soil health. So, we should try to supplement a part of chemical fertilizer by organic manure and application of vermicompost and conventional compost gave better performance of curd height of cauliflower. However, alone inorganic fertilizers use may cause problems for human health and the environment (Arisha and Bardisi, 1999). Organic manure can serve as alternative practice to mineral fertilizers for improving soil structure and microbial biomass (Dauda *et al.*, 2008).

### 4.1.5 Total weight of cauliflower plant$^{-1}$

Total weight of cauliflower means weight of curd with leaves. Effects of different levels of vermicompost and conventional compost were significant on weight of cauliflower. The maximum curd weight (1.60 kg plant$^{-1}$) was recorded with $T_4$ treatment ((1.5 t ha$^{-1}$ vermicompost with 100% RDCF). The lowest weight (0.71 kg plant$^{-1}$) was obtained in control plots ($T_{12}$).
Application of different doses of vermicompost and conventional compost with different doses of inorganic fertilizer showed different result. The highest result (1.60 kg plant$^{-1}$) was obtained from $T_4$ treatment which was followed by $T_8$ (1.50 kg plant$^{-1}$) treatment (Table-6). In case of $T_4$ and $T_8$ treatments, same dose inorganic fertilizers were used but difference was the type of manure.

**Table-6. Total weight and Marketable weight of cauliflower as influenced by chemical fertilizers and organic manure**

| Treatments | Total weight (kg plant$^{-1}$) | Marketable weight (kg plant$^{-1}$) |
|---|---|---|
| $T_1$ | 1.30 cde | 1.07 ab |
| $T_2$ | 1.13 fg | 0.95 bcd |
| $T_3$ | 1.05 gh | 0.91 bcd |
| $T_4$ | 1.60 a | 1.30 a |
| $T_5$ | 1.40 bc | 1.14 ab |
| $T_6$ | 1.20 def | 1.04 abc |
| $T_7$ | 0.94 hi | 0.80 cde |
| $T_8$ | 1.50 b | 1.18 ab |
| $T_9$ | 1.33 bcd | 1.09 ab |
| $T_{10}$ | 1.20 efg | 0.77 de |
| $T_{11}$ | 0.90 i | 0.60 e |
| $T_{12}$ | 0.71 j | 0.28 f |
| **$LSD_{0.05}$** | **0.131** | **0.119** |
| **CV (%)** | **6.38** | **7.38** |

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly as per DMRT

### 4.1.6 Marketable weight of cauliflower plant$^{-1}$

Use of different levels of vermicompost and conventional compost along with chemical fertilizer increased the marketable curd weight of cauliflower significantly (Table-6). Among the different doses of vermicompost and conventional compost in combination with chemical fertilizer or alone the highest marketable weight (1.30 kg plant$^{-1}$) was observed in $T_4$ treatment which was statistically similar with $T_8$ (1.18 kg plant$^{-1}$) and $T_5$ (1.14 kg plant$^{-1}$) respectively. The lowest marketable weight (0.28 kg plant$^{-1}$) was recorded with $T_{12}$ (control) treatment.

Higher marketable weight of cauliflower was obtained from combined application of vermicompost with chemical fertilizer. Das *et al.*, (2002) reported that yield components were increased significantly by integrated application of vermicompost and chemical fertilizers compared to application of chemical fertilizer treatments.

### 4.1.7 Curd yield of cauliflower

Application of different doses of vermicompost exhibited significant influence on the curd yield of cauliflower (Table-7). Among the different doses of vermicompost and conventional compost the highest yield (37.63 t $ha^{-1}$) was observed in $T_4$ treatment (1.5 t $ha^{-1}$ vermicompost with 100% RDCF) which was statistically identical with $T_8$ treatment where same doses conventional compost was applied. The lowest cauliflower yield (12.60 t $ha^{-1}$) was recorded in $T_{12}$ treatment where no fertilizer was applied (Table-7). In $T_5$ treatment vermicompost @ 3 t $ha^{-1}$ along with 80% RDCF was applied and yield was 34.07 t $ha^{-1}$ which was statistically identical with $T_9$ (33.19 t $ha^{-1}$) where same dose of conventional compost was used instead of vermicompost and also similar with $T_1$ treatment where only chemical fertilizer was applied. Treatments having vermicompost showed better yield than conventional compost incase of yield of cauliflower.

**Table-7. Curd yield and Stover yield of cauliflower as influenced by chemical fertilizers and organic manure**

| Treatments | Curd yield (t $ha^{-1}$) | Stover yield (t $ha^{-1}$) |
|---|---|---|
| $T_1$ | 32.44 bcd | 24.90 bcd |
| $T_2$ | 30.37 cd | 21.07 def |
| $T_3$ | 28.15 de | 18.67 ef |
| $T_4$ | 37.63 a | 29.67 a |
| $T_5$ | 34.07 ab | 25.83 abc |
| $T_6$ | 30.96 cd | 22.47 cde |
| $T_7$ | 24.59 ef | 18.87 ef |
| $T_8$ | 34.67 ab | 28.17 ab |
| $T_9$ | 33.19 abc | 24.23 bcd |
| $T_{10}$ | 29.33 d | 20.57 def |
| $T_{11}$ | 22.62 f | 16.67 f |
| $T_{12}$ | 12.60 g | 5.76 g |
| **$LSD_{0.05}$** | **6.066** | **4.230** |
| **CV (%)** | **12.04** | **10.92** |

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly as per DMRT

Same dose fertilizer was applied in $T_6$ and $T_{10}$ treatments. But comparatively higher yield was observed in $T_6$ (30.96 t $ha^{-1}$) where 6 t $ha^{-1}$ vermicompost with 60% chemical fertilizer was applied. But in $T_{10}$ treatment 6 t conventional compost was applied along with 60% chemical fertilizer and the result was (29.33 t $ha^{-1}$). It was notable that, without chemical fertilizer vermicompost or conventional compost could not gave better yield. Compare with $T_4$ treatment lowest yield was observed in $T_7$ and $T_{11}$ treatments where only 6 t vermicompost and 6 t conventional compost were applied respectively. Without chemical fertilizer vermicompost and conventional compost alone could not perform better yield. Increased head weight and yield of cabbage under integrated use of higher amount of organic manure and reduced level of inorganic fertilizer may be due to large uptake of nutrients and effective utilization of these nutrients for increased synthesis of carbohydrates, greater vegetative growth and subsequent partitioning and translocation from leaf (source) to the head sink (Yadav *et al.*, (2001).

### 4.1.8 Stover yield

Significant variation in stover yield of cauliflower was observed with different doses of vermicompost and compost along with the different doses of chemical fertilizers (Table-7). Among the different doses of organic fertilizer vermicompost with chemical fertilizer treatment, $T_4$ (1.5 t $ha^{-1}$ with 100% RDCF) showed the highest stover yield (29.67 t $ha^{-1)}$ which was statistically identical with $T_8$ (28.17 t $ha^{-1}$) treatment. On the other hand, the lowest stover yield (5.76 t $ha^{-1}$) was observed in the $T_{12}$ (control), where no fertilizer or manure was applied.

## 4.2 Effect of vermicompost and conventional compost on the nutrient content and uptake by cauliflower

### 4.2.1 Nitrogen content in cauliflower curd

A statistically significant variation was observed in nitrogen content in cauliflower curd at harvest for different treatments (figure-4 and appendix-1). The highest nitrogen content (1.99%) was recorded in $T_4$ (1.5 t $ha^{-1}$ vermicompost with 100% RDCF) treatment which was found statistically identical to $T_5$ treatment and the lowest nitrogen content (0.76%) was recorded in the $T_{12}$ treatment where no fertilizer or organic manures were applied. Jat and Ahlawat (2004) reported that application of vermicompost to chickpea improved nitrogen and phosphorus uptake by the cropping system over no vermicompost treatment or compost.

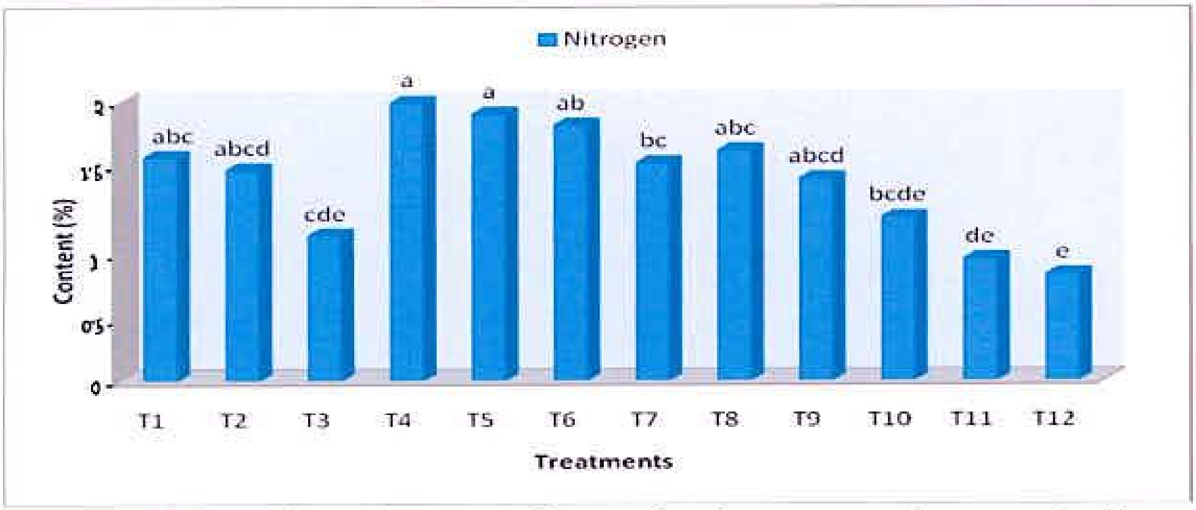



**Figure-4. Effect of vermicompost and conventional compost on nitrogen content in cauliflower curd**

Significant variation in nitrogen concentration was observed from $T_8$ (2.89%) treatment where (1.5 t $ha^{-1}$ compost was used along with 100% RDCF from $T_4$ treatment. This result showed that with similar dose of chemical fertilizer (100% RDCF) but change in nature of organic manure, nitrogen content was lower with conventional compost than vermicompost.

### 4.2.2 Nitrogen uptake by cauliflower curd

The highest nitrogen uptake by curd (131.66 kg $ha^{-1}$) was recorded in plants having treated with 100% RDCF along with 1.5 t vermicompost $ha^{-1}$ in $T_4$ treatment (Figure-5 and appendix-1). This result was statistically superior to all other treatments except $T_5$ treatment where 80% RDCF with 3 t vermicompost $ha^{-1}$ was applied. The lowest nitrogen uptake (16.04 kg $ha^{-1}$) was found in native treatment ($T_{12}$).

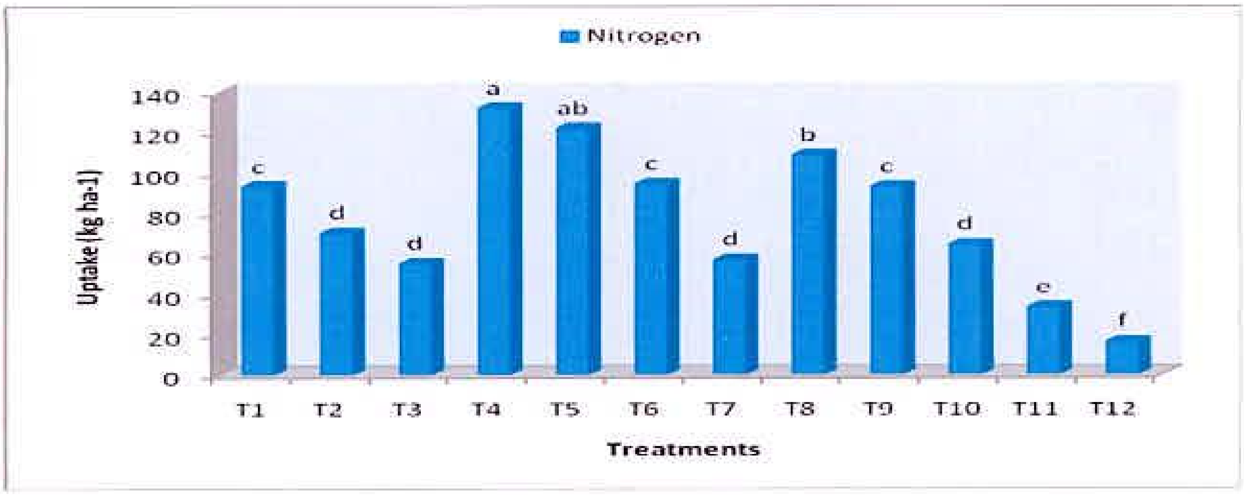



**Figure-5. Effect of vermicompost and conventional compost on nitrogen uptake by cauliflower curd**

### 4.2.3 Phosphorus content in cauliflower curd

Significant variation was recorded with phosphorus content in curd when organic manure with chemical fertilizer was applied with different doses (Figure-6 and appendix-2). Considering the effect of different doses of vermicompost, the highest phosphorus content (0.30%) was recorded in $T_4$ treatment (1.5 t $ha^{-1}$ vermicompost with 100% RDCF) which was statistically similar to $T_5$ (0.27%) treatment where 3 t $ha^{-1}$ vermicompost with 80% RDCF was applied. The lowest phosphorus content (0.16%) was recorded in $T_{12}$ treatment.

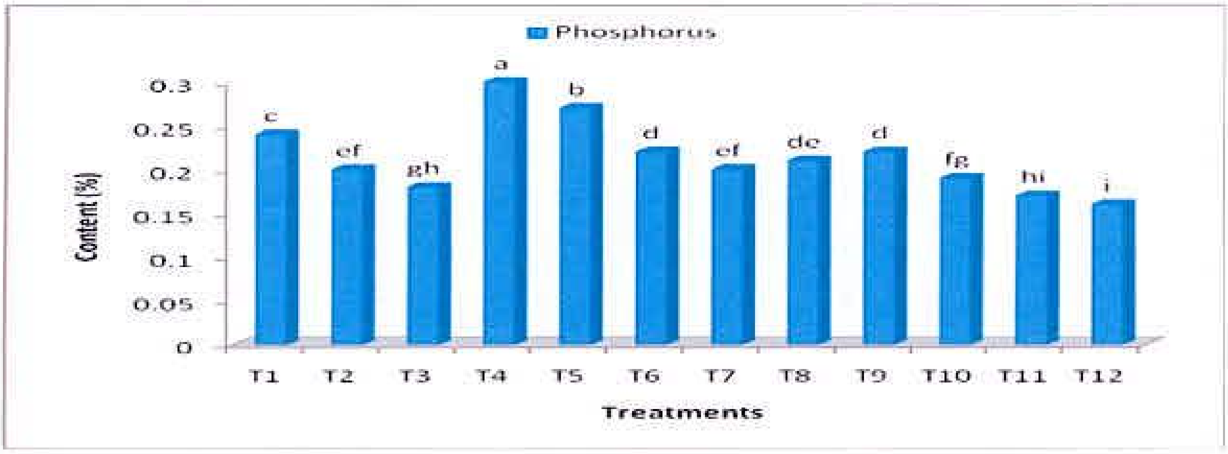



**Figure-6. Effect of vermicompost and conventional compost on phosphorus content in cauliflower curd**

### 4.2.4 Phosphorus uptake by cauliflower curd

Effect of vermicompost and conventional compost along with chemical fertilizer on phosphorus uptake by curd was also found significant (Figure-7 and appendix-2). Phosphorus uptake by the curd of cauliflower found highest (13.09 kg ha$^{-1}$) in the integrated treatment of 100% RDCF with 1.5 t vermicompost ha$^{-1}$ which showed significant similar result to 80% RDCF with 3 t vermicompost ha$^{-1}$ treatments. But the uptake was statistically superior to all other treatments. The lowest phosphorus uptake (1.22 kg ha$^{-1}$) was in curds produced by native nutrient treatment. The result relates that the application of organic manures increased efficiency of chemical fertilizer and phosphorus uptake by different crops. (Dixit and Gupta, 2000).

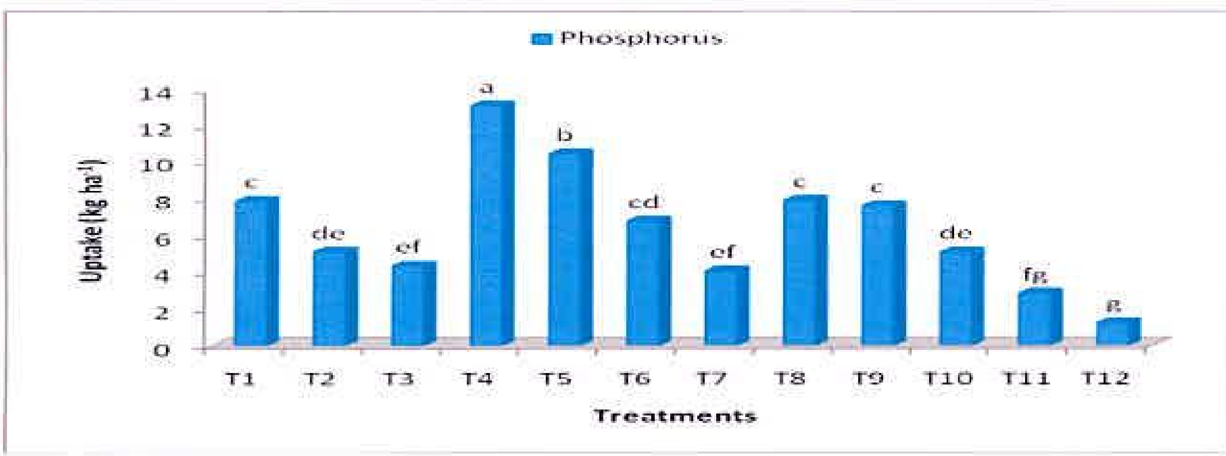



**Figure-7. Effect of vermicompost and conventional compost on phosphorus uptake by cauliflower curd**

### 4.2.5 Potassium content in cauliflower curd

Application of different doses of vermicompost showed a significant variation in the potassium content in cauliflower curd (Figure-8 and appendix-3). The highest potassium content (1.98%) was recorded in $T_4$ (1.5 t $ha^{-1}$ vermicompost along with 100% RDCF), which was statistically identical with $T_5$, $T_6$ and $T_8$. The lowest potassium content (0.09%) was recorded in the $T_{12}$ treatment where no organic manure was used. Application of chemical fertilizer with different doses of organic manure showed significant variation in respect of potassium content in cauliflower curd. Bongkyoon (2004) reported that the effect of vermicompost (EWC) application were favorable than the effects of the application of a chemical fertilizers in case of both yield and content and uptake of nutrients of crops.

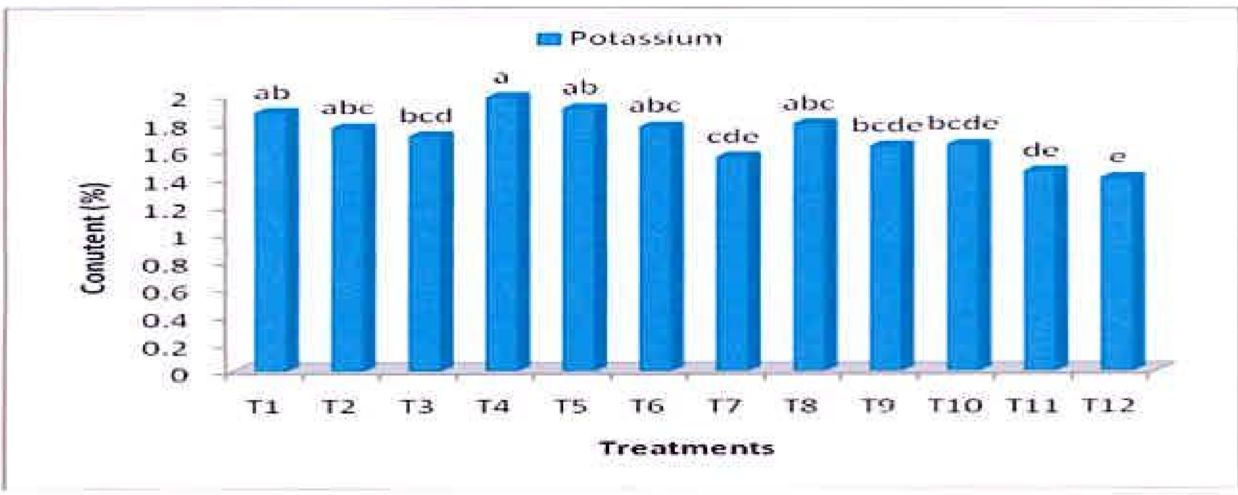



**Figure-8. Effect of vermicompost and conventional compost on potassium content in cauliflower curd**

### 4.2.6 Potassium uptake by cauliflower curd

In $T_4$ treatment, 1.5 t vermicompost $ha^{-1}$ with 100% RDCF showed the maximum potassium uptake (80.80 kg $ha^{-1}$) which was statistically significant over all other treatments except $T_5$ and $T_8$ treatments. The lowest potassium uptake (10.64 kg $ha^{-1}$) was recorded by the cauliflower curd produced in the native nutrient treatment $T_{12}$ (Figure-9 and appendix-3). Hochmuth *et al.* (1993 b) showed that recommended dose of fertilizer and organic manure (vermicompost) influenced head characteristics and head yield of cabbage, accordingly potassium with other nutrient uptake when they were applied in an integrated manner because the slow nutrient releasing vermicompost provided substantial amount of nutrients consistently to cabbage.

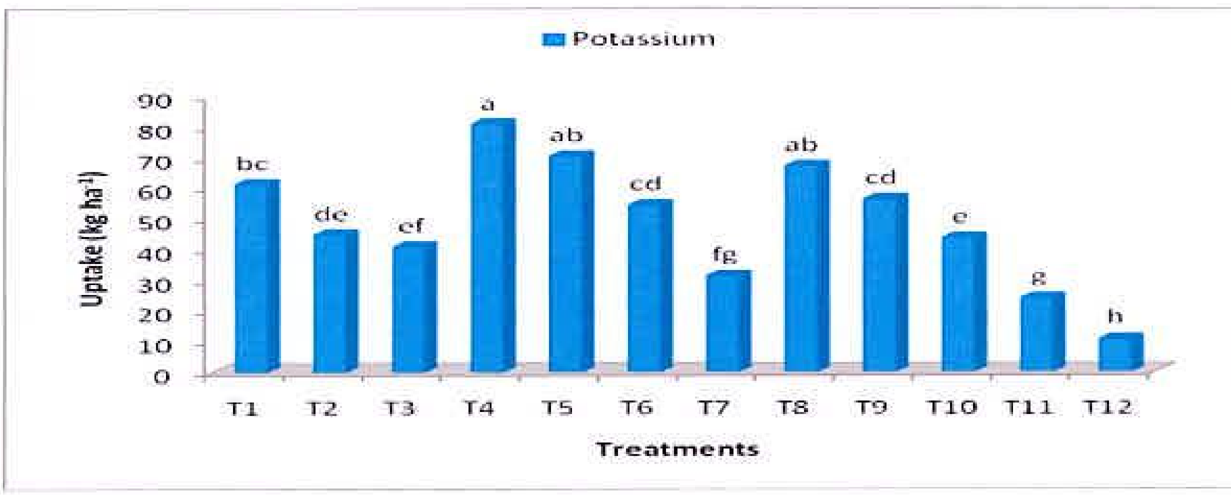



**Figure-9. Effect of vermicompost and conventional compost on potassium uptake by cauliflower curd**

### 4.2.7 Sulphur content in cauliflower curd

Statistically significant variation was recorded in sulphur content of curd when different doses of vermicompost and compost were applied with inorganic fertilizer (Figure-10 and appendix-4). Considering the effect of different doses of compost with chemical fertilizers, the highest sulphur content (0.31%) was recorded in $T_4$ (1.5 t $ha^{-1}$ vermicompost with 100% RDCF), which was identical with $T_6$ (0.30%) where only 60% RDCF and 6 t $ha^{-1}$ vermicompost was applied and the lowest sulphur content (0.17%) was recorded in the $T_{12}$ (no vermicompost + no chemical fertilizer) treatment.

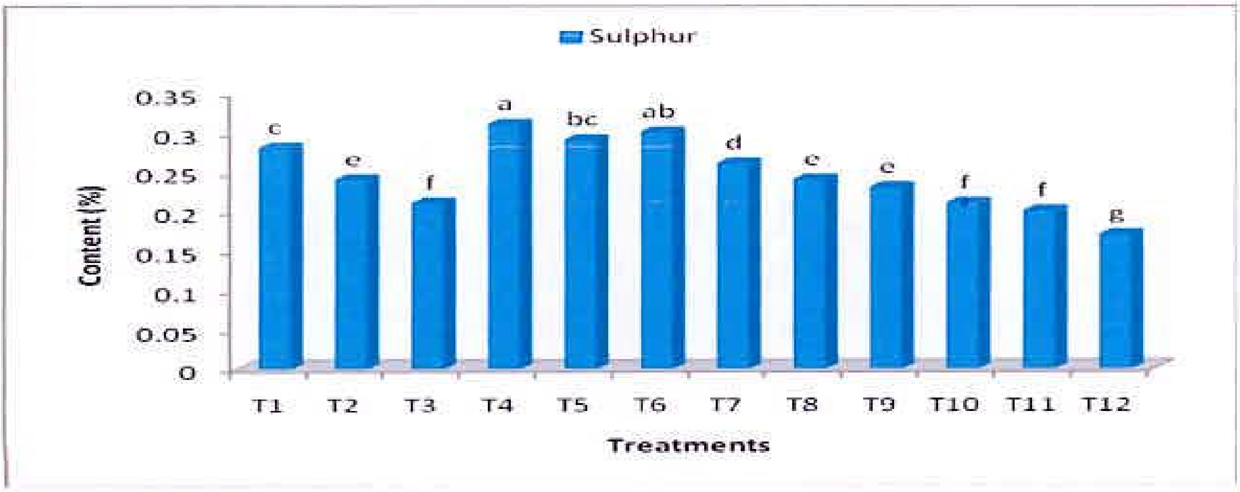



**Figure-10. Effect of vermicompost and conventional compost on sulphur content in cauliflower curd**

### 4.2.8 Sulphur uptake by cauliflower curd

The maximum sulphur uptake by the curd of cauliflower (12.50 kg $ha^{-1}$) was found in $T_4$ treatment which statistically similar with the treatment of $T_5$, but they were statistically superior to all other treatments. The lowest sulphur uptake (1.29 t $ha^{-1}$) was found in the control treatment (Figure-11 and appendix-4).

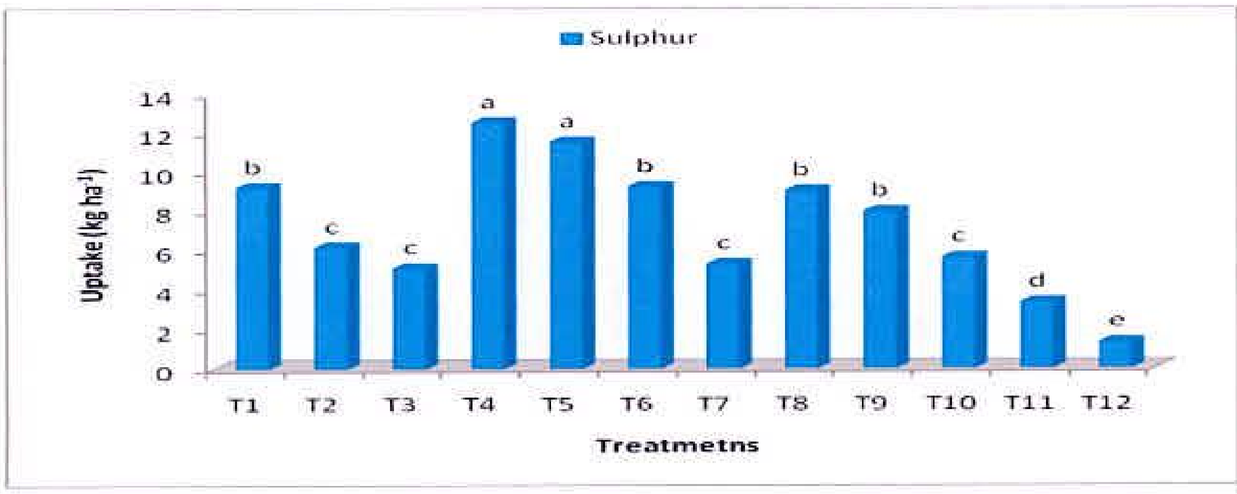



**Figure-11. Effect of vermicompost and conventional compost on sulphur uptake by cauliflower curd**

## 4.3 Effect of vermicompost and compost on the nutrient content and uptake by cauliflower stover

### 4.3.1 Nitrogen content in stover

Statistically significant variation was observed in nitrogen content in cauliflower stover at harvest when different doses of vermicompost and conventional compost were applied along with chemical fertilizer (Table-8). The highest nitrogen content in stover was recorded in $T_4$ treatment (1.5 t $ha^{-1}$ vermicompost along with 100% RDCF) which was statistically identical with $T_6$ and $T_5$ treatments where 80% RDCF with 3 t $ha^{-1}$ vermicompost and 60% RDCF with 6 t vermicompost $ha^{-1}$, respectively was applied. The lowest nitrogen content (1.09%) was recorded in the $T_{12}$ treatment where no fertilizer was applied.

**Table-8. Effect of vermicompost and conventional compost on nitrogen content and uptake by cauliflower stover**

| Treatments | Content (%) | Uptake (kg $ha^{-1}$) |
|---|---|---|
| | Nitrogen | Nitrogen |
| $T_1$ | 1.52 ab | 19.76 b |
| $T_2$ | 1.45 abc | 17.11 c |
| $T_3$ | 1.35 c | 13.91 d |
| $T_4$ | 1.58 a | 26.86 a |
| $T_5$ | 1.52 ab | 25.38 a |
| $T_6$ | 1.55 ab | 18.60 bc |
| $T_7$ | 1.35 c | 13.23 d |
| $T_8$ | 1.40 bc | 18.48 bc |
| $T_9$ | 1.45 abc | 19.58 b |
| $T_{10}$ | 1.41 bc | 17.20 c |
| $T_{11}$ | 1.11 d | 9.99 e |
| $T_{12}$ | 1.09 d | 8.50 e |
| **$LSD_{0.05}$** | **0.141** | **1.549** |
| **CV(%)** | **6.58** | **5.26** |

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly as per DMRT

### 4.3.2 Nitrogen uptake by stover

A statistically significant variation was observed in nitrogen uptake by stover of cauliflower with different doses of organic manure. Nitrogen uptake was maximum (26.86 kg $ha^{-1}$) in the treatment $T_4$ (1.5 t $ha^{-1}$ vermicompost with 100% RDCF) which was statistically superior to all other treatments except $T_5$ (80% RDCF with 3 t vermicompost $ha^{-1}$). The minimum nitrogen uptake (8.50 kg $ha^{-1}$) by cauliflower stover was recorded in control $T_{12}$ treatment (Table- 8).

### 4.3.3 Phosphorus content in stover

Statistically significant variation was observed in phosphorus content in cauliflower stover at harvest when the effects of different doses of vermicompost were compared (Table-9). Considering the effect of different doses of chemical fertilizer with vermicompost and conventional compost, the highest phosphorus content (0.39%) was recorded in $T_4$ treatment. The lowest phosphorus content was found in the stover of cauliflower treated with native nutrients ($T_{12}$ treatment).

**Table-9: Effect of vermicompost and conventional compost on phosphorus content and uptake by cauliflower stover**

| Treatment code | Content (%) | Uptake (kg $ha^{-1}$) |
|---|---|---|
| | Phosphorus | Phosphorus |
| $T_1$ | 0.34 ab | 4.42 b |
| $T_2$ | 0.30 bc | 3.54 bc |
| $T_3$ | 0.29 bc | 2.99 cd |
| $T_4$ | 0.39 a | 6.63 a |
| $T_5$ | 0.36 ab | 6.01 a |
| $T_6$ | 0.37 ab | 4.44 b |
| $T_7$ | 0.29 bc | 2.84 cd |
| $T_8$ | 0.34 ab | 4.49 b |
| $T_9$ | 0.33 ab | 4.46 b |
| $T_{10}$ | 0.32 ab | 3.90 bc |
| $T_{11}$ | 0.22 cd | 1.98 de |
| $T_{12}$ | 0.20 d | 1.56 e |
| **$LSD_{0.05}$** | **0.0853** | **1.104** |
| **CV(%)** | **5.97** | **6.58** |

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly as per DMRT

### 4.3.4 Phosphorus uptake by stover

Phosphorus uptake by cauliflower was significantly influenced due to the addition of vermicompost in contrast with control and compost (Table-9). Significantly maximum phosphorus (6.63 kg ha$^{-1}$) was taken up by cauliflower stover in $T_4$ treatment with the application of 1.5 t ha$^{-1}$ vermicompost with 100% RDCF which was statistically identical with $T_5$ treatment. The lowest phosphorus uptake (1.56 kg ha$^{-1}$) was recorded in control treatment ($T_{12}$).

### 4.3.5 Potassium content in stover

Statistically significant variation was recorded in potassium content in stover of cauliflower when different doses of vermicompost and conventional compost were applied (Table-10). When different doses of vermicompost and conventional compost were considered, the highest potassium content in stover (1.19%) was recorded in $T_4$ (1.5 t ha$^{-1}$ vermicompost with 100% RDCF) which was statistically identical with $T_1$, $T_6$ and $T_5$ treatment. The lowest potassium content (0.90%) was recorded in the $T_{12}$ treatment (No compost + No chemical fertitizer).

### 4.3.6 Potassium uptake by stover

The amount of potassium taken up by cauliflower stover with different doses of organic manures showed significantly higher values over the control (Table 10). Potassium uptake by cauliflower stover was maximum (20.23 kg ha$^{-1}$) in $T_4$ treatment where 100% RDCF was applied with 1.5 t ha$^{-1}$ vermicompost which was identical to $T_5$ treatment. The minimum potassium uptake by cauliflower (7.02 kg ha$^{-1}$) was in control treatment. It is evident that vermicompost along with chemical fertilizer supply more potassium than conventional compost or any combination of chemical fertilizer.

**Table-10. Effect of vermicompost and conventional compost on potassium content and uptake by cauliflower stover**

| Treatment | Content (%) | Uptake (kg $ha^{-1}$) |
|---|---|---|
| | Potassium | Potassium |
| $T_1$ | 1.15 ab | 14.95 b |
| $T_2$ | 1.12 abc | 13.22 bc |
| $T_3$ | 1.10 bc | 11.33 cd |
| $T_4$ | 1.19 a | 20.23 a |
| $T_5$ | 1.18 ab | 19.71 a |
| $T_6$ | 1.15 ab | 13.80 bc |
| $T_7$ | 0.99de | 9.70 de |
| $T_8$ | 1.10 bc | 14.52 b |
| $T_9$ | 1.10 bc | 14.85 b |
| $T_{10}$ | 1.05 cd | 12.81 bc |
| $T_{11}$ | 0.95 ef | 8.55 ef |
| $T_{12}$ | 0.90 f | 7.02 f |
| **$LSD_{0.05}$** | **0.075** | **2.356** |
| **CV(%)** | **4.14** | **10.39** |

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly as per DMRT

### 4.3.7 Sulphur content in stover

Statistically significant variation was observed with sulphur content in stover of cauliflower (Table-11). The highest sulphur content (0.26%) was recorded in $T_4$ treatment which was statistically superior to all other treatments. The lowest sulphur content (0.16%) was recorded invariably in $T_{12}$ treatment (control). Atiyeh *et al.* (2000b) found that vermicompost has higher sulphur availability than the conventional compost on a weight basis and the supply of several other plant nutrients e.g. phosphorus (P), potassium (K), sulphur (S) and magnesium (Mg), were significantly increased by adding vermicompost as compared to conventional compost to soil.

**Table-11: Effect of vermicompost and conventional compost on the sulphur content and uptake by cauliflower stover.**

| Treatment | Content (%) | Uptake (kg $ha^{-1}$) |
|---|---|---|
| | Sulphur | Sulphur |
| $T_1$ | 0.21 c | 2.73 cd |
| $T_2$ | 0.19 d | 2.24 de |
| $T_3$ | 0.18 d | 1.85 ef |
| $T_4$ | 0.26 a | 4.42 a |
| $T_5$ | 0.23 b | 3.84 b |
| $T_6$ | 0.23 b | 2.76 cd |
| $T_7$ | 0.19 d | 1.86 ef |
| $T_8$ | 0.22 bc | 2.90 c |
| $T_9$ | 0.22 bc | 2.97 c |
| $T_{10}$ | 0.21 c | 2.56 cd |
| $T_{11}$ | 0.18 d | 1.62 fg |
| $T_{12}$ | 0.16 e | 1.25 g |
| **$LSD_{0.05}$** | **0.016** | **0.551** |
| **CV(%)** | **5.00** | **8.61** |

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly as per DMRT

### 4.3.8 Sulphur uptake by stover

Sulphur uptake by cauliflower stover was significantly influenced with different treatments of vermicompost or conventional compost with chemical fertilizer (Table-11). The maximum sulphur (4.42 kg $ha^{-1}$) was taken up by stover of cauliflower from $T_4$ treatment with the application of 1.5 t $ha^{-1}$ vermicompost with 100% RDCF which was statistically identical to $T_5$ treatment (3.84 kg $ha^{-1}$) but superior to all other treatments. The lowest sulphur uptake (1.25 kg $ha^{-1}$) was found in native nutrient treatment ($T_{12}$).

### 4.4 Effect of vermicompost and conventional compost application on the nutrient status of soil after harvest

#### 4.4.1 Organic matter content in soil

A nonsignificant variation was recorded on the organic matter content after cauliflower harvest where the vermicompost and conventional compost were incorporated in soil (Table-12). Among the different doses of vermicompost, $T_6$ (6 t $ha^{-1}$ vermicompost with 60% RDCF) treatment showed the highest organic matter content (1.04%) after the harvest of crops. Where combined application of same dose compost with 60% RDCF showed (0.99%). On the other hand the lowest organic matter content (0.84%) was observed in $T_{12}$ treatment which was absolute control treatment. Similar results was obtained by Kamal *et al.* (2002) who explained that soil organic matter percentage increased when organic fertilizers were supplied instead of NPK fertilizer.

#### 4.4.2 Total nitrogen content in soil

Significant variation was recorded on the nitrogen content of cauliflower field after harvest of the crop when field was treated with different doses of vermicompost and conventional compost (Table-12). The effect of different doses of vermicompost revealed that the highest total nitrogen content (0.10%) was recorded in $T_5$ (3 t $ha^{-1}$ vermicompost with 80% RDCF) which was followed by $T_6$ (6 t $ha^{-1}$ vermicompost with 60% RDCF) and $T_4$ (1.5 t $ha^{-1}$ vermicompost with 100% RDCF). The lowest nitrogen content (0.04%) was recorded in the $T_{12}$ treatment (control). Banger *et al.* (1990) found that compost enriched the nitrogen content of soil. This might have happened due to the nitrogen accumulation in soil by the mineralization of organic nitrogen. From the table it was also observed that nitrogen status in the control treatment was exhausted.

#### 4.4.3 Available phosphorus status of soil

Phosphorus content of post harvest soil showed more or less similar trend like nitrogen as showed in the (Table-12). Combined effect of different doses of vermicompost and conventional compost recorded significant variation of available phosphorus content in post harvest soil. Among the different doses of composts and chemical fertilizers, $T_5$ (3 t $ha^{-1}$ vermicompost with 80% RDCF) treatment showed the highest (16 ppm) available phosphorus content after the harvest of crops. On the other hand, the lowest available phosphorus content (8 ppm) was observed in $T_{12}$ treatment (absolute control). Guan (1989) reported that the application of compost increased the availability of phosphorus in soil in comparison with the control treatment. The result showed that all the treatments where phosphorus used from any source left some residual phosphorus in soil and it was also obvious that the treatment where organic manure were used alone or along with inorganic fertilizer left more phosphorus in the post harvest soil which is the indication of enrichment of soil fertility.

**Table-12. Effect of vermicompost and conventional compost on the Organic Matter (OM), total N, available P, exchangeable K, available S and Zn contents in the soil after cauliflower harvest**

| Treatments | Soil properties | | | | | |
|---|---|---|---|---|---|---|
| | OM | Exchangeable K | Total N | Available P | Available S | Available Zn |
| | % | meq $100g^{-1}$ soil | % | ppm | | ppm |
| $T_1$ | 0.93 | 0.16 ab | 0.08 abc | 13 abcd | 9 bc | 1.3 |
| $T_2$ | 0.91 | 0.15 ab | 0.07 b | 11 cde | 8 bc | 1.2 |
| $T_3$ | 0.90 | 0.12 b | 0.05 bc | 10 de | 6 bcd | 1.1 |
| $T_4$ | 0.98 | 0.20 a | 0.09 ab | 14 abc | 12 b | 1.5 |
| $T_5$ | 0.99 | 0.20 a | 0.10 a | 16 a | 15 a | 1.7 |
| $T_6$ | 1.04 | 0.19 ab | 0.09 ab | 15 ab | 14 ab | 1.4 |
| $T_7$ | 1.00 | 0.16 ab | 0.06 bc | 12 bcd | 9 bc | 0.8 |
| $T_8$ | 0.96 | 0.17 ab | 0.07 b | 13 abcd | 12 b | 1.4 |
| $T_9$ | 0.98 | 0.18 ab | 0.08 abc | 14 abc | 14 ab | 1.6 |
| $T_{10}$ | 0.99 | 0.16 ab | 0.08 abc | 9 cde | 9 bc | 1.2 |
| $T_{11}$ | 0.99 | 0.13 ab | 0.06 bc | 11 cde | 5 c | 0.8 |
| $T_{12}$ | 0.84 | 0.12 b | 0.04 c | 8 e | 5 c | 0.6 |
| **$LSD_{0.05}$** | **NS** | **0.075** | **0.107** | **3.060** | **5.705** | **NS** |
| **CV (%)** | | **6.16** | **12.68** | **11.66** | **8.39** | |

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly as per DMRT

### 4.4.4 Exchangeable Potassium content in soil

Significant variation was recorded in exchangeable potassiun content in soil after harvest of the crop (Table-12). Application of vermicompost at the rate of 1.5 t $ha^{-1}$ with 100% RDCF in $T_4$ treatment and 3t vermicompost $ha^{-1}$ with 80% RDCF in $T_5$ treatment showed the highest exchangeable potassium content (0.20 meq100g-$^1$ soil). The lowest (0.12 meq100g-$^1$ soil) potassium content was observed in the $T_{12}$ treatment where no fertilizer was applied. Ramalingam (1999) reported that vermicompost increased significantly potassium by 40% over the control compost along with a reduction in C: N (15:1) and C: P (6:1) ratio due to mineralization and combined action of earthworms and microbes.

### 4.4.5 Available sulphur content in soil

Significant variation was recorded in sulphur content of soil after cauliflower harvest where the plots were incorporated with different doses of vermicompost and conventional compost (Table-12). Sulphur content was found the highest (15 ppm) in $T_5$ treatment where 3 t vermicompost $ha^{-1}$ was used. Here also, sulphur content was more in vermicompost treated plots. The lowest was obviously (5 ppm) from $T_{12}$ treatment where no fertilizer was used.

### 4.4.6 Available zinc content in soil

A nonsignificant variation was recorded in the available zinc content of soil after cauliflower harvest where the soil were incorporated with different doses of vermicompost and conventional compost (Table-12). Zinc content was found the highest (1.7 ppm) with the application of 3 t vermicompost $ha^{-1}$ with 80% RDCF in $T_5$ tratment. Here also zinc content was found more in vermicompost treated plot than conventional compost. Being a micronutrient its requirement by plant is very little. So, the supplied zinc from the organic source influenced its accumulation in soil after crop cultivation. Vasanthi and Kumaraswamy (1999) showed from an experiment with vermicompost and NPK fertilizers that organic carbon content and fertility status as reflected by the available status of micronutrients such as zinc were higher and bulk density were lower in the treatments that received vermicompost plus N, P and K than in the treatments with N, P and K alone.

# CHAPTER 5

# SUMMERY AND CONCLUSIONS

# CHAPTER V

## SUMMARY AND CONCLUSIONS

A field experiment was conducted at Soil Science Division of Bangladesh Agricultural Research Institute (BARI), Gazipur, in Grey Terrace Soil under AEZ -28 during the rabi season of 2008-2009 to study the response of cauliflower to vermicompost and conventional compost. The soil belongs to the Chhiata series having pH 6.4, organic matter 0.94%. Randomized Complete Block Design (RCBD) was followed with twelve treatment having unit plot size of 3.0 m x 2.7 m ($8.1m^2$) which were replicated thrice. The treatments were $T_1$ = 100% RDCF, $T_2$ = 80% RDCF, $T_3$ = 60% RDCF, $T_4$ = 100% RDCF + VC @ 1.5 t $ha^{-1}$, $T_5$ = 80% RDCF + VC @ 3 t $ha^{-1}$, $T_6$ = 60% RDCF + VC @ 6 t $ha^{-1}$, $T_7$ = VC @ 6 t $ha^{-1}$, $T_8$ = 100% RDCF + CC @ 1.5 t $ha^{-1}$, $T_9$ = 80% RDCF + CC @ 3 t $ha^{-1}$, $T_{10}$ = 60% RDCF + CC @ 6 t $ha^{-1}$, $T_{11}$ = CC @ 6 t $ha^{-1}$, $T_{12}$ = absolute control. The doses of 100% N-P-K-S–Zn-B were 250-35-65-40-5-1 kg $ha^{-1}$, respectively and these were used in the form of urea, TSP (triple super phosphate), MP (muriate of potash), gypsum, zinc sulphate and boric acid, respectively. The whole amount of P, K, S, Zn, B, and $^1/_3$ N were broadcast and thoroughly incorporated into the soil at the time of final land preparation and the remaining $^2/_3$ N was top dressed in two equal installments at 25 and 45 days after transplanting. Vermicompost and conventional compost were applied in the pit. Cauliflower seedlings were sown in the seed bed on the 31$^{st}$ October 2008. Then seedlings were transplanted in the main field on the 25$^{th}$ November, 2008 with a spacing of 60 cm from row to row and 45 cm from plant to plant. Intercultural operations were done as and when necessary. The data were collected plot wise for plant height, number of leaves $plant^{-1}$, circumference, curd height, marketable curd weight $plant^{-1}$, total weight of plant, stover yield $ha^{-1}$ and curd yield. The post harvest soil was analyzed for organic matter, N, P, K, S and Zn contents. All the data were statistically analyzed following the computer package MSTATC and the mean comparison was made by DMRT at 5% level. The results of the experiment are summarized below.

Statistically significant difference was observed on the yield and yield contributing characters of cauliflower with the application of vermicompost and conventional compost. Among the treatments, $T_4$ (1.5 t vermicompost $ha^{-1}$ with 100% RDCF) treatment showed the highest plant height (49.4 cm), the highest (16.33) no. of leaves, the circumference (46.5 cm) and the highest curd height (20.73cm). The highest curd weight $plant^{-1}$ (1.60 kg) and the highest marketable weight (1.30 kg $plant^{-1}$) of cauliflower was found also from $T_4$ treatment. On the other hand, the lowest result was observed from $T_{12}$ treatment, where no organic or inorganic fertilizer was applied. Curd yield of cauliflower responded significantly to the vermicompost and conventional compost treatments. The highest curd yield (37.63 t $ha^{-1}$) was obtained in $T_4$ (1.5 t $ha^{-1}$ vermicompost with 100% RDCF) treatment. The lowest yield of cauliflower (12.60 t $ha^{-1}$) was recorded in $T_{12}$ treatment. The results revealed that when vermicompost was applied in combination with recommended fertilizers, the effect showed better performance on yield rather than applying vermicompost or NPKS fertilizers alone or compost with recommended dose. The highest stover yield (29.67t $ha^{-1)}$ was recorded in $T_4$ (1.5 t $ha^{-1}$ vermicompost with 100% RDCF) treatment and the lowest (5.76 t $ha^{-1}$) in $T_{12}$. Here $T_5$ ((3 t $ha^{-1}$ vermicompost with 80% RDCF) showed the highest performance of cauliflower.

The N, P, K and S contents and uptake of these nutrients by cauliflower plant were influenced significantly in response to application of vermicompost, conventional compost and chemical fertilizers. The highest N, P, K and S contents in curd (1.99%, 0.30%, 1.98% and 0.31%, respectively) were recorded in $T_4$ (1.5 t $ha^{-1}$ vermicompost + 100 RDCF) treatment. The lowest N, P, K and S contents in curd (0.67%, 0.16, 1.40% and 0.17% respectively) were obtained with $T_{12}$ (control) treatment. The N, P, K, and S content were found more in vermicompost treated curd either alone or in combination with RDCF.

Statistically significant variation was observed in nutrient uptake by cauliflower curd after harvest when different doses of vermicompost and conventional compost were applied with recommended doses of chemical fertilizer. The highest uptake of (131.66, 13.09, 80.80 and 12.50 kg $ha^{-1}$ of N, P, K and S, respectively by cauliflower curd were found in $T_4$ (1.5 t $ha^{-1}$ vermicompost with 100% RDCF) treatment and the lowest uptake (16.04, 1.22, 10.64 and 1.29 kg $ha^{-1}$) of N, P, K and S, respectively in $T_{12}$ control treatment.

The N, P, K and S contents and uptake of these nutrients by cauliflower stover were influenced significantly by the application of vermicompost and chemical fertilizers. The highest N, P, K and S content in stover (1.58%, 0.39%, 1.19% and 0.26% respectively) were recorded in $T_4$ (1.5t ha $^{-1}$ vermicompost with 100% RDCF) treatment whereas the lowest N, P, K and S content (1.09%, 0.20%, 0.96% and 0.16%, respectively) were obtained with in $T_{12}$ treatment.

The highest uptake (26.86, 6.63, 20.23 and 4.42 kg $ha^{-1}$) and the lowest uptake (8.50, 1.56, 7.02 and 1.25 kg $ha^{-1}$) of N, P, K and S, respectively by cauliflower stover were found in $T_4$ (1.5 t $ha^{-1}$ vermicompost with 100% RDCF) and $T_{12}$ treatments in every case.

The soil properties such as organic matter, total nitrogen, phosphorus, potassium, sulphur and zinc contents were increased due to the application of vermicompost and fertilizers after the harvest of the crop as compared to the initial nutrient status of the soil. After all the post harvest soil indicated more soil fertility in vermicompost treated plots.

## CONCLUSIONS

From the backdrop of the above all-out study on the response of cauliflower to vermicompost and conventional compost, the following conclusion may be drawn:

- Combined application of vermicompost and inorganic fertilizer has a positive effect on yield and yield components of cauliflower than conventional compost.

- The treatment $T_4$, comprising 100% RDCF and 1.5 t vermicompost per hectare showed better performance for the cultivation of cauliflower.

- Application of vermicompost can supplement huge amount of soil nutrients for the standing crop as well as enrich the soil health providing improved chemical and physical properties.

- Use of vermicompost is more suitable than conventional compost because of slow mineralization and state release of nutrients to plants.

- In $T_5$ treatment, 20% inorganic fertilizers can be reduced with application of 3t vermicompost $ha^{-1}$.

# CHAPTER 6

# REFERENCES

## CHAPTER VI

# REFERENCES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# CHAPTER 7

# APPENDICES

## CHAPTER VII

# APPENDICES

**Appendix I. Effect of vermicompost and conventional compost on Nitrogen content and uptake by cauliflower curd**

| Treatments | Content (%) | Uptake (kg $ha^{-1}$) |
|---|---|---|
| | Nitrogen | Nitrogen |
| $T_1$ | 1.60 abc | 92.87 c |
| $T_2$ | 1.51 abcd | 69.85 d |
| $T_3$ | 1.04 cde | 54.72 d |
| $T_4$ | 1.99 a | 131.66 a |
| $T_5$ | 1.91 a | 121.59 ab |
| $T_6$ | 1.83 ab | 94.25 c |
| $T_7$ | 1.56 bc | 56.56 d |
| $T_8$ | 1.65 abc | 108.38 b |
| $T_9$ | 1.45 abcd | 92.81 c |
| $T_{10}$ | 1.17 bcde | 64.11 d |
| $T_{11}$ | 0.87 de | 33.20 e |
| $T_{12}$ | 0.67 e | 16.04 f |
| **$LSD_{0.05}$** | **0.584** | **13.980** |
| **CV(%)** | **14.99** | **10.58** |

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly as per DMRT

**Appendix II. Effect of vermicompost and conventional compost on Phosphorus content and uptake in cauliflower curd**

| Treatments | Content (%) | Uptake (kg ha$^{-1}$) |
|---|---|---|
| | Phosphorus | Phosphorus |
| $T_1$ | 0.24 c | 7.85 c |
| $T_2$ | 0.20 ef | 5.08 de |
| $T_3$ | 0.18 gh | 4.32 ef |
| $T_4$ | 0.30 a | 13.09 a |
| $T_5$ | 0.27 b | 10.42 b |
| $T_6$ | 0.22 d | 6.75 cd |
| $T_7$ | 0.20 ef | 4.04 ef |
| $T_8$ | 0.21 de | 7.88 c |
| $T_9$ | 0.22 d | 7.59 c |
| $T_{10}$ | 0.19 fg | 5.05 de |
| $T_{11}$ | 0.17 hi | 2.82 fg |
| $T_{12}$ | 0.16 i | 1.22 g |
| **$LSD_{0.05}$** | **0.016** | **1.978** |
| **CV(%)** | **5.47** | **8.17** |

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly as per DMRT

**Appendix III. Effect of vermicompost and conventional compost on Potassium content and uptake by cauliflower curd**

| Treatments | Content (%) | Uptake (kg ha$^{-1}$) |
|---|---|---|
| | Potassium | Potassium |
| $T_1$ | 1.87 ab | 61.15 bc |
| $T_2$ | 1.76 abc | 44.70 de |
| $T_3$ | 1.70 bcd | 40.80 ef |
| $T_4$ | 1.98 a | 80.80 a |
| $T_5$ | 1.90 ab | 70.34 ab |
| $T_6$ | 1.77 abc | 54.34 cd |
| $T_7$ | 1.55 cde | 31.31 fg |
| $T_8$ | 1.79 abc | 67.13 ab |
| $T_9$ | 1.63 bcde | 56.24 c |
| $T_{10}$ | 1.64 bcde | 43.62 e |
| $T_{11}$ | 1.45 de | 24.07 g |
| $T_{12}$ | 1.40 e | 10.64 h |
| **$LSD_{0.05}$** | **0.245** | **10.120** |
| **CV(%)** | **8.50** | **12.41** |

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly as per DMRT

**Appendix IV. Effect of vermicompost and conventional compost on Sulphur content and uptake in cauliflower curd**

| Treatments | Content (%) | Uptake (kg ha$^{-1}$) |
|---|---|---|
| | Sulphur | Sulphur |
| $T_1$ | 0.28 c | 9.16 b |
| $T_2$ | 0.24 e | 6.10 c |
| $T_3$ | 0.21 f | 5.04 c |
| $T_4$ | 0.31 a | 12.50 a |
| $T_5$ | 0.29 bc | 11.50 a |
| $T_6$ | 0.30 ab | 9.21 b |
| $T_7$ | 0.26 d | 5.25 c |
| $T_8$ | 0.24 e | 9.00 b |
| $T_9$ | 0.23 e | 7.94 b |
| $T_{10}$ | 0.21 f | 5.59 c |
| $T_{11}$ | 0.20 f | 3.32 d |
| $T_{12}$ | 0.17 g | 1.29 e |
| **$LSD_{0.05}$** | **0.017** | **1.397** |
| **CV(%)** | **4.50** | **3.63** |

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly as per DMRT