YIELD PERFORMANCE OF CABBAGE UNDER DIFFERENT COMBINATIONS OF MANURES AND FERTILIZERS

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BY

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DEDICATED

TO

MY BELOVED PARENTS

BAIDYA NATH SANA

AND

MINOTI RANI

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ABSTRACT

An investigation was made on yield performance of cabbage (*Brassica oleracea* var. *capitata*) under different combinations of manures and fertilizers at Hogladanga village under Botiaghata upazila, Khulna during the period from November, 2013 to March, 2014. The experiment was carried out in a Randomized Complete Block Design (RCBD) with three replications. The experiment consisted of seven treatments.The treatments were T_1 = recommended doses of NPK (urea @ 350 kg ha^{-1}, TSP @ 250 kg ha^{-1}, MoP @ 300 kg ha^{-1}, respectively), T_2= cowdung @10 t ha^{-1}, T_3= vermicompost @ 10 t ha^{-1}, T_4=*Trichoderma* compost @10 t ha^{-1}, T_5= 50 % cowdung + 50 % recommended doses of fertilizer, T_6 = 50 % vermicompost + 50 % recommended doses of fertilizer and T_7 =50 % *Trichoderma* compost + 50 % recommended doses of fertilizer. The growth and physio-morphological characteristics, yield attributes and yield were positively and significantly influenced by the application of vermicompost with recommended dose of NPK and also cowdung compost with the recommended dose of NPK. In most cases 50 % vermicompost + 50 % recommended doses of fertilizer receiving treatment performed better. However, the maximum yield of cabbage (57.16 t ha^{-1}) was obtained from the treatment receiving 50 % vermicompost + 50 % recommended doses of fertilizers and the lowest yield of cabbage (38.48 t ha^{-1}) was obtained from the control. But considering the highest benefit cost ratio of cabbage (3.63) was noted when applied 50 % cowdung + 50 % recommended doses of fertilizer was applied for sustainable crop production.

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LIST OF ABBREVIATIONS

AEZ	:	Agro Ecological Zone
BARC	:	Bangladesh Agricultural Research Council
BAU	:	Bangladesh Agricultural University
BBS	:	Bangladesh Bureau of Statistics
CD	:	Cowdung
cv.	:	Cultivar
DAT	:	Days after transplanting
FYM	:	Farmyard manure
g	:	Gram
ha	:	Hectare
kg	:	Kilogram
KU	:	Khulna University
LSD	:	Least significant difference
MOC	:	Mustard oil cake
MoP	:	Muriate of potash
Pd	:	Poultry drop
pH	:	Negative logarithm of hydrogen ion concentration
Pl	:	Poultry litter
PM	:	Poultry manure
RCBD	:	Randomized complete block design
RDF	:	Recommended dose of fertilizer
T	:	Treatment
t	:	Ton
TSP	:	Triple supper phosphate
VC	:	Vermicompost
@	:	At
%	:	Percentage

Chapter I

INTRODUCTION

Cabbage (*Brassica oleracea* var. *capitata*) is one of the most important leafy vegetables in Bangladesh. It is an important member of cole crops and belongs to the family Cruciferae. It is a herbaceous plant distinguished by a short stem upon which is crown with a mass of leaves (head), usually green but in some varieties red or purplish (Sarker *et al.,* 2002). Cabbage is an excellent source of vitamin C, in addition to containing vitamin B complex, cabbage supplies some potassium and calcium to the diet (Haque, 2006). The leading cabbage growing districts in Bangladesh are Kustia, Meherpur, Jessore, Bogra and Tangail (Sarker *et al.,* 2002). Cabbage is cultivated in an area of 15.79 thousand hectares with a production of 207 thousand tons (BBS, 2011).

Organic matter acts as a reservoir for plant nutrients and prevents leaching loss of nutrients which are vital for plant growth. Organic manure also creates an environment that encourages beneficial soil organisms i.e. earthworms. Organic matter undergoes mineralization with the release of substantial quantities of nitrogen, phosphorus, sulpher and small amount of micronutrients. A good agricultural soil should contain at least 5 % organic matter, while soils of Bangladesh contain less than 2 % organic matter in most of the regions (Bhuiyan, 1994). Cowdung compost, vermicompost and *Trichoderma* compost will play a vital role to make soil fertile (Islam, 2011). Cowdung is a rich source of different nutrients. It provides 0.5 % N, 0.15 % P, 0.5 % K and moisture 60 ± 6 % (BARC, 2012). Cowdung manure is available in the rural area and it is widely used from the past by the farmers of Bangladesh. Application of vermicompost in crop production is an important aspect of organic farming and it finds a wide range of applications in various types of agricultural plants. Vermicompost can be used as an effective manure in crop production as well as biofertilizer

in maintaining soil health (Edwards and Lofly, 1977; Lee, 1985). Vermicompost is a rich nutritive organic fertilizer due to rich in humus, micronutrients, beneficial soil microbes- 'nitrogen fixing and phosphorous solubilizing bacteria' and actinomycetes and growth hormones 'auxins', 'gibberlins' and 'cytokinins' (Sinha *et al.,* 2010). Vermicompost contains several nutrient elements such as N -1.9 %, C: N-13.6, P -2 %, K- 0.8 %, Zn- 100 ppm, Cu- 48 ppm and Mn-500 ppm (Shahi, 2013). *Trichoderma* compost (Tricho-compost), a *Trichoderma* based compost fertilizer, was developed by mixing a definite concentration of spore suspension of a *Trichoderma harzianum* strain with measured amounts of processed raw materials, such as cowdung, poultry refuse, water hyacinth, vegetable wastes, saw dust, maize bran and molasses. Tricho-compost is rich in various nutrients. Tricho-compost contained as much as 20 % organic carbon and considerable amount of 11 different nutrient elements i.e. N- 1.2 %, P- 0.61 %, K -0.77 %, S- 0.24 %, Ca- 1.71 %, Mg- 0.4 %, B- 0.01 %, Cu- 0.01 %, Fe- 0.12 %, Mn- 0.026 % and Zn- 0.02 % (Nahar *et al.,* 2012).

In Bangladesh the productivity of cabbage per unit area is quite low as compared to developed countries of the world (Anonymous, 2006). This low yield may be attributed to the method of production practices followed by the farmers especially use of poor quality seeds, maintenance of lower soil fertility, inadequate irrigation and use of imbalanced fertilizers. Among the various factors involved judicious nutrient supply is an important inputs for realizing higher cabbage yield and its nutrient content. In Bangladesh soil deterioration is a major constraint for higher crop production. The increasing land use intensity without adequate and balanced use of chemical fertilizers and with little or no use of organic manures have caused severe fertility deterioration of soils resulting in stagnating or even declining of crop productivity. The farmers of this country use on an average 172 kg nutrients ha^{-1} annually (132 kg N, 27 kg P, 17 kg K, 4 kg S and 2 kg Zn), while the nutrient removal by crop is about 250 kg ha^{-1} (Islam, 2002).

Fertile soil is the fundamental resource for crop production and soil organic matter plays a key role for long term sustainable soil fertility and crop productivity. More use of inorganic fertilizers in crop production deteriorates soil health, causes health hazard and creates imbalance to the environment (Islam, 2011). Soil management practices have recently changed dramatically including an increased use in synthetic fertilizers and pesticides to help crop yields. However, excessive use of these agrochemicals may actually increase pest problems in long run (Altieri and Nicholls, 2003). Higher synthetic fertilizer inputs may lead to higher herbivore damage (Letourneau, 1996). There are many problems in agriculture of Bangladesh among them degradation of soil health is one of the major problem. This problem creates due to use of more agrochemicals such as fertilizers, pesticides, herbicides etc. in crop fields as well as for intensive cropping to produce more foods for the fast and vast growing populations without considering the negative impact of chemicals on soil. Besides, excess application of inorganic fertilizer causes hazard to public health and to the environment. Organic agricultural practices might be a potential alternative to mitigate the soil health degradation problem. However, concept of organic farming is very preliminary in Bangladesh. This practice maintains crops yield at optimum level by assuring soil health. Considering the above factors, the present experiment was done with the following objective-

- To investigate the effect of different combinations of organic manures and fertilizers on growth and yield performance of cabbage.

Chapter II

REVIEW OF LITERATURE

Cabbage is one of the most important leafy vegetables in Bangladesh as well as in the world. However, some of the researches and their findings related to the present study carried out at home and abroad are reviewed in this chapter under the following headings.

2.1 Effect of cowdung compost on growth and yield of cabbage and other vegetable crops

A field experiment was conducted at the Horticultural farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh. The study was carried out to evaluate the performance of fertilizers (organic and inorganic) on growth of cabbage. The experiment comprised of two different factors such as three varieties : V_1 (Atlas 70), V_2 (Keifu 65) and V_3 (Autumn 60) and four different fertilizers: F_0 (control), F_1 (cowdung @ 15 t ha^{-1}), F_2 (poultry manure @ 15 t ha^{-1}), F_3 (inorganic fertilizer i.e. urea, TSP, MoP @ 330, 200 and 250 kg ha^{-1}, respectively) and also their combined effects were tested. The experiment was set up in randomized Complete Block Design (factorial) with three replications. There were 12 treatment combinations. The experimental plot was fertilized as per treatment with organic and inorganic fertilizers. Among the varieties, Atlas 70 (V_1) achieved the highest results of plant height (31.94 cm), leaf length with petiole (32 cm), stem length (4.19 cm), diameter of head (20.24 cm), weight of whole plant (2.23 kg $plant^{-1}$), gross yield (46.67 t ha^{-1}), marketable yield (45.29 tha^{-1}) and economic production (1.576 kg $plant^{-1}$) at the time of harvest. V_1F_2 (Atlas 70 × poultry manure) represented the highest weight of plant (2.56 kg) and marketable yield (61.52 t ha^{-1}). V_1F_1 (Atlas 70 × cowdung compost) also performed good compare to control (Hasan and Solaiman, 2012).

A field experiment is carried out to evaluate the effect of different organic manures (cowdung, vermicompost and *Trichoderma* compost) on growth and yield of cabbage cv. Autumn Queen and their residual effect on stem amaranth cv. Bhutan soft during the period of October, 2010 to March, 2011 at Horticulture Farm, BAU, Mymensingh. The experiment considered of eight treatments. The treatments were control (recommended dose of NPK, N @ 131 kg ha^{-1}, P @ 29 kg ha^{-1} and K @ 109 kg ha^{-1}), cowdung @ 15 t ha^{-1} + recommended dose of NPK, vermicompost @ 15 t ha^{-1} + recommended dose of NPK, *Trichoderma* compost @ 15 t ha^{-1} + recommended dose of NPK, cowdung @ 5 t ha^{-1} + vermicompost @ 5 t ha^{-1} + *Trichoderma* compost @ 5 t ha^{-1} + recommended dose of NPK, vermicompost @ 7.5 t ha^{-1} + *Trichoderma* compost @ 7.5 t ha^{-1} + recommended dose of NPK, cowdung @ 7.5 t ha^{-1} + vermicompost compost @ 7.5 t ha^{-1} + recommended dose of NPK, cowdung @ 7.5 t ha^{-1} + *Trichoderma* compost @ 7.5 t ha^{-1} + recommended dose of NPK. In most cases cowdung @ 5 t ha^{-1} + vermicompost @ 5 t ha^{-1} + *Trichoderma* compost @ 5 t ha^{-1} + recommended dose of NPK receiving treatment performed better. The maximum yield of cabbage (104.73 t ha^{-1}) and stem amaranth (23.05 t ha^{-1}) were obtained from the treatment receiving cowdung @ 5 t ha^{-1} + vermicompost @ 5 t ha^{-1} + *Trichoderma* compost @ 5 t ha^{-1} + recommended dose of NPK and the lowest yields of cabbage (45.50 t ha^{-1}) and stem amaranth (9.43 t ha^{-1}) were obtained from the control (Islam, 2011).

Kedino *et al.* (2009) conducted a field experiment during the year 2006-07 in Nagaland, India to study the effect of organic manures and biofertilizers on growth, yield and quality of cabbage. Nine treatments were included in the experiment. They reported that application of FYM @ 60 t ha^{-1} recorded significantly higher plant height (33.87 cm), head diameter (21.42 cm), gross yield (49.34 t ha^{-1}), marketable yield (47.22 t ha^{-1}).

Yan *et al.* (2004) carried out an experiment in China to study the effects of combined application of organic manure and chemical fertilizer on the yield and quality of Chinese cabbage. The combined application of organic manure and fertilizer improved the yield and quality of Chinese cabbage. Higher yield and quality were obtained when organic manure was applied at 3750 kg/667 m^2, and when the chemical fertilizer was applied at 30 kg/667 m^2. This treatment gave the highest soluble substance, soluble sugar and nitrite contents (6.25 %, 45.38 g kg^{-1} and 0.56 mg kg^{-1} respectively). The nitrate content did not significantly vary among the treatments. The quality of treated Chinese cabbage was classified under the third level food standard.

Kabir *et al.* (2002) carried out an experiment on farm of BARI, Gazipur, Bangladesh to find out the effect of nutrient application on cabbage cv. Atlas 70. The treatments included inorganic fertilizers according to the yield goal (high yield goal, medium yield goal and low yield goal) and organic manure (cowdung, poultry, manure and compost). Individual treatment at full recommended rate and treatment combinations of inorganic and organic sources (each applied at half the recommended rates) were used. The most compact head (0.54 g cc^{-1}) was obtained with MYG (Moderate yield goals) + cowdung. Protein content was the highest at HYG (High yield goals) + poultry manure and ascorbic acid content was the highest with HYG + cowdung. Application of HYG + poultry manure was the most profitable with a benefit- cost ratio of 2.21.

Yadav *et al.* (2001) conducted a field experiment to evaluate the effect of NICAST (organic manure) in comparison to recommended doses of manure and fertilizers in cabbage. There were 10 treatments under that experiment. Among the treatment T_7 (NICAST : 500 kg ha^{-1} + recommended NPK) showed significantly highest head yield

(207.48 q ha^{-1}) with maximum head weight (2.89 kg).

Sannigrahi and Borate (2000) conducted a field experiment in Assam with tomatoes, French beans and cabbage by the application of organic manures (FYM or compost) with or without NPK fertilizer and root inoculation with mycorrhizas. They reported that tomato yield was the highest (17.3 t ha^{-1}) with the application of recommended NPK fertilizers, while the yield of French beans (36.1 t ha^{-1}) and cabbage (26.6 t ha^{-1}) were highest with FYM @10 t ha^{-1} + Inoculation + N @ 15 kg ha^{-1} + K_2O @ 10 kg ha^{-1} and compost @ 10 t ha^{-1} + Inoculation + N @ 40 kg ha^{-1} + K_2O @ 30 kg ha^{-1}, respectively.

Farid *et al.* (1998) conducted an experiment at Joydebpur, Gazipur, Bangladesh to study the efficiency of poultry manure and cowdung alone and in combination with mineral fertilizers on the yield of cabbage (var. Atlas-70). They mentioned that the head yield of cabbage was increased both by cowdung and poultry manure with macro and micro-nutrients added to the treatments. But the increase due to poultry manure was always higher than that of cowdung. Poultry manure alone increased the yield significantly when it was applied at the rate of 20 t ha^{-1}. Economically, the treatments using 5 t ha^{-1} of poultry manure along with 200, 120, 100 and 50 kg ha^{-1} of N, P_2O_5, K_2O and S, respectively. Thus organic manures gave significantly higher yield (85.0 t ha^{-1}) of cabbage and more profit when applied in combination with mineral fertilizers.

Dixit (1997) carried out an experiment on Himachal Pradesh to investigate the efficacy of nitrogen and organic manure on cabbage. The result of the experiment showed that the yield of cabbage increased with increasing N (from 136.8 to 175.1 q ha^{-1} after

addition of 0 and 160 kg N ha^{-1}, respectively) and FYM rate (from 129.5 to 144 q ha^{-1}). Addition of FYM to N treatments further increased yield (yields of 176.1 q ha^{-1} in presence of FYM + N @ 160 kg ha^{-1}).

Aktar *et al.* (1996) carried out an experiment at Joydebpur, Gazipur, Bangladesh during the rabi season of 1993-94 and 1994-95 to find out the effects of poultry manure (PM) and cowdung (CD) in presence and absence of chemical fertilizer on growth and yield of broccoli and reported that 10 t ha^{-1} of poultry manure with recommended dose of fertilizers produced the highest curd yield of broccoli. Application of only poultry manure and cowdung caused yield depression even at higher doses. The highest curd yield of 20.70 t ha^{-1} and 16.75 t ha^{-1} were obtained with poultry manure and cowdung against 9.0 t ha^{-1} in the control treatment. In absence of NPK, only organic manure could not produce higher yield of curd.

Aditya (1993) conducted an experiment to investigate the effect of cowdung and inorganic fertilizer on growth and yield of cabbage (var. Atlas-70). He reported that the highest yield (60 t ha^{-1}) was obtained by the application of N @375 kg ha^{-1}, P @ 225 kg ha^{-1} and K @ 225 kg ha^{-1} along with cowdung @ 10 t ha^{-1}.

Kropisz (1992) carried out an experiment using composted pine bark (CPB) + vegetable matter, composted sawdust (CS) + vegetable matter (added to CPB and CS at 10, 20 or 30% by volume) and FYM were applied at 25 t ha^{-1} in 3-year field trials with cabbage, onion and carrot. All the organic fertilizers were applied in the first year only. NPK fertilizers were applied annually and there were plots where NPK alone was applied. Organic fertilizers in all cases improved cropping, with the highest

average yields being obtained on plots receiving FYM + NPK. These were 50.2 t ha^{-1}, 28.3 t ha^{-1} and 31.5 t ha^{-1} for cabbage, onions and carrots, respectively.

The effect of spacing and different fertilizer management practices on the growth and yield of cabbage were examined from 1987 to 1988 at farm laboratory of Horticultural Department of BAU, Mymensingh. The plants were spaced at 60 cm × 30 cm, 60 cm × 45 cm or 60 cm × 60 cm and subjected to 3 different fertilization schedules. Combined application of cowdung @ 8.3 t ha^{-1}, mustard oil cake @ 200 kg ha^{-1}, urea @ 326 kg ha^{-1}, TSP @ 125 kg ha^{-1} and MoP @ 200 kg ha^{-1} gave the highest marketable yield (86.50 t ha^{-1}) of cabbage (Farooque and Islam, 1989).

Subhan (1988) carried out an experiment on cabbage cv. Gloria Osena and applied15, 20, 25 or 30 t ha^{-1} of cattle manure, decomposed maize straw, or decomposed rice straw. He observed that application of organic manure increased head diameter at 60 days after planting and the average number of leaves $plant^{-1}$ and reduced the number of days to crop maturity. Application of cattle manure @ 25 -30 t ha^{-1} gave the largest cabbage and the highest yield $plot^{-1}$.

2.2 Effect of vermicompost on growth and yield of cabbage and other vegetable crops

A field experiment was conducted from June 2011 to March 2012 in Ethiopia to investigate the influence of vermicompost on cabbage growth. There were five treatments i.e. vermicompost @ 25 g $plant^{-1}$, vermicompost @ 50 g $plant^{-1}$, vermicompost @ 100 g $plant^{-1}$, vermicompost @ 200 g $plant^{-1}$ and control (no vermicompost). Totally 40 plants were used including control group in which 10 plants

were selected randomly. The highest leaf length (21.9 cm), leaf width (18.1 cm), plant height (34.9 cm) and maximum number of leafs plant^{-1} (35.6) and plant root (17.39 cm) was recorded at 200 g of vermicompost plant^{-1} compare to control (Getnet and Raja, 2013).

A field experiment was conducted in the garden of life Sciences Department, Manipur University Campus during three consecutive crop seasons (2006-2007, 2007-2008, 2008-2009) to study the efficacy of vermicompost on the yield of cabbage (*Brassica oleracea* var. *capitata*) cv. Pride of India. There were six treatments (T_1 : control i.e. without fertilizer, T_2 : NPK @ 140 : 140 : 140 kg ha^{-1} , T_3 : NPK @ 105 : 105 : 105 kg ha^{-1} + vermicopmost @ 1 t ha^{-1}, T_4: NPK @ 70 : 70 : 70 kg ha^{-1} + vermicompost @ 2 t ha^{-1}, T_5 : NPK @ 35 : 35 : 35 kg ha^{-1} + vermicompost @ 3 t ha^{-1}, T_6 : vermicompost @ 4 t ha^{-1}) each replicated four times. The maximum plant height was recorded in T_4 (28.65 cm) in 2nd and 3rd years with a significant increase of 35.95 % over control (21.08 cm). The maximum yield was recorded in T_4 (91.92 t ha^{-1}) in 2nd and 3rd years and the minimum yield was recorded in T_1 (41.21 t ha^{-1}). The yield also showed a significant increase of 58.67 % over control (Devi and Singh, 2012).

Ghuge *et al.* (2007) conducted a field experiment during 2002-03 in Parbhani, Maharashtra, India to assess the effect of combined use of organic and inorganic nutrients sources on the growth and yield of cabbage. The experiment was consisted of 10 treatments. Among the treatments 50 % recommend doses of fertilizer + 50 % vermicompost i.e. treatment T_2 gave the maximum plant spread (30.21 cm) and head weight (3.0 kg head^{-1}).

Bahadur *et al.* (2004) carried out an experiment during 2001-2002 and 2002-2003 at Varanasi, Uttar Pradesh, India to evaluate the effect of organic and biofertilizers on the growth and yield of cabbage. There were 13 treatments consisting of 4 organic manures (farmyard manure, pressmud, digested sludge and vermicompost) in combination with 3 biofertilizer (Azospirillum, Vesicular arbuscular mycorrhiza (VAM) and phosphate sulubilizing microorganisms (PSM) plus the control (recommended NPK only). All treatment received the recommended dose of NPK (120, 60, 80 kg ha^{-1}). Pressmud + VAM recorded the highest values for all the parameters studied.

Chaudhary *et al.* (2003) conducted a field experiment in Orissa, India starting from 1999 to investigate the use of vermicompost in cabbage cv. S-22 and tomato cv. Golden Acre production. Vermicompost was prepared using Gliricidia leaves and *Eisenia fetida* and was applied at 100 and 200 g /plant with or without farmyard manure (FYM), at 250 and 500 $plant^{-1}$. The treatment received VC at 200 g $plant^{-1}$ + FYM at 250 $plant^{-1}$ was the best for obtaining sustainable yields in both crops.

An experiment was conducted by Siag and Yadav (2004) in Rajasthan, India, during 1999-2001 to study the effect of vermicompost (0, 1, 2 and 3 t ha^{-1}) and fertilizers (0, 50 and 100% recommended dose) on mungbean (*Vigna radiata*) yield. Significant increase in seed yield was observed by the application of vermicompost up to 2 t ha^{-1} owing to increased secondary branches $plant^{-1}$, pods $plant^{-1}$. Increased in secondary branches and nodules $plant^{-1}$ resulted in improved yield attributes and seed yield over the control. Application of vermicompost (2 t ha^{-1}) along with 50 % recommended dose of fertilizers (N @ 10 kg ha^{-1} and P @ 8.7 kg ha^{-1}) was found to be the optimum dose for mugbean grown on sandy-loam soil.

Rajkhowa *et al.* (2003) investigated the effect of vermicompost alone or in combination with fertilizers on the performance of mungbean in the summer season of 2002 on the sandy loam soil of Jorhat, Assam, India. The treatment included: a control, 100 % fertilizers (N @ 15 kg ha^{-1}+ P @ 35 kg ha^{-1}), 100% CFs + VC @ 2.5 t ha^{-1}, 75 % fertilizer + VC, 50% fertilizer + VC, VC alone. They observed that combination of vermicompost with fertilizers (50 % fertilizers + VC) resulted in the highest numbers of nodules $plant^{-1}$ (24.33).

Jahan *et al.* (2014) carried out an experiment on the experiment field of soil science division, Bangladesh Agricultural Research Institute, Gazipur, Bangladesh during the period from 2008 to March 2009 to study the effect of vermicompost and conventional compost on the growth and yield of of cauliflower. The experiment comprised of twelve treatments viz. T_1: 100 % recommended dose of chemical fertilizer (RDCF = N @ 250, P @ 35, K@ 65, S@ 40, Zn @ 5 and B@ 1 kg ha^{-1}), 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} and T_{12}: Control (No fertilization) following Randomized Complete Block Design with three replications. Maximum plant height (49.4 cm), number of leaves $plant^{-1}$ (16.3), circumference of curd (46.5 cm), curd height (20.7 cm), total weight (1.60 kg $plant^{-1}$), marketable weight (1.30 kg $plant^{-1}$), curd yield (37.6 t ha^{-1}) and stover yield (29.7 t ha^{-1}) were found from T_4 which was statistically identical with or followed by T_8 and T_5. From the experiment it was found that vermicompost was better that conventional compost in combination with chemical fertilizers.

Sohrab and Sarwar (2001) conducted an experiment and found that incase of Lady's finger (okra), the vermicompost had played very effective role in all economic aspects of the vegetables crop. The yield of okra was 18.40 t ha^{-1} from the experimental plotstreated with vermicompost in one season. On the contrary, production of 12.43 t ha^{-1} was estimated on the basis of harvested crop from untreated plots.

2.3 Effect of *Trichoderma* compost on growth and yield of cabbage and other crops

Haque *et al.* (2012) conducted an experiment to evaluate the impact of trichoderma enriched biofertilizer on growth and yield of mustard (*Brassica rapa* L.) and tomato (*Solanum lycopersicon* Mill.). He worked with following treatments T_1 (control), T_2 (NPK fertilizers only), T_3 (BioF/compost), T_4 (BioF/pellets), T_5 (BioF/suspension), T_6 (50 % N + 50 % BioF/compost), T_7 (50 % N + 50 % BioF/pellets) and T_8 (50 % N + 50 % BioF/suspension). In his experiment he found biofertilizer plays a significant role in crop cultivation with reduced chemical fertilizer use. Three *Trichoderma* enriched bio-fertilizers were evaluated in mustard and tomato cultivation at field condition. Sole application of biofertilizers didn't show remarkable contribution but all *Trichoderma* enriched biofertilizers when supplemented with N fertilizer significantly boosted up the growth and yield of mustard and tomato. Application of 50 % N fertilizer along with 50 % *Trichoderma*-enriched biofertilizers augmented 108 and 203 % yields over control both in mustard and tomato, respectively which were 81.90 and 61.82 % in mustard and tomato at standard doses of nitrogen, phosphorus and potassium fertilizers. The present results suggest that *Trichoderma*-enriched biofertilizer could save at least 50% N fertilizer uses for mustard and tomato and could reduce excessive uses of NPK for crop cultivation.

In experiment of Adkins (2010), the overall plant growth of tomato (*Lycopersicon esculentum* L. cv. Glacier) cultivated in greenhouse conditions along with inoculation treatments of beneficial fungi species were observed. This study included 2 brand name products containing species of fungi which include: 1) *Botanicare Guardian TR* containing *Trichoderma harzianum* 10,000,000 CFU/g, *T. hamatum* 10,000,000 CFU/g, *T. koningii* 10,000,000 CFU/g; and 2) *Botanicare Guardian MY* containing *Glomus intraradices* 57 propagules/g; *G. fasiculatum* 57 propagules/g; *G. etunicatum* 57 propagules/g; *G. clarum* 57 propagules/g. Treatments include: 1) 2g *Botanicare Guardian TR*; 2) 2g *Botanicare Guardian MY*; 3) 1g *Botanicare Guardian TR* + 1g *Botanicare Guardian MY;* and 4) Control. The overall height increase was 55.04 %, 49.36 %, 44.42 % for treatments 3, 2, 1, respectively. The overall fresh weight increase was 50.47 %, 40.95 %, 33.55 % for treatments 3, 2, 1, respectively. The overall dry weight increase was 62.67 %, 53.23 %, 42.60 % for treatments 3, 2, 1, respectively.

Bal and Altintas (2006) carried out an experiment to observe seedling growing media (a peat and soil-based mixture or greenhouse soil with *Trichoderma harzianum*) at the time of sowing, at transplanting to vials and at planting. The factorial experiment using 2 seedling growing media, 2 cultivars and 4 dosages of *T. harzianum* at 0 (control), 4 g m^{-2}, 10 g $m^{-2}$and 24 g m^{-2} showed that the compost dosage had no significant effect on the yield or fruit quality. None of the 3 factor interactions between the criteria studied, that is, total yield, marketable yield, early yield, individual fruit weight, total soluble solids and titratable acidity were significant except for fruit diameter. The three factor combination resulted in the highest total yield, marketable yield and early yield with 1552, 1373 and 681 g $plant^{-1}$, respectively. The interaction between media and cultivars was significant for all the yield characteristics studied. However, the main effect of *T. harzianum* on early yield was the highest at 4 g, producing 527 g $plant^{-1}$ in comparison to the control with 374

g plant^{-1}. It was, therefore, hypothesised that the positive effect of *T. harzianum*, observed in the early yield, may be extended to the whole growing period by further applications, that is, by periodical renewal of the *T. harzianum* population at the root zone.

It is revealed from the above review of literature that different organic manures and inorganic fertilizers had significant effect on growth, development and yield of tomato as reported by different authors. But the work on yield performance of cabbage under different combination of manures and fertilizer is meager as in Bangladesh. So, the present study was undertaken.

Chapter III

MATERIALS AND METHODS

This chapter describes the materials and methods that were used in carrying out the field experiment. The details of the materials used and methods adopted in this experiment are presented in this chapter.

3.1 Experimental site

The field experiment was conducted at Hogladanga village under the Botiaghata upazila of Khulna District. The experiment was performed during the period from November, 2013 to March, 2014.

3.2 Climatic condition

The experimental area was under the sub-tropical climate which is characterized by heavy rainfall, high humidity, high temperature and relatively long day during the Kharif season (April to September) and scanty rainfall, associated with moderate low temperature and short day period during the Rabi season (October to March). Plenty of sunshine and moderately low temperature are suitable for growing cabbage, which prevails during Rabi season in Bangladesh. Details of the meteorological data for the period under study have been shown in Appendix III.

3.3 Characteristics of soil

The soil of experiment area was medium high in topography and clay loam to sandy loam in texture belonging to the Ganges Tidal Floodplain Tract under the Agro Ecological Zone-13 (FAO, 1988).

3.4 Materials used for the experiment

Cabbage cultivar Atlas 70 was collected from Shikdar Seed House, Gollamari, Khulna. Vermicompost was collected from Plant Breeding and Biotechnology laboratory under Agrotechnology discipline, Khulna University, Khulna. *Trichoderma* compost was collected from Grameen Krishok Sohayak Sangstha (GKSS), Gabtali, Bogra.

3.5 Raising of seedling

Cabbage seedlings were raised at Hogladanga village, Khulna under special care in one seedbed. The size of the seedbed was 5 m × 1 m. The soil of the seedbed was well ploughed and clods were broken into small pieces. All weeds, stubbles, dead roots of the previous crops were removed carefully. Twenty gram of seeds were sown in the seedbed on 20 October, 2013. After sowing, the seeds were covered with light soil. Within 9 days, seeds were completely germinated. Irrigation, weeding and mulching were done from time to time to provide a favorable condition for healthy growth. Seedlings were raised on seedbed until transplanting i.e. 25 days old.

3.6 Treatments of the experiment

The single factor experiment was consisted of seven treatments as follows :

T_1 = Recommended doses of NPK (urea 350 kg ha^{-1}, TSP 250 kg ha^{-1}, MoP 300 kg ha^{-1}, respectively)

T_2= Cowdung @10 t ha^{-1}

T_3= Vermicompost @ 10 t ha^{-1}

T_4=*Trichoderma* compost @10 t ha^{-1}

T_5= 50 % Cowdung + 50 % Recommended doses of fertilizer

T_6=50 % Vermicompost + 50 % Recommended doses of fertilizer

T_7=50 % *Trichoderma* compost + 50 % Recommended doses of fertilizer

3.7 Design and layout of the experiment

The single factor experiment was laid out in the Randomized Complete Block Design (RCBD) with three replications. The experimental area was divided into 3 blocks each containing 7 unit plots. In total, there were 21 unit plots. Seven treatments were randomly assigned to each unit plot as a result no repetition was occurred in a block. The unit plot was 2.4 m × 1.6 m in size with block to block distance 1 m and plot to plot distance 0.5 m. Thus each unit plot accommodated 16 plants.

3.8 Methods of cabbage cultivation

3.8.1 Land preparation

The selected land for the experiment was opened on 24 November, 2013 with a power tiller. The experimental field was then thoroughly prepared by ploughing and cross ploughing followed by laddering several times to provide a good tilth and favorable conditions for transplanting of cabbage seedlings. Weeds and stubbles were collected and large clods were broken into tiny pieces. The field was leveled and the experimental plots were laid out according to plan.

Plate 1. Showing over all view of the experimental plot.

3.8.2 Soil Test

Chemical analysis of soil sample was done after fertilization as well as after harvesting from SRDI, Daulatpur, Khulna. Here, pH , EC, organic matter, N, P, K, Cu and Zn content of soil was analysed (Appendix-I). Standard methods were used to chemical analysis of soil sample.

3.8.3 Application of manures and fertilizers

The experiment plots which were treated with recommended dose of NPK receiving 350 kg ha^{-1} urea, 250 kg ha^{-1} TSP and 300 kg ha^{-1} MoP. The recommended dose of NPK was followed according to the recommendation of Krishi Projukti Hat Boi, 2012. Cowdung, Vermicompost, *Trichoderma* compost, full amount of TSP, one third amount of urea and MoP were applied during final land preparation in the respective plots. The rest of the MoP and urea were applied in 2 equal installments at 20 and 40 days after transplanting. Each top dressing was followed by irrigation. The different dose of organic manures and synthetic fertilizers are shown in Table 1. Composition of different organic manures are presented in Appendix I.

Table 1. Used Doses of manures and fertilizers

SL. No.	Treatments	Name of fertilizers	Dose/ha
1	T_1	Urea TSP MoP	350 kg 250 kg 300 kg
2	T_2	Cowdung	10 ton
3	T_3	Vermicompost	10 ton
4	T_4	*Trichoderma* compost	10 ton
5	T_5	Cowdung Urea TSP MoP	5 ton 175 kg 125 kg 150 kg
6	T_6	Vermicompost Urea TSP MoP	5 ton 175 kg 125 kg 150 kg
7	T_7	*Trichoderma* compost	5 ton

		Urea TSP MoP	175 kg 125 kg 150 kg

3.8.4 Transplanting of seedlings

Twenty five days old healthy and uniform size seedlings were transplanted in the experimental plots on 6 December, 2013, maintaining a spacing of 60 cm × 40 cm accommodating 16 seedlings in each unit plot. Seedbed was watered in the morning before uprooting of the seedlings in the afternoon of the same day to avoid damage of the roots. The seedlings were uprooted carefully from the seedbed to ensure minimum injury to the root system. Transplanting was done in the afternoon and lightly watered with watering cane immediately after transplanting for better establishment. The young transplanted seedling were protected from scorching sunlight with the help of banana leaf sheath. At night they were kept open to allow them receiving dew. Shading and watering were continued for 4 days until the seedlings were established. A number of seedlings were planted in the border of experimental plot for gap filling.

Plate 2. Transplanting of cabbage seedlings in the main field and watered them immediately after transplanting.

3.8.5 Intercultural operations

3.8.5.1 Gap filling

The transplanted seedlings were lightly watered up to 4 days depending on the soil moisture condition. Plots with transplanted seedlings were regularly observed to find out any damage and dead seedlings for replacement. Gap filling was done by using the border plants that were kept for this purpose.

3.8.5.2 Weeding and pest management

Cutworm attack was the problem after transplanting the seedlings. After few days later, cabbage butterflies were seen in the field. Sinocord @ 1 ml litre^{-1} was sprayed to control the insect. The plots were kept weeds free by hand weeding whenever necessary. Parasitic leaves of the plants were removed while necessary.

Plate 3. Showing the cabbage field before weeding.

Plate 4. Showing the cabbage field after weeding.

3.8.5.3 Earthing up

Earthing up around the plants was done at 30, 45 and 60 days after transplanting by taking the soil from the surrounding plants by hand.

3.8.5.4 Irrigation

Water was applied by observing the soil moisture condition. After a certain period, furrow irrigation was used for supplying the sufficient moisture in the soil thus head formation uniformly occurred.

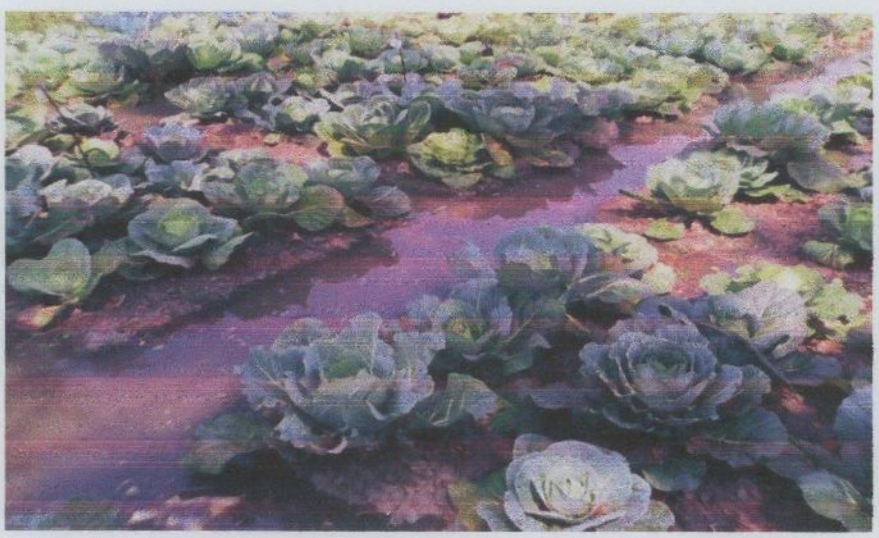

Plate 5. Showing the furrow irrigation in cabbage field.

3.9 Harvesting

The cabbage was harvested over a period from 3 March to 14 March, 2014. Harvesting was done plot wise at different dates after attaining maturity. Before harvesting, head compactness of the cabbage was tested by pressing with thumb. The compact mature head showed comparatively hard feelings. Personal judgment was involved to select mature head. After uprooting, weight of the whole plant was taken except roots for gross yield. Then loose leaves were removed and then weight of head was taken to determine the marketable yield.

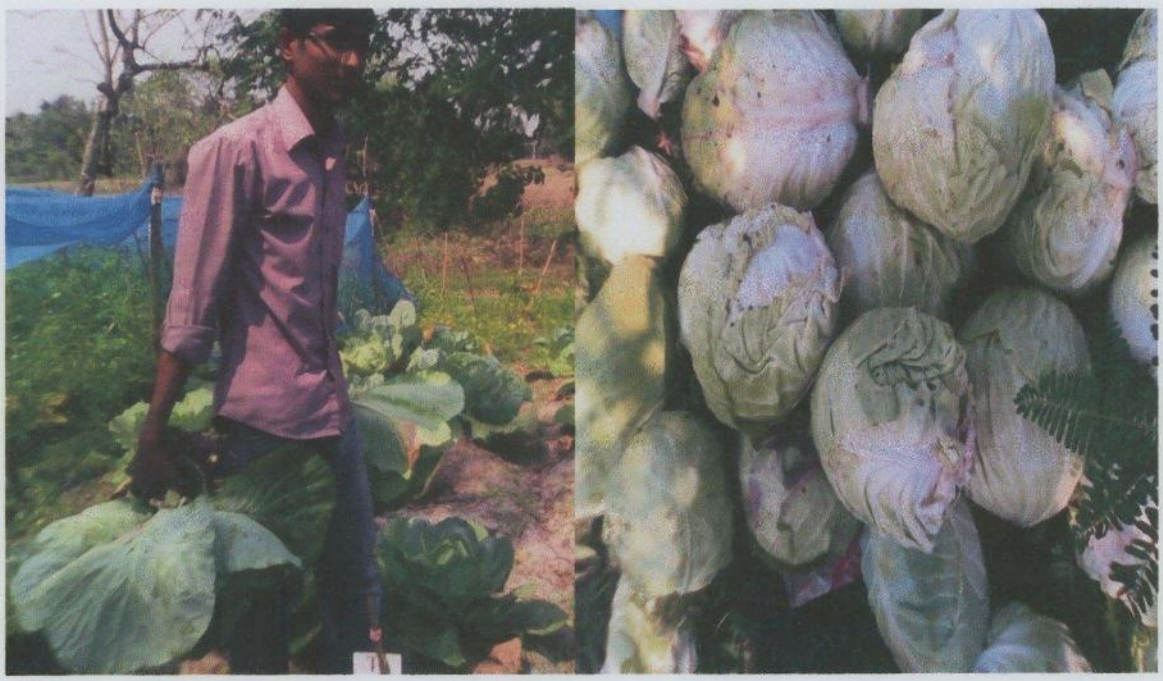

Plate 6. Harvesting of cabbage (on the left side) and harvested cabbage (on the right side) in the main field.

3.10 Methods of data collection

Ten plants were selected randomly from each unit plot for data collection. Data were recorded from sample plants during the period of the experiment. Data on the following parameters were recorded.

3.10.1 Plant height

The plant height was measured at 10, 20, 30, 40, 50, 60 and 70 days after transplanting (DAT) by using meter scale. The measurement was taken from the ground level to the tip of the largest leaf of an individual plant. Mean value of the ten selected plants was calculated for each unit plot and expressed in centimeter (cm).

3.10.2 Plant spread

The spread of the plant was measured with a meter scale as the surrounding area covered by the plant. The data were recorded from ten selected plants at 10, 20, 30, 40, 50, 60 and 70 DAT and mean value was calculated for each unit plot and expressed in centimeter (cm).

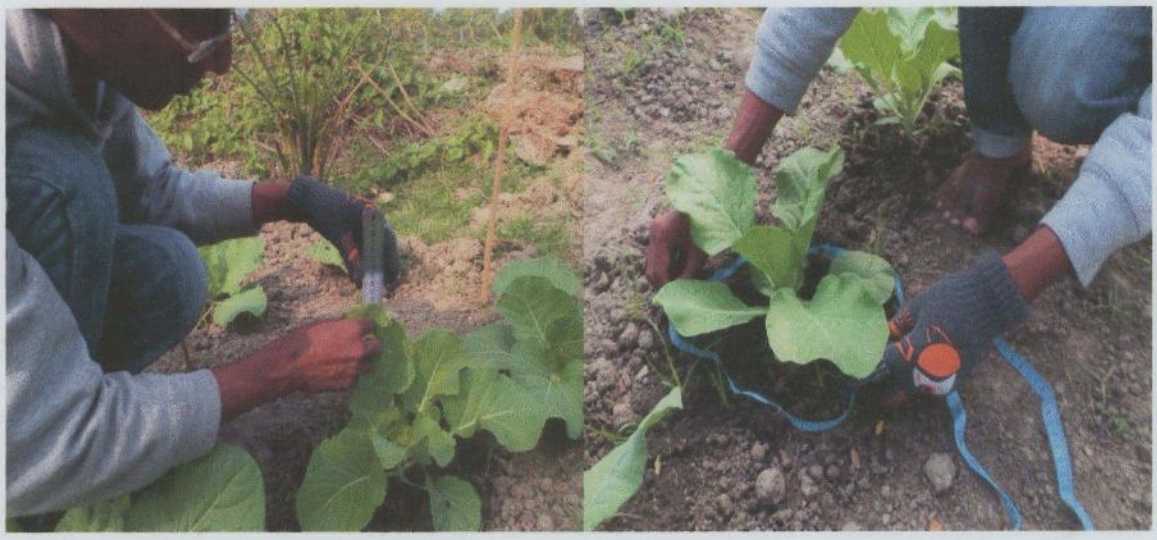

Plate 7. Showing the measurement of plant height (left side) and plant spread (right side).

3.10.3 Number of loose leaves plant^{-1}

The total number of loose leaves plant^{-1} was counted from 10 selected plants at 10, 20, 30, 40, 50, 60 and 70 DAT and mean value was recorded.

3.10.4 Length of the unfolded leaves

Length of the unfolded Leaves was measured at 10, 20, 30, 40, 50, 60 and 70 DAT by using a meter scale. The measurement was taken from base to tip of the leaf. Thus mean was recorded and expressed in centimeter (cm).

3.10.5 Breadth of the unfolded leaves

The breadth of the unfolded leaves was measured from 10 selected plants by a meter scale and mean of 10 plants was recorded at 10, 20, 30, 40, 50, 60 and 70 DAT and was expressed in centimeter (cm).

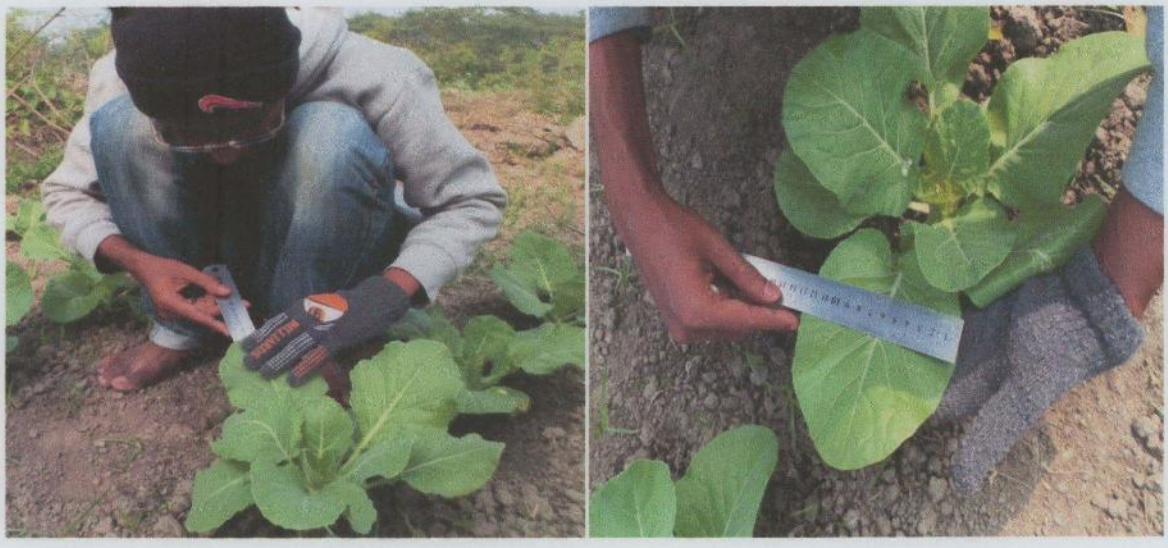

Plate 8. Showing the measurement of length of the unfolded leaves (left side) and breadth of the unfolded leaves (right side)

3.10.6 Days required for 80 % head formation

Days were counted from the date of transplanting to start of 80 % head formation i.e. 13 plants out of 16 plants plot^{-1} and mean value for a unit plot was recorded.

3.10.7 Days required for head maturity

Days required for harvesting was counted from the date of transplanting to that of attaining head maturity for selected sample plants and mean value for a unit plot was recorded.

3.10.8 Per-cent head formation of cabbage plot^{-1}

Development of head plot^{-1} was counted at harvest by the number of plants, which developed head and percent head formation plot^{-1} was calculated by using the following formula:

$$\% \text{ Head formation plot}^{-1} = \frac{\text{Number of head developed plant} \times 100}{\text{Total number of plants}}$$

3.10.9 Number of lateral roots

After harvest, the main roots of the ten sample plants were pulled out from the soil and the soil was washed out by water. Then the numbers of lateral roots of plants were counted and the mean value was recorded.

3.10.10 Length of stem

The length of stem at harvest was recorded in millimeter (mm) with a digital slide calipers as the distance from the ground level to the base of the unfolded leaves and mean value was recorded.

3.10.11 Diameter of stem

The diameter of stem at harvest was recorded in millimeter (mm) with a digital slide calipers from the average of ten plants.

3.10.12 Gross weight of cabbage plant^{-1}

Ten sample cabbage plants including the loose leaves were weighed and the mean gross weight plant^{-1} was computed and was expressed in kilogram (kg).

3.10.13 Weight of marketable head of cabbage plant^{-1}

The weight of the compact heads of all head developing plants of a plot was taken and that was taken in kilogram (kg) and mean value was calculated as the fresh weight of marketable head.

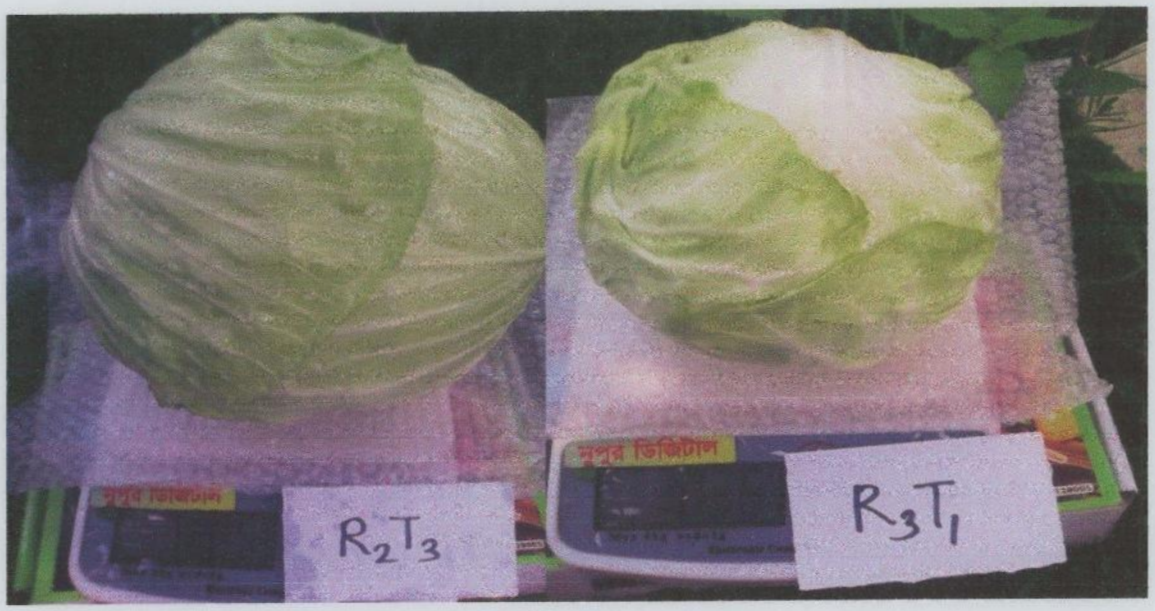

Plate 9. Showing the measurement of marketable cabbage.

3.10.14 Gross yield of cabbage plot^{-1}

The gross yield in kilogram (kg) plot^{-1} was converted into yield hectare^{-1} basis and was expressed in ton (t).

3.10.15 Marketable yield of cabbage plot^{-1}

The marketable yield in kilogram (kg) plot^{-1} was converted into yield hectare^{-1} basis and was expressed in ton (t).

3.10.16 Gross yield of cabbage hectare^{-1}

The gross yield in kilogram (kg) plot^{-1} was converted into yield per hectare basis and was expressed in ton (t).

3.10.17 Marketable yield hectare^{-1}

The marketable yield in kilogram (kg) plot^{-1} was converted into yield hectare^{-1} basis and was expressed in ton (t).

3.11 Benefit cost ratio of cabbage

To find out the BCR the following formula was used

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

3.12 Statistical analysis

Data were recorded from the sample plants during the course of experiment. Recorded data were analyzed statistically with the help of computer package program MSTAT-C and the mean differences were adjusted with Duncan's New Multiple Range Test (Gomez and Gomez, 1984).

day by day at different treatment combination.

4.2 Plant spread

Plant spread was significant up to 30 DAT. But after 30 DAT effects of different combinations of manures and fertilizers showed no significant variation (Appendix-2). It is reveal that the plant spread was the highest (181.27 cm) in treatment T_5 and the lowest plant spread (163.93 cm) was found in treatment T_4 at 70 DAT. But these are statistically non significant (Table 2). According to Islam (2011) the higher plant spread from vermicompost and *Trichoderma* compost with NPK fertilizer than single NPK. Plant spread increases due to progress of time. It is because vermicompost and recommended doses of fertilizers creates healthy and optimum condition in the soil. As a result, plant spread increased vigorously in the open air.

Table 2. Effect of different of organic manures, inorganic fertilizers and their combinations on plant height and plant spread at different days after transplanting

Treatments	Plant height (cm) at							Plant spread (cm) at						
	10 DAT	20 DAT	30 DAT	40 DAT	50 DAT	60 DAT	70 DAT	10 DAT	20 DAT	30 DAT	40 DAT	50 DAT	60 DAT	70 DAT
T_1	10.37 c	16.47ab	22.27 ab	27.93 ab	29.77 ab	32.70 b	34.37 ab	51.60 ab	75.47 ab	106.60 d	138.93	156.67	166.40	170.77
T_2	11.47 abc	16.40ab	21.63 b	27.60 ab	30.10 ab	32.13 b	34.53 ab	51.27 ab	74.50 ab	105.83 d	139.73	162.63	163.73	166.27
T_3	12.20 ab	18.50a	23.33 ab	30.07 a	32.73 a	33.53 ab	35.07 ab	48.33 b	74.03 b	112.13 cd	143.60	154.43	166.10	169.07
T_4	12.15 ab	16.00b	20.57 b	25.93 b	28.33 b	34.20 ab	33.67 b	50.87 ab	73.60 b	115.23 c	136.27	149.27	161.83	163.93
T_5	11.20 bc	15.87 b	23.70 ab	29.43 ab	31.71 ab	33.37 ab	35.30 ab	52.87 a	75.80 ab	122.50 b	144.47	158.60	170.23	173.50
T_6	12.70 a	18.77 a	25.17 a	31.27 a	33.27 a	36.97 a	37.07 a	52.40 a	78.67 a	133.17 a	150.73	169.57	178.07	181.27
T_7	11.45 abc	17.43ab	23.50 ab	29.23 ab	31.00 ab	33.43 ab	34.70 ab	48.13 b	72.77 b	108.07 d	143.30	155.37	164.90	166.47
Level of significance	**	**	**	**	**	**	**	*	*	**	ns	ns	ns	ns
CV (%)	4.36	5.73	5.52	5.06	5.23	4.70	3.58	4.13	5.46	3.07	6.85	7.32	6.31	5.96

T_1 = recommended doses of NPK (urea @ 350 kg ha^{-1}, TSP @ 250 kg ha^{-1}, MoP @ 300 kg ha^{-1})
T_2= cowdung @10 t ha^{-1}
T_3= vermicompost @ 10 t ha^{-1}
T_4= *Trichoderma* compost @10 t ha^{-1}
T_5= 50 % cowdung + 50 % recommended doses of fertilizer
T_6= 50 % vermicompost + 50 % recommended doses of fertilizer
T_7= 50 % *Trichoderma* compost + 50 % recommended doses of fertilizer

** Significant at 1 % level of probability
* Significant at 5 % level of probability
ns = non significant

4.3 Number of loose leaves plant^{-1}

In the present investigation it was found that different organic and inorganic fertilizers had significant effect on the number of loose leaves plant^{-1} (Appendix-IV). The highest numbers of loose leaves was obtained from treatment T_6 (50 % vermicompost + 50 % recommended doses of fertilizer) at different DAT. The highest number of loose leaves were 10.73, 13.20, 17.20, 18.00, 19.00 and 19.20 at 20, 30, 40, 50, 60 and 70 DAT, respectively. On the other hand, the lowest numbers of loose leaves varied with its different growth stages in different treatment combinations as well as in different times. At statistical point of view it is almost similar at the earlier stage of days after transplanting i.e. 10 DAT for all treatment combinations. After that, the lowest number of loose leaves was counted from T_7 treatment (50 % *Trichoderma* compost+ 50 % recommended doses of fertilizer) i.e. 15.80 at 70 DAT which was statistically almost similar with T_5 and T_7 treatment (Table 3). Organic manure mainly vermicompost creates good soil environment. It facilitated proper growth of cabbage plants. On the other hand, plant absorbed more sunlight and produced more food for plant growth, that's why the number of loose leaves plant^{-1} increased.

4.5 Length of the unfolded leaves

Different organic and inorganic fertilizers played a significant role on length of the unfolded leaves at different days after transplanting (Appendix-IV). The longest unfolded leaf (36.40 cm) was obtained from the treatment T_6. The shortest unfolded leaf was (32.33 cm) from the treatment T_1 which was statistically similar with treatments T_2, T_3, T_4 and T_7 (Table 3).

Table 3. Effect of different of organic manures, inorganic fertilizers and their combinations on loose leaves plant^{-1} and length of the unfolded leaves at different days after transplanting

Treatments	Number of loose leaves plant^{-1} at							Length of the unfolded leaves(cm) at						
	10 DAT	20 DAT	30 DAT	40 DAT	50 DAT	60 DAT	70 DAT	10 DAT	20 DAT	30 DAT	40 DAT	50 DAT	60 DAT	70 DAT
T_1	7.13	9.67 b	11.07 bc	14.50 cd	15.43 c	16.10 c	16.57b c	8.63 b	13.87 b	18.30 b	24.07 bc	25.93 d	27.50 d	32.33 b
T_2	7.33	9.73 b	12.10 ab	15.87 b	16.80 b	17.90 ab	16.87 bc	9.13 ab	14.13 b	18.43 b	24.70 bc	27.07 cd	28.07 cd	32.87 b
T_3	7.47	11.20 a	12.97 a	15.50 bc	16.97 b	18.60 a	18.00 ab	9.20 ab	15.30 ab	20.87 a	25.20abc	29.27 ab	30.63 ab	33.40 b
T_4	7.20	10.20 ab	10.93 c	14.13 d	15.17 cd	16.83 bc	15.80 c	9.47 ab	13.63 b	18.00 b	23.43 c	26.13 d	28.47 cd	32.37 b
T_5	6.77	10.63 ab	12.13 ab	14.30 d	14.90 cd	15.87 c	15.83c	8.97 ab	15.80 ab	21.57 a	26.17 ab	28.50 abc	29.80 bc	34.63 ab
T_6	7.13	10.73 ab	13.20 a	17.20 a	18.00 a	19.00 a	19.20a	9.80 a	16.47 a	21.37 a	27.50 a	29.83 a	32.33 a	36.40 a
T_7	6.67	9.47 b	11 bc	13.73 d	14.27 d	15.67 c	16.73b c	8.93 ab	14.40 ab	19.47 ab	26.40 ab	27.50 bcd	28.97 bcd	32.70 b
Level of significance	ns	*	**	**	**	**	**	*	**	*	**	**	**	*
CV (%)	7.04	7.31	5.18	4.17	3.81	4.24	4.91	5.37	5.93	6.18	4.95	4.18	3.46	4.95

T_1 = recommended doses of NPK (urea @ 350 kg ha^{-1}, TSP @ 250 kg ha^{-1}, MoP @ 300 kg ha^{-1})
T_2= cowdung @10 t ha^{-1}
T_3= vermicompost @ 10 t ha^{-1}
T_4= *Trichoderma* compost @10 t ha^{-1}
T_5= 50 % cowdung + 50 % recommended doses of fertilizer
T_6= 50 % vermicompost + 50 % recommended doses of fertilizer
T_7= 50 % *Trichoderma* compost + 50 % recommended doses of fertilizer

** Significant at 1 % level of probability
* Significant at 5 % level of probability
ns = non significant

Islam (2011) was also obtained the similar type of result i.e. the longest unfolded leaf of cabbage (41.69 cm) with a combined treatment i.e. cowdung @ 5 t ha^{-1}, vermicompost @ 5 t ha^{-1}, *Trichoderma* compost @ 5 t ha^{-1} and the recommended doses of N,P,K and i.e. 131, 29 and 109 kg ha^{-1}, respectively. On the other hand, the shortest unfolded leaf was 34.63 cm from treatment T_1 (control i.e. recommended dose of NPK where N @131 kg ha^{-1}, P@ 29 kg ha^{-1} and K@ 109 kg ha^{-1}). Organic manure mainly vermicompost and inorganic fertilizer combinedly create good soil environment that supplied adequate plant nutrients for proper vegetative growth of cabbage plants, which ultimately influenced the unfolded healthy larger type leaves.

4.6 Breadth of the unfolded leaves

Breadth of the unfolded leaves was also influenced significantly due to the effect of different organic and inorganic fertilizers (Appendix-IV). It increased with the advancement of time and reached the highest at 70 days after transplanting. The maximum breadth of the unfolded leaves (29.13 cm) was obtained from the treatment T_6 , on the other hand, the lowest (23.17 cm) was found in the treatment T_1 which was statistically similar with treatments of T_2, T_4, T_5 and T_7 (Table 4). Islam (2011) was also found the similar type of result in his research work. The highest breadth of the unfolded leaf of cabbage (30.20 cm) with a combined treatment T_5 i.e. cowdung @ 5 t ha^{-1}, vermicompost @ 5 t ha^{-1}, *Trichoderma* compost @ 5 t ha^{-1} and the recommended doses of N,P,K and i.e. 131, 29 and 109 kg ha^{-1}, respectively. On the contrary, the lowest breadth of the unfolded leaves (25.75 cm) was from treatment T_1 (control i.e. recommended dose of NPK where N @ 131 kg ha^{-1}, P @ 29 kg ha^{-1} and K@ 109 kg ha^{-1}) which was statistically similar to T_2 (cowdung @ 15 tha^{-1}). Organic manure mainly vermicompost creates good soil environment and inorganic fertilizer influence the plant

growth. As a result, combination of organic and inorganic fertilizers probably supplied adequate plant nutrients and showed the highest performance.

Table 4. Breadth of the unfolded leaves of cabbage at different days after transplanting

Treatments	Breadth of the unfolded leaves (cm) at						
	10 DAT	20 DAT	30 DAT	40 DAT	50 DAT	60 DAT	70 DAT
T_1	5.89	9.40 c	14.00 bc	17.20 cd	19.43 c	22.33 b	23.17 b
T_2	6.06	9.42 c	14.70 ab	17.17 cd	20.27 bc	23.43 b	25.17 b
T_3	6.14	10.27 b	15.77 a	21.10 a	21.10 bc	26.07 a	27.63 a
T_4	6.34	10.33 b	15.80 a	17.57 cd	19.80 bc	22.83 b	24.90 b
T_5	6.23	10.53 b	13.00 c	16.97 d	21.50 b	23.73 b	24.83 b
T_6	6.21	11.27 a	15.23 ab	19.63 b	24.03 a	27.37 a	29.13 a
T_7	5.91	9.22 c	14.03 bc	18.50 bc	21.20 bc	22.90 b	24.27 b
Level of significance	ns	**	**	**	**	*	*
CV (%)	5.86	3.90	5.62	4.06	4.55	4.43	4.42

T_1 = Recommended doses of NPK (urea @ 350 kg ha^{-1}, TSP @ 250 kg ha^{-1}, MoP @ 300 kg ha^{-1})

T_2= Cowdung @10 t ha^{-1}

T_3= Vermicompost @ 10 t ha^{-1}

T_4= *Trichoderma* compost @10 t ha^{-1}

T_5= 50 % Cowdung + 50 % Recommended doses of fertilizer

T_6= 50 % Vermicompost + 50 % Recommended doses of fertilizer

T_7= 50 % *Trichoderma* compost + 50 % Recommended doses of fertilizer

** Significant at 1 % level of probability

* Significant at 5 % level of probability

ns = non significant

4.7 Days required for 80 % head formation

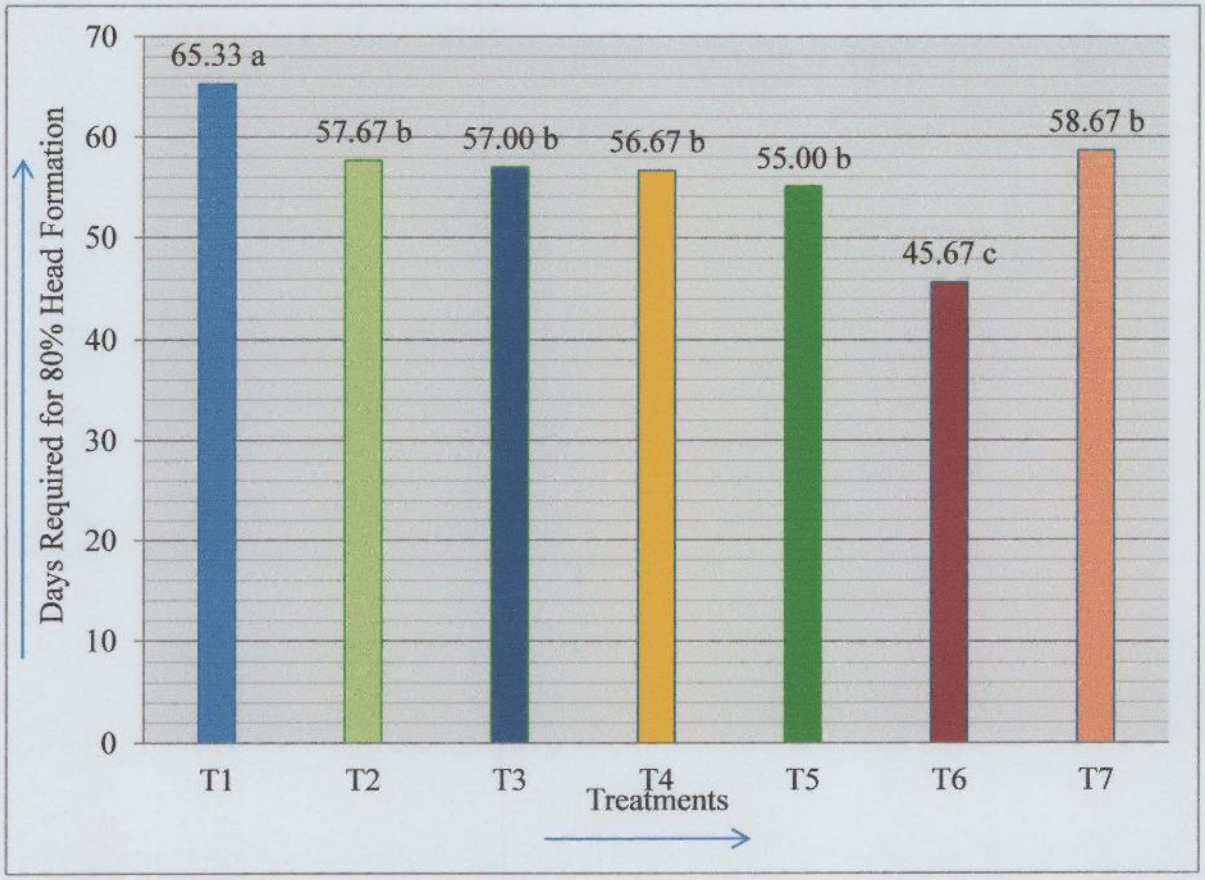

Fig. 1. Days required for 80 % head formation influenced by cowdung, vermicompost, *Trichoderma* compost and NPK fertilizers

T_1 = Recommended doses of NPK (Urea @ 350 kg ha^{-1}, TSP @ 250 kg ha^{-1}, MoP @ 300 kg ha^{-1})

T_2= Cowdung @10 t ha^{-1}

T_3= Vermicompost @ 10 t ha^{-1}

T_4= *Trichoderma* compost @10 t ha^{-1}

T_5= 50 % Cowdung + 50 % Recommended doses of fertilizer

T_6= 50 % Vermicompost + 50 % Recommended doses of fertilizer

T_7= 50 % *Trichoderma* compost + 50 % Recommended doses of fertilizer

The use of different organic and inorganic fertilizers showed significant influence on days required for 80 % head formation (Appendix-IV). The plants with treatment T_6 required shortest possible time (45.67 DAT). Whereas the treatment T_1 applied plants required the longest time (65.33 DAT) for 80 % head formation (Fig. 1) which is statistically

significant at 1 % level. It appears that different combination of organic and inorganic fertilizers showed better performance. It might be due to the fact that combination of organic and inorganic fertilizers probably supplied adequate plant nutrients due to higher microbial activities in the soil resulting in earlier head formation. Islam (2011) observed the similar type of findings. In his observation, treatment T_1 (control i.e. recommended dose of NPK where N @ 131 kg ha^{-1}, P @ 29 kg ha^{-1} and K @ 109 kg ha^{-1}) required the longest time (59.66 days) for 80 % head formation. T_6 treatment carries the less number days (more earlier) required for 80% head formation due to the better soil condition. It is possible because of the combination of vermicompost and the synthethic fertilizer makes soil more friendly for the formation of cabbage head.

4.8 Days required for head maturity

The use of different organic and inorganic fertilizers exhibited significant difference in respect of time required for maturity of head (Appendix-IV). The cabbage grown with the treatment T_6 (50 % vermicompost + 50 % recommended doses of fertilizer) matured earlier (78.33 D A T). The delayed head maturity (96 DAT) was found from cabbage, grown in the treatment T_1 (urea @ 350 kg ha^{-1}, TSP @ 250 kg ha^{-1}, and MoP @ 300 kg ha^{-1}) which was statistically significant. It was found that the cabbage grown in the treatment T_6 (50 % vermicompost + 50 % recommended doses of fertilizer) matured 17.67 days earlier than treatment T_1 (Urea @ 350 kg ha^{-1}, TSP @ 250 kg ha^{-1}, and MoP @ 300 kg ha^{-1}) (Fig.1).

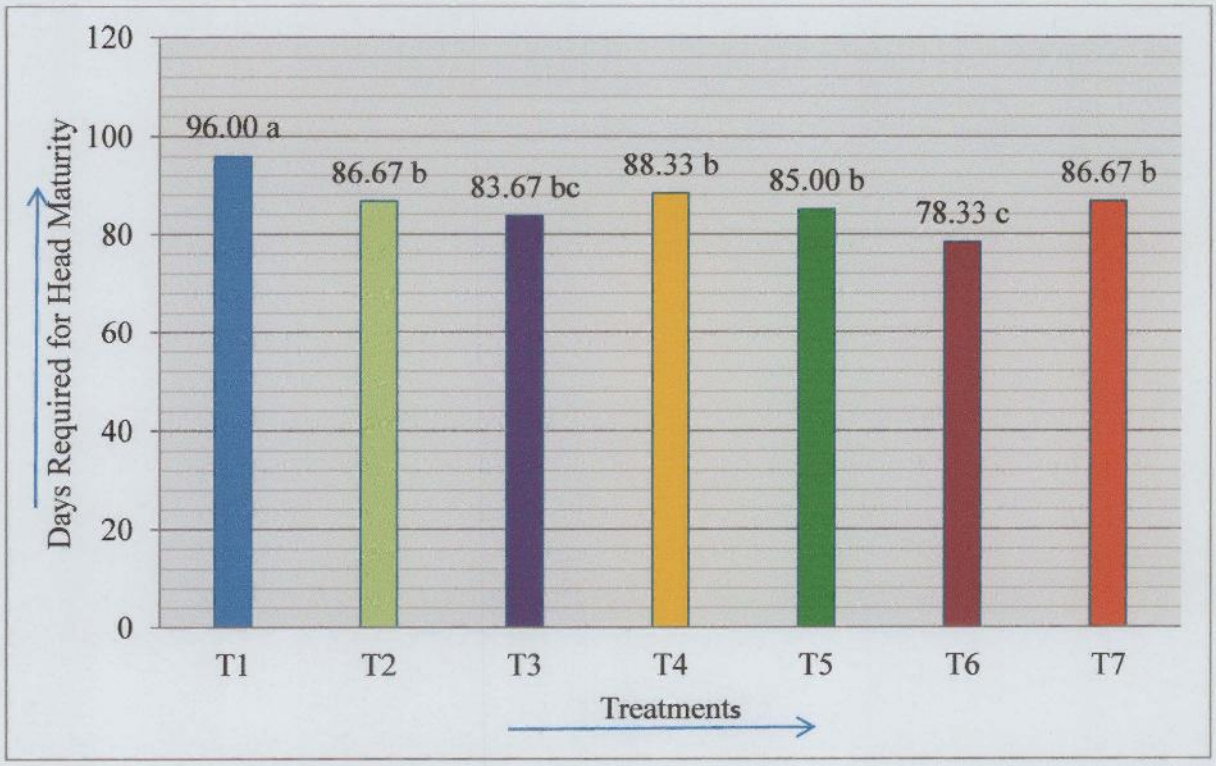

Fig. 2. Days required for head maturity influenced by cowdung, vermicompost, *Trichoderma* compost and NPK fertilizers

T_1 = Recommended doses of NPK (Urea @ 350 kg ha^{-1}, TSP @ 250 kg ha^{-1}, MoP @ 300 kg ha^{-1})

T_2= Cowdung @10 t ha^{-1}

T_3= Vermicompost @ 10 t ha^{-1}

T_4= *Trichoderma* compost @10 t ha^{-1}

T_5= 50 % Cowdung + 50 % Recommended doses of fertilizer

T_6= 50 % Vermicompost + 50 % Recommended doses of fertilizer

T_7= 50 % *Trichoderma* compost + 50 % Recommended doses of fertilizer

These findings are in agreement with the observation of Subhan (1988), reported that application of manure reduced the number of days for cabbage head maturity. Islam (2011) also reported that, delay head maturity was found in control treatment that is 90.33 days (DAT) and the earlier maturity 78.33 days. Organic manure mainly vermicompost creates good soil environment and inorganic fertilizer influence the plant growth. As a result, combination of organic and inorganic fertilizers probably supplied adequate plant nutrients and showed the earlier head maturity.

4.9 Per-cent head formation of cabbage plot^{-1}

It was found that there was significant variation among the treatments in respect of percent head formation plot^{-1} due to different organic and inorganic fertilizers (Appendix-IV). The highest percentage of head formation (93.75 %) was found in treatment T_6 and the lowest (81.25 %) was found in the treatment T_4 which was statistically significant (Fig. 3).

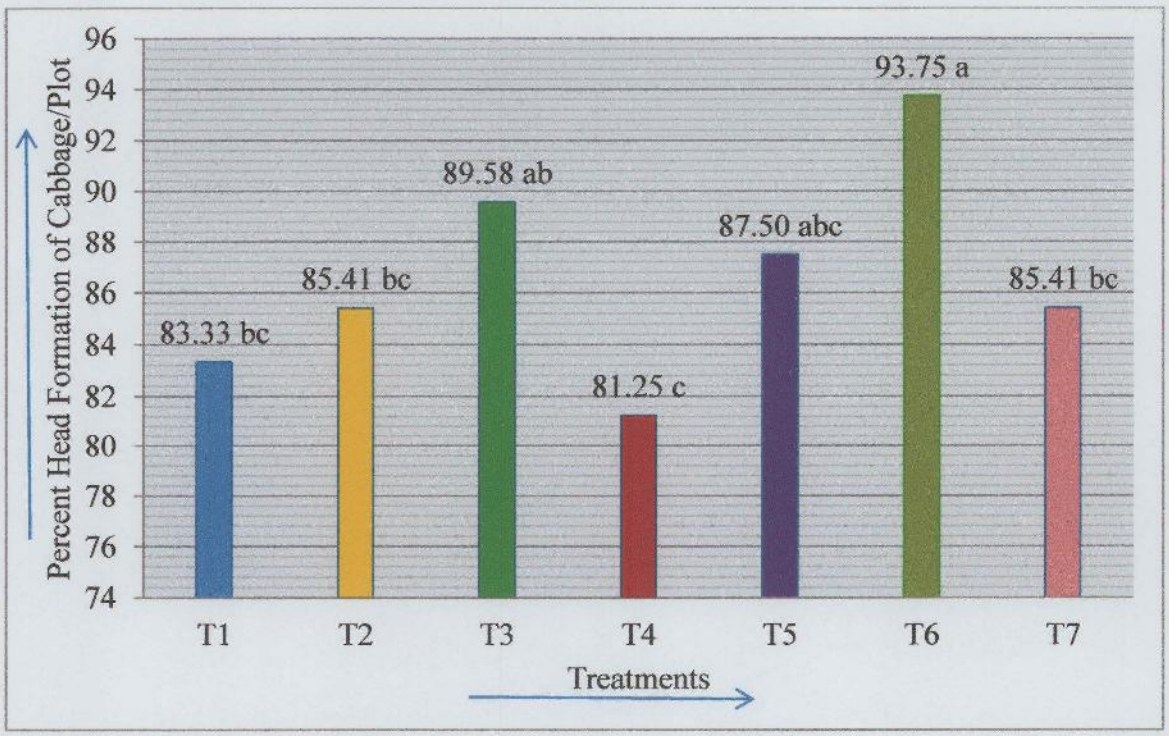

Fig. 3. Per-cent head formation of cabbage plot^{-1} as influenced by cowdung, vermicompost, *Trichoderma* compost and NPK fertilizers

T_1 = Recommended doses of NPK (Urea @ 350 kg ha^{-1}, TSP @ 250 kg ha^{-}1, MoP @ 300 kg ha^{-1})

T_2= Cowdung @10 t ha^{-1}

T_3= Vermicompost @ 10 t ha^{-1}

T_4= *Trichoderma* compost @10 t ha^{-1}

T_5= 50 % Cowdung + 50 % Recommended doses of fertilizer

T_6=50 % Vermicompost + 50 % Recommended doses of fertilizer

T_7=50 % *Trichoderma* compost + 50 % Recommended doses of fertilizer

It was found that different combinations of organic and inorganic fertilizers combinedly supplied adequate available plant nutrients and provide better growing conditions which helps to form head. Islam (2011) also found almost similar types of results that the highest percentage of head formation (94 %) was appeared with a combined treatment of vermicompost and recommended doses of fertilizer.

4.10 Number of lateral roots plant^{-1}

Different organic and inorganic fertilizers caused significant variation in relation to number of lateral roots plant^{-1} (Appendix-IV). The highest number of lateral roots plant^{-1} (26.20) was recorded from the treatment T_6 followed by T_5, T_3, T_7, T_4, T_1 and the lowest number of lateral roots (22.30) was obtained from the treatment T_2 which was statistically significant (Table 4). From the above results, it was noted that combined use of vermicompost and synthetic fertilizers provided proper aeration, increased microbial activities as a result plant nutrients became available for better growth and development of roots which ultimately increased the number of lateral roots.

4.11 Length of stem

There was significant variation in relation to the length of stem among the treatments due to different organic and inorganic fertilizers (Appendix-IV). The longest stem of cabbage (50.57 mm) was recorded from the treatment T_6 followed by T_3, T_7, T_4, T_2, T_5 and the shortest stem (43.74 mm) was obtained from the treatment T_1 which was statistically significant (Table 5). Islam (2011) also support the result of the present findings i.e. the shortest stem (5.85 cm) of cabbage was found from T_1 (control i.e. recommended dose of NPK where N @ 131 kg ha^{-1}, P @ 29 kg ha^{-1} and K @109 kg ha^{-1}) and the longest stem (6.86 cm) was recorded from the treatment T_5 (cowdung @ 5 t ha^{-1}, vermicompost @ 5 t ha^{-1}, *Trichoderma* compost @ 5 t ha^{-1} and the recommended doses

of N, P, K and i.e. 131, 29 and 109 kg ha^{-1}, respectively). Combined used of vermicompost and synthetic fertilizers help a healthy soil environment that not only improve the proper soil aeration but also increase microbial activities as a result plant nutrients became available for better growth of stem length.

4.12 Diameter of stem

Different organic and inorganic fertilizers significantly influenced in stem diameter of cabbage (Appendix-IV). The maximum stem diameter (23.45 mm) was recorded from the treatment T_6 followed by T_5, T_3, T_7, T_2, T_4 and the lowest diameter of stem (19.94 mm) was obtained from the treatment T_1 which was statistically significant (Table 5). Organic manure mainly vermicompost creates good soil environment and inorganic fertilizer influence the plant growth. As a result, combination of organic and inorganic fertilizers probably supplied adequate plant nutrients and showed the healthy large stem as well as its diameter.

Table 5. Effect of different of organic manures, inorganic fertilizers and their combinations on lateral roots plant^{-1}, length of stem and diameter of stem at harvest and benefit cost ratio.

Treatments	Number of lateral roots plant^{-1}	Length of stem (mm)	Diameter of stem (mm)	Benefit cost ratio
T_1	22.50 c	43.74 d	19.94 b	3.21 b
T_2	22.30 c	46.05 c	20.37 ab	3.38 a
T_3	24.23 b	47.80 b	21.77 ab	1.49 e
T_4	24.17 b	46.31 c	20.12 b	1.10 f
T_5	24.63 b	47.14 bc	21.86 ab	2.49 c
T_6	26.20 a	50.57 a	23.45 a	3.63 a
T_7	24.30 b	46.88 bc	20.52 ab	1.82 d
Level of significance	*	**	**	**
CV (%)	3.68	4.63	3.49	7.80

T_1 = recommended doses of NPK (urea @ 350 kg ha^{-1}, TSP @ 250 kg ha^{-1}, MoP @ 300 kg ha^{-1})
T_2= cowdung @10 t ha^{-1}
T_3= vermicompost @ 10 t ha^{-1}
T_4= *Trichoderma* compost @10 t ha^{-1}
T_5= 50 % cowdung + 50 % recommended doses of fertilizer
T_6= 50 % vermicompost + 50 % recommended doses of fertilizer
T_7= 50 % *Trichoderma* compost + 50 % recommended doses of fertilizer

** Significant at 1 % level of probability
* Significant at 5 % level of probability
ns = non significant

4.13 Gross weight of cabbage plant^{-1}

Different organic and inorganic fertilizers significantly influenced the gross weight of cabbage plant^{-1} (Appendix-IV). The maximum gross weight of cabbage plant^{-1} (2.81 kg) was obtained from the treatment T_6 followed by T_5, T_3, T_7, T_2, T_4 and the lowest gross weight of cabbage plant^{-1} (2.35 kg) was obtained from the treatment T_1. The second lowest gross weight of cabbage plant^{-1} (2.49 kg) was obtained from the treatment T_4. Data relating to gross weight of cabbage plant^{-1} and the marketable weight of head was recorded at harvest (Fig. 4).

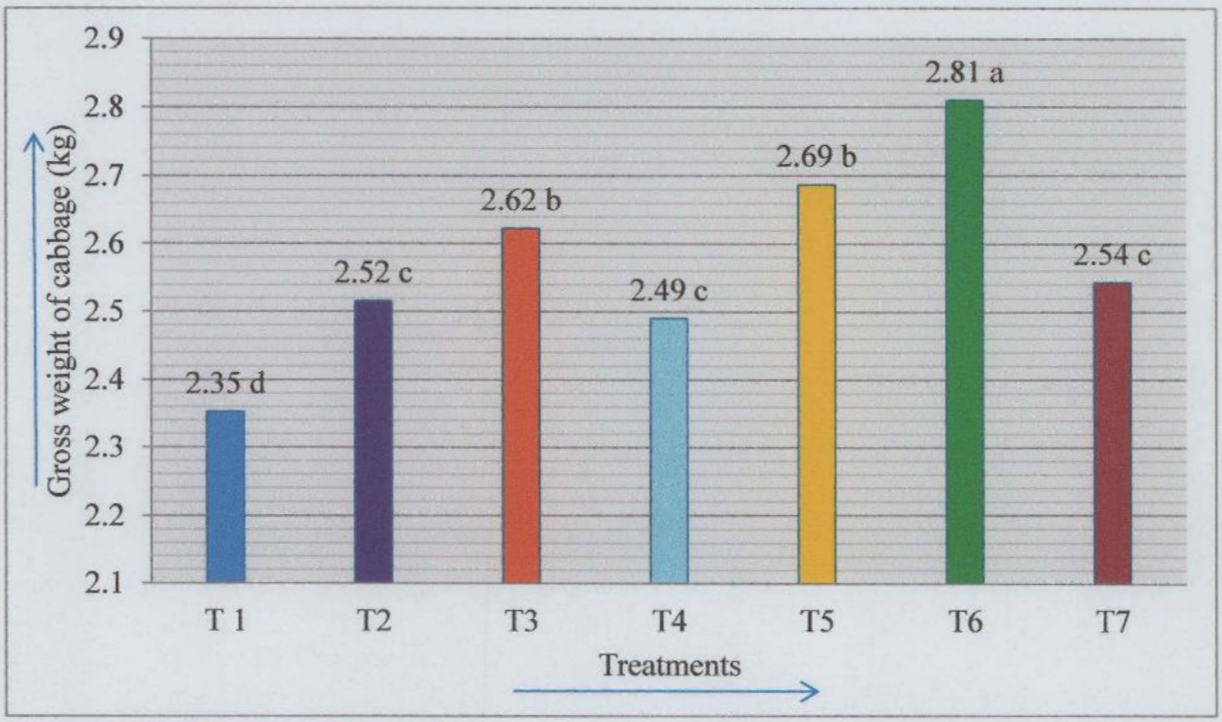

Fig. 4. Gross weight of cabbage plant^{-1} as influenced by cowdung, vermicompost, *Trichoderma* compost , NPK fertilizers and their combinations

T_1 = Recommended doses of NPK (Urea @ 350 kg ha^{-1}, TSP @ 250 kg ha^{-1}, MoP @ 300 kg ha^{-1})

T_2= Cowdung @10 t ha^{-1}

T_3= Vermicompost @ 10 t ha^{-1}

T_4= *Trichoderma* compost @10 t ha^{-1}

T_5= 50 % Cowdung + 50 % Recommended doses of fertilizer

T_6= 50 % Vermicompost + 50 % Recommended doses of fertilizer

T_7= 50 % *Trichoderma* compost + 50 % Recommended doses of fertilizer

Islam (2011) reported that the average highest gross weight of cabbage plant^{-1} being obtained from the applied with cowdung @ 5 t ha^{-1}, vermicompost @ 5 t ha^{-1}, *Trichoderma* compost @ 5 t ha^{-1} and the recommended doses of N, P, K and i.e. 131, 29 and 109 kg ha^{-1}, respectively. Organic manure mainly vermicompost and inorganic fertilizer combinedly create good soil environment that supplied adequate plant nutrients for proper vegetative growth of cabbage plants, which ultimately influenced the unfolded healthy larger type leaves.

4.14 Weight of marketable head of cabbage

Weight of marketable head of cabbage varied significantly among the treatments due to different organic and inorganic fertilizers (Appendix-IV). Considering the weight of marketable head, it was evident that the treatment T_6 produced the highest individual marketable cabbage head (1.46 kg) followed by T_5, T_3, T_7, T_2, T_4 and the lowest weight of marketable head (1.14 kg) was obtained from the treatment T_4 which was statistically significant. The second lowest weight of marketable head (1.18 kg) was recorded in the treatment T_1 (Fig. 5). The result showed that organic and inorganic fertilizers performed better when used combinedly than the inorganic fertilizer alone. In case of head formation of cabbage combined effect of organic and inorganic fertilizers influenced very much. Because it creates a healthy environment within the soil and it facilitates proper growth of the plant and finally those plant produce good head.

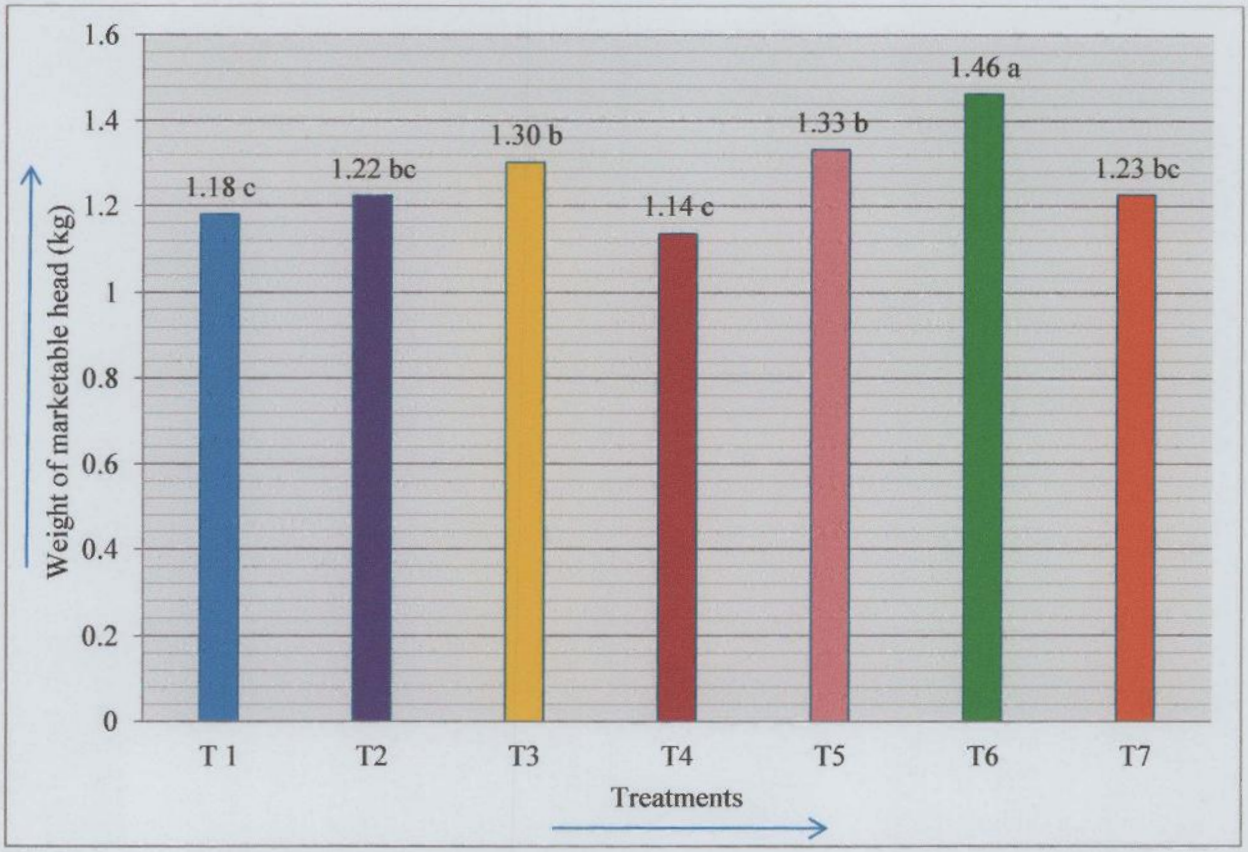

Fig. 5. Weight of marketable head of cabbage as influenced by cowdung, vermicompost, *Trichoderma* compost, NPK fertilizers and their combinations

T_1 = Recommended doses of NPK (Urea @ 350 kg ha^{-1}, TSP @ 250 kg ha^{-1}, MoP @ 300 kg ha^{-1})

T_2= Cowdung @10 t ha^{-1}

T_3= Vermicompost @ 10 t ha^{-1}

T_4= *Trichoderma* compost @10 t ha^{-1}

T_5= 50 % Cowdung + 50 % Recommended doses of fertilizer

T_6= 50 % Vermicompost + 50 % Recommended doses of fertilizer

T_7= 50 % *Trichoderma* compost + 50 % Recommended doses of fertilizer

4.15 Gross yield of cabbage $plot^{-1}$

The gross yield of cabbage $plot^{-1}$ was significantly influenced due to the application of different organic and inorganic fertilizers (Appendix-IV). The highest gross yield of cabbage (42.15 kg) $plot^{-1}$ was obtained from the treatment T_6 followed by T_3, T_5, T_7, T_2, T_4 and the lowest yield (31.38 kg) $plot^{-1}$ was obtained from the treatment T_1 (Fig. 6) which was statistically significant. It might be due to the fact that in addition to

supply of plant nutrients, organic manures kept the soil cool, loose and friable that conserved more soil moisture and maintained proper aeration for better root growth. On the other hand, inorganic fertilizers supplied sufficient plant nutrients readily for vigorous vegetative growth. Therefore, the combination of 50 % vermicompost + 50 % recommended doses of NPK fertilizer produced the highest gross yield of cabbage plot^{-1}.

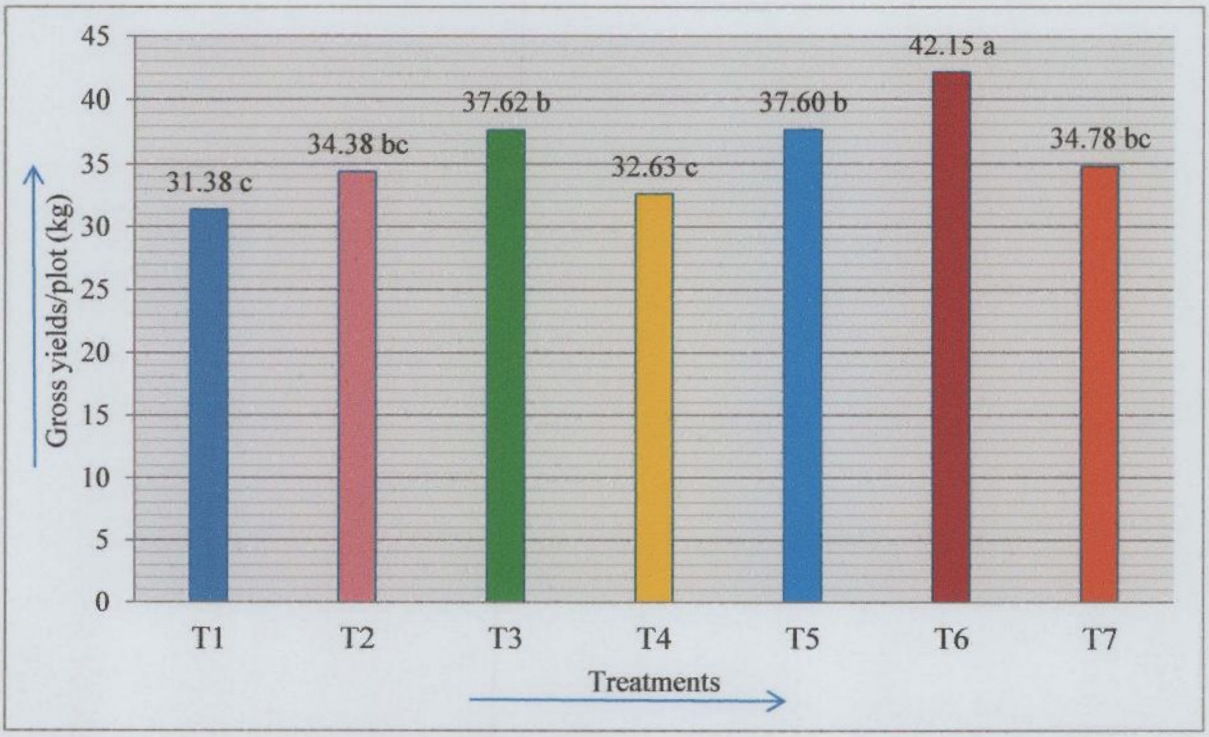

Fig. 6. Gross yield of cabbage plot^{-1} as influenced by cowdung, vermicompost, *Trichoderma* compost, NPK fertilizers and their combinations

T_1 = Recommended doses of NPK (Urea @ 350 kg ha^{-1}, TSP @ 250 kg ha^{-1}, MoP @ 300 kg ha^{-1})

T_2= Cowdung @10 t ha^{-1}

T_3= Vermicompost @ 10 t ha^{-1}

T_4= *Trichoderma* compost @10 t ha^{-1}

T_5= 50 % Cowdung + 50 % Recommended doses of fertilizer

T_6= 50 % Vermicompost + 50 % Recommended doses of fertilizer

T_7= 50 % *Trichoderma* compost + 50 % Recommended doses of fertilizer

These results are partially supported by the findings of Islam (2011) who reported that

the highest average gross yield being obtained from plots applied with cowdung + vermicompost+ *Trichoderma* compost and recommended doses of NPK fertilizer. Organic manure mainly vermicompost and inorganic fertilizer combinedly create good soil environment that supplied adequate plant nutrients for proper vegetative growth of cabbage plants, which ultimately influenced the number of healthy folded leaves. As a result the gross weight of cabbage head is increased as well as gross yield of cabbage plot^{-1} is increased.

4.16 Marketable yield plot^{-1}

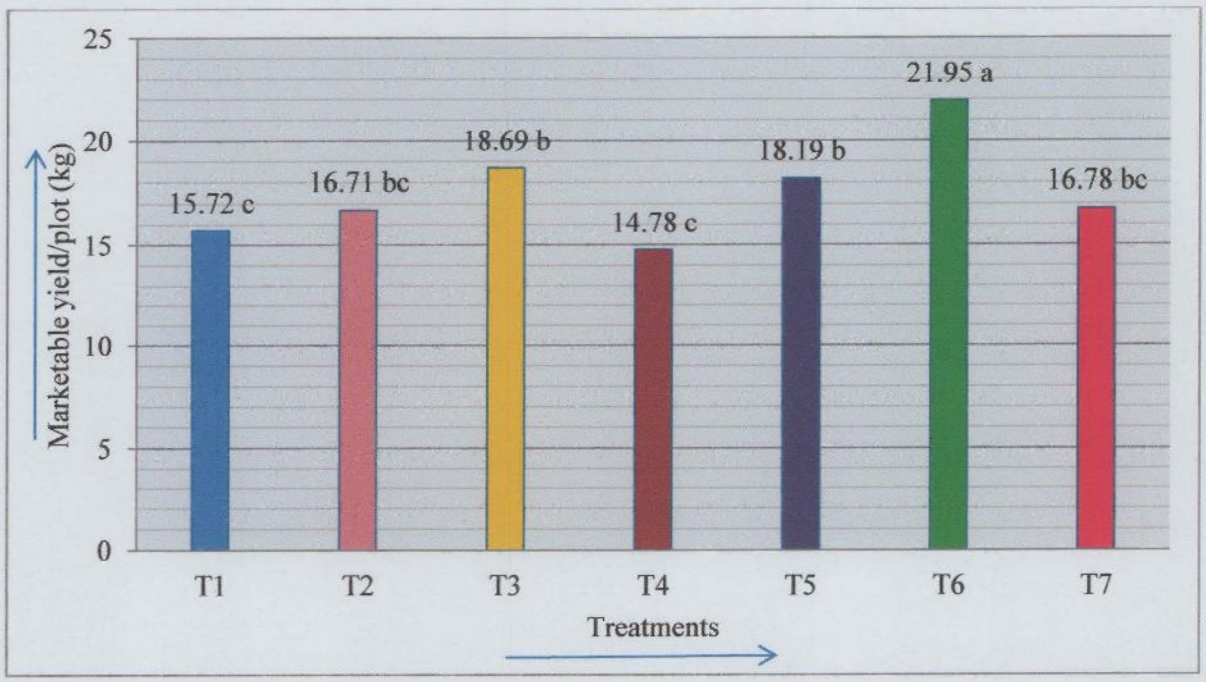

Fig. 7. Marketable yield of cabbage plot^{-1} as influenced by cowdung, vermicompost, *Trichoderma* compost, NPK fertilizers and their combinations

T_1 = Recommended doses of NPK (Urea @ 350 kg ha^{-1}, TSP @ 250 kg ha^{-1}, MoP @ 300 kg ha^{-1})

T_2= Cowdung @10 t ha^{-1}

T_3= Vermicompost @ 10 t ha^{-1}

T_4= *Trichoderma* compost @10 t ha^{-1}

T_5= 50 % Cowdung + 50 % Recommended doses of fertilizer

T_6= 50 % Vermicompost + 50 % Recommended doses of fertilizer

T_7= 50 % *Trichoderma* compost + 50 % Recommended doses of fertilizer

The variation among marketable yields of cabbage obtained from different plots was highly significant due to the different organic and inorganic fertilizers (Appendix-IV).The highest average marketable yield of cabbage (21.95 kg) plot^{-1} was obtained from the treatment T_6 followed by T_3, T_5, T_7, T_2, T_1 and the lowest (14.77 kg) was recorded from T_4 and the second lowest marketable yield of cabbage (15.72 kg) plot^{-1} was obtained from the treatment T_1 (Fig. 7) which was statistically significant. These results are partially support by the findings of Islam (2011) who reported that the highest average marketable yield being obtained from plots applied with cowdung + vermicompost + Trichoderma compost and recommended doses of NPK fertilizer. Organic manure mainly vermicompost and inorganic fertilizer combinedly create good soil environment that influenced the number of healthy folded leaves. As a result the gross weight of cabbage head is increased as well as gross yield of cabbage plot^{-1} is increased. So, ultimately marketable yield of cabbage plot^{-1} is increased.

4.17 Gross yield hectare^{-1}

In the present study significant influence of different organic and inorganic fertilizers on gross yield of cabbage hectare^{-1} was observed (Appendix-IV). It is apparent from the (Fig. 8) that the maximum gross yield of cabbage (90.77 t ha^{-1}) was recorded when the plants were grown with the combination of organic and NPK fertilizers in the treatment T_6 (50 % Vermicompost + 50 % Recommended doses of fertilizer) followed by T_3, T_5, T_7, T_2, T_1 and the lowest gross yield (81.71 t ha^{-1}) was obtained from the treatment T_1 (urea @ 350 kg ha^{-1}, TSP @ 250 kg ha^{-1} and MoP @ 300 kg ha^{-1}). It was observed that the combination of vermicompost with recommended dose of NPK fertilizers provided better growing condition for cabbage plant by increasing soil fertility and nutrients availability resulting maximum gross yield per hectare.

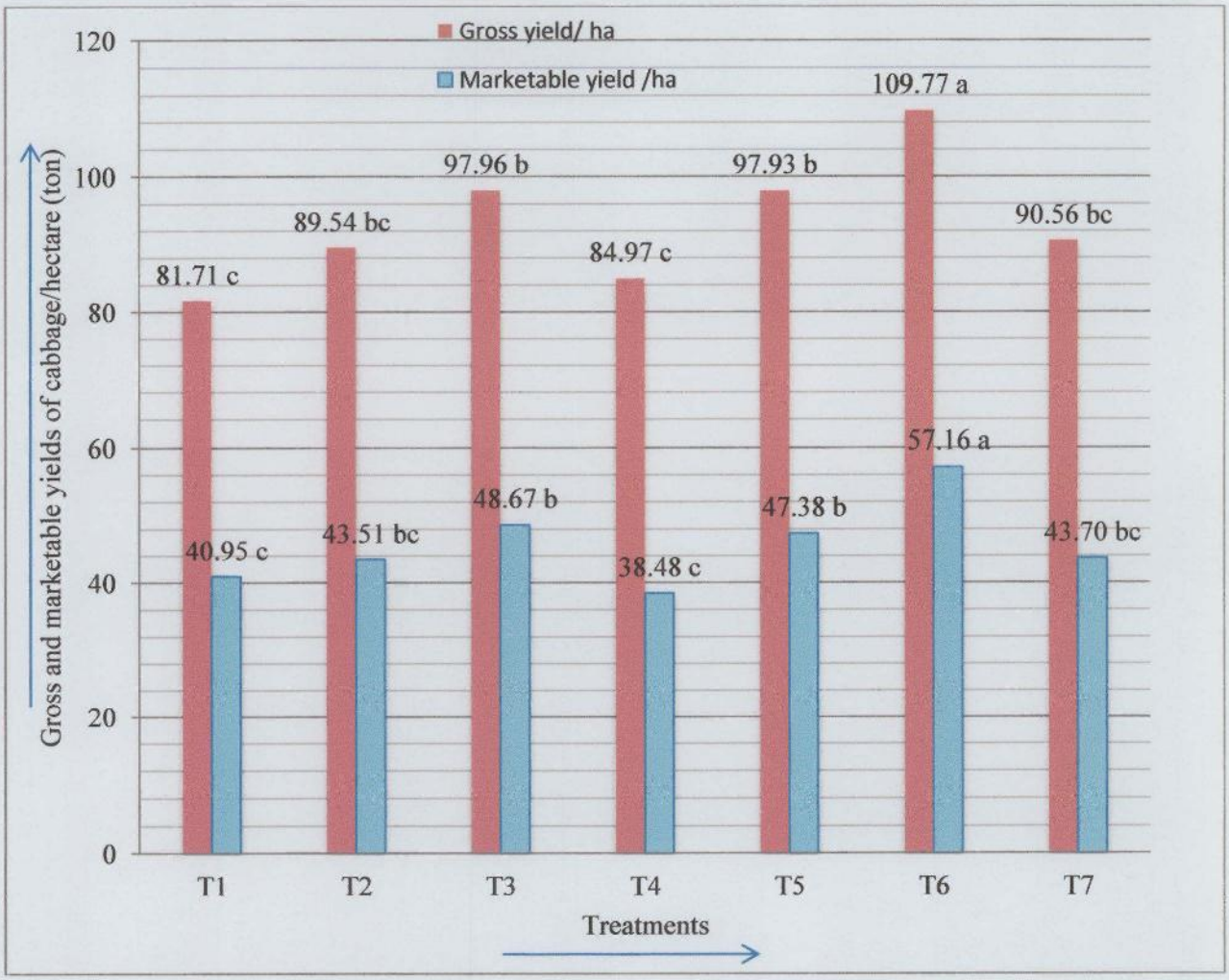

Fig. 8. Gross and marketable yields of cabbage hectare^{-1} as influenced by cowdung, vermicompost, *Trichoderma* compost, NPK fertilizers and their combinations

T_1 = Recommended doses of NPK (Urea @ 350 kg ha^{-1}, TSP @ 250 kg ha^{-1}, MoP @ 300 kg ha^{-1})

T_2= Cowdung @10 t ha^{-1}

T_3= Vermicompost @ 10 t ha^{-1}

T_4=Trichoderma compost @10 t ha^{-1}

T_5= 50 % Cowdung + 50 % Recommended doses of fertilizer

T_6=50 % Vermicompost + 50 % Recommended doses of fertilizer

T_7=50 % Trichoderma compost + 50 % Recommended doses of fertilizer

These results are partially supported by the findings of Islam (2011) who reported that the highest average gross yield being obtained from hectare applied with cowdung + vermicompost + *Trichoderma* compost and recommended doses of NPK fertilizer.

Organic manures mainly vermicompost goes mineralization and return available nutrient for purpose plant growth and attributed to physiological changes within the plant and helps to increasing number healthy head formation of cabbage plants plot^{-1} and finally the total gross yield hectare^{-1} increased.

4.18 Marketable yield hectare^{-1}

There was a significant effect of different organic and inorganic fertilizers on the marketable yield of cabbage hectare^{-1} (Appendix-IV). The highest marketable yield of cabbage (57.16 t ha^{-1}) was obtained which received organic manures with recommended dose of NPK fertilizers in the treatment T_6 followed by T_3, T_5, T_7, T_2, T_1 and the lowest yield (38.48 t ha^{-1}) was obtained from the treatment T_4 (Fig. 8) which was statistically significant. Organic manures mainly vermicompost goes mineralization and return available nutrient for purpose plant growth and attributed to physiological changes within the plant and helps to increasing number healthy head formation of cabbage plants plot^{-1} and finally the total yield hectare^{-1} increased.

4.19 Benefit cost ratio of cabbage

Benefit cost ratio varied significantly among the treatments (Table 5). The highest benefit cost ratio (3.63) was found in T_6 which was statistically similar to T_2 (3.38). On the other hand, the lowest benefit cost ratio (1.10) hectare^{-1} was obtained from T_4 treatment. T_6 treatment produced the highest benefit cost ratio because organic manure mainly vermicompost and inorganic fertilizer combinedly create good soil environment increased the production. As a result, for good yield performance and for good marketable selling price influenced the highest benefit cost ratio is T_6 treatment.

Chapter V

SUMMARY AND CONCLUSION

The present study was conducted at Hogladanga village under the Botiaghata upazila of Khulna during the period of November, 2013 to March, 2014 in order to investigate the yield performance of cabbage under different combinations of manures and fertilizers. The experiment consisted of seven treatments. The treatments were T_1 = recommended doses of NPK (urea @ 350 kg ha^{-1}, TSP @ 250 kg ha^{-1} , MoP 300 kg ha^{-1}, respectively), T_2= cowdung @10 t ha^{-1}, T_3= vermicompost @ 10 t ha^{-1}, T_4=*Trichoderma* compost @10 t ha^{-1}, T_5= 50 % Cowdung + 50 % Recommended doses of fertilizer, T_6 =50 % Vermicompost + 50 % Recommended doses of fertilizer and T_7 =50 % *Trichoderma* compost + 50 % Recommended doses of fertilizer. The experiment was laid out in a Randomized Complete Block Design (RCBD) with 3 replications.

The experiment was carried out to study the yield performance of cabbage cv. Atlas 70 under different combinations of manures and fertilizers. Twenty five days old seedlings of cabbage were transplanted on 22 November, 2013 at a spacing 60 cm × 40 cm in 2.4 m × 1.6 m plot. Data were collected from 10 randomly selected plants from each unit plot on vegetative, physio-morphological characters, yield components and yield. The collected data were analyzed statistically and the mean differences were evaluated by DMRT at 1 % and 5 % level of probability.

The combination of 50 % vermicompost + 50 % recommended doses of fertilizer gave the

highest values in respect of plant height (37.07 cm), plant spread (181.27 cm), maximum number of loose leaves per plant (19.20), length of the unfolded leaves (36.70 cm) and breadth of the unfolded leaves (29.13 cm) while the minimum (33.67 cm, 163.93 cm, 15.80 cm, 29.00 cm and 32.33 cm, respectively) were recorded in T_1, T_4, T_4, T_1 and T_1, respectively.

Time required for eighty 80 % head formation and head maturity were less compared to the recommended doses of fertilizer where no organic manure was given. The treatment having 50 % vermicompost + 50 % recommended doses of fertilizer advanced the eighty percent head formation and head maturity by 19.66 days and 17.67 days, respectively compared to recommended doses of fertilizer.

The highest number of lateral roots (26.20), stem length (50.57 mm), diameter of stem (23.45 mm) were found in plants treated with 50 % vermicompost + 50 % recommended doses of fertilizer while the lowest (22.30, 43.74 mm and 19.94 mm respectively) was recorded in T_2, T_1 and T_1, respectively.

Yield attributes were significantly affected by different organic manures and inorganic fertilizers. The highest gross weight of cabbage (2.81 kg), gross yields of cabbage per plot (42. 15 kg) and per hectare (109.77 ton), weight of marketable head (1.46 kg), diameter of head (21.30 cm) and marketable yields of cabbage per plot (21.95 kg) and per hectare (57.16 ton) were recorded from the treatment T_6 (50 % vermicompost + 50 % recommended doses of fertilizer) while the lowest (2.35 kg, 31.38 kg, 81.71 ton, 1.18 kg, 16.90 cm, 14.78 kg and 38.78 t, respectively) were recorded with treatment T_1 i.e.

recommended doses of fertilizer except the minimum marketable yields of cabbage per plot and per hectare were recorded with treatment T_4.

The present study revealed that vermicompost with recommended dose of NPK fertilizers increased the cabbage yield. Based on the findings of the experiment, it may be concluded that for efficient production of cabbage and maintenance of soil health, judicial use of different organic manures with chemical fertilizers is needed. So treatment T_6 (50 % vermicompost + 50 % recommended doses of fertilizer) may be used by the farmers for profitable cabbage production. However, the present research work was carried out at Hogladanga village under the Botiaghata upazila, Khulna in one season only. Further trial in different locations of Bangladesh is needed before final recommendation at farmer's level.

Chapter VI

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43-47.

Appendix I: Chemical analysis of soil sample

Treatments	pH		EC (dS / m)		Oragic matter (%)		Potassium (mg/ 100 g soil)		Total Nitrogen (%)		Phosphorus (µ g/ g soil)		Cupper (µ g/ g soil)		Zinc (µ g/ g soil)	
	After application	After harvest	After application	After harvest	After application	After harvest	After application	After harvest	After application	After harvest	After application	After harvest	After application	After harvest	After application	After harvest
T_1	7.2	7.1	1	1	2.41	2.46	0.4	0.46	0.14	0.14	88.25	51.28	40.15	20.19	0.69	0.67
T_2	7.2	7.2	1	1.6	2.74	2.7	0.5	0.45	0.16	0.16	43.84	34.32	27.79	27.35	1.76	0.57
T_3	7	7.1	1.8	1.7	2.95	2.61	0.54	0.48	0.17	0.15	107.8	42.16	21.81	34.98	1.23	0.97
T_4	7	7.1	1.6	0.9	2.92	2.79	0.52	0.38	0.17	0.16	119.5	132.2	29.47	18.34	1.26	1.42
T_5	7	7.1	1.2	1	2.63	2.79	0.45	0.37	0.15	0.16	126	60.31	44.91	19.02	1.44	0.74
T_6	7	7	1.6	1.2	2.89	2.9	0.48	0.43	0.17	0.17	103.1	50.48	38.89	30.03	1.44	0.86
T_7	7.1	7.2	1	1.3	2.75	3.06	0.47	0.41	0.16	0.18	131.5	43.22	32.62	20.93	0.92	0.65
Range (Min. to Max.)	7-7.2	7-7.2	1-1.8	0.9-1.7	2.41-2.95	2.46-3.06	0.4-0.54	0.37-0.48	0.14-0.17	0.14-0.18	43.84-131.5	34.32-132.2	21.81-44.91	18.34-34.98	0.69-1.76	0.57-1.42
Average	7.07	7.11	1.31	1.24	2.76	2.76	0.48	0.43	0.16	0.16	102.86	59.14	33.66	24.41	1.25	0.84
SD	0.10	0.07	0.34	0.31	0.19	0.19	0.05	0.04	0.01	0.12	29.87	33.25	8.06	6.43	0.35	0.29
CV (%)	1.35	0.97	26.15	24.95	6.92	7.06	9.70	9.67	6.97	7.28	29.04	56.22	23.94	26.33	28.42	34.42

Appendix II: Compositon of different organic manures

Cowdung compost :

N = 0.5 %	P = 0.15%	K = 0.5%	Moisture = 60 ± 6

Vermicompost :

N = 1.9 %	P = 2.0%	K = 0.8%	C : N = 13.60%
Mn = 500 ppm	Zn = 100 ppm	Cu = 48 ppm	pH = 8.0

Source: Fertilizer Recommendation Guide-2005, Bangladesh Agricultural Research Council

***Trichoderma* compost :**

Organic carbon=20%	N =1.2 %	P = 0.61 %	K = 0.77 %
S = 0.24 %	Ca =1.71 %	Mg = 0.4 %	B = 0.01 %
Cu = 0.01 %	Fe = 0.12 %	Mn =0.026 %	Zn = 0.02 %

Source : Nahar *et al.*, 2012

Appendix III. Monthly record of temperature, relative humidity, rainfall and sunshine during the period from October, 2013 to April, 2014.

Year	Months	Air temperature (^{0}C)		Relative humidity (%)	Rainfall (mm)	Sunshine (hrs)
		Maximum	Minimum			
2013	October	31.6	24.4	85	260	4.43
	November	30.4	18.2	76	000	8.25
	December	27.0	15.0	79	000	5.98
2014	January	24.0	12.6	82	000	5.23
	February	27.7	15.2	75	024	7.35
	March	32.9	20.1	69	005	8.38
	April	37.7	25.1	65	000	8.76

Source : Regional Inspection Center, Bangladesh Metrological Department, Gollamari, Khulna, Bangladesh.

Appendix-IV. Analysis of variance of data on growth parameters and yield of cabbage as influenced by different combination of organic and inorganic fertilizers

Source of variance	Degree of freedom	Mean sum square													
		Plant height (cm) at							Plant spread (cm) at						
		10 DAT	20 DAT	30 DAT	40 DAT	50 DAT	60 DAT	70 DAT	10 DAT	20 DAT	30 DAT	40 DAT	50 DAT	60 DAT	70 DAT
Replication	2	0.27	0.63	0.59	0.27	0.38	3.32	0.32	22.72	12.10	6.00	266.59	448.56	365.08	321.36
Treatment	6	1.79**	4.40**	6.846**	9.34**	9.05**	7.28**	4.46**	10.44*	11.22*	298.45**	66.35ns	126.64ns	87.57ns	101.82ns
Error	12	0.26	0.96	1.59	2.12	2.63	2.52	0.70	4.10	5.46	12.43	95.15	133.89	111.32	102.76

** Significant at 1% level of probability
* Significant at 5% level of probability
ns= non-significant.

Appendix-IV. Contd.

Source of variance	Degree of freedom	Mean sum square													
		Number of loose leaves at							Length of the unfolded leaves (cm) at						
		10 DAT	20 DAT	30 DAT	40 DAT	50 DAT	60 DAT	70 DAT	10 DAT	20 DAT	30 DAT	40 DAT	50 DAT	60 DAT	70 DAT
Replication	2	1.17	1.12	0.28	0.34	0.55	0.24	0.37	0.04	0.09	2.34	5.52	1.12	2.68	1.17
Treatment	6	0.25ns	1.25*	2.68**	4.64**	5.39**	5.57**	3.51**	0.44*	3.43**	7.07*	6.08**	6.82**	8.37**	6.69*
Error	12	0.25	0.56	0.38	0.39	0.37	0.53	0.15	0.22	0.77	1.48	1.58	1.35	1.04	2.75

** Significant at 1% level of probability
* Significant at 5% level of probability
ns = non-significant.

Appendix-IV. Contd.

Source of variance	Degree of freedom	Mean sum square								
		Breadth of the unfolded leaves (cm) at							Days required for 80% head formation	Days required for head maturity
		10 DAT	20 DAT	30 DAT	40 DAT	50 DAT	60 DAT	70 DAT		
Replication	2	0.06	0.22	1.12	0.88	3.27	4.26	2.11	2.29	22.62
Treatment	6	0.49^{ns}	1.67^{**}	3.22^{**}	7.23^{**}	6.96^{**}	10.64^{*}	12.79^{*}	101.97^{**}	85.27^{**}
Error	12	0.13	0.15	0.69	0.55	0.92	1.34	1.28	4.23	6.68

** Significant at 1% level of probability
* Significant at 5% level of probability
ns = non-significant.

Appendix-IV. Contd.

Source of variance	Degree of freedom	Mean sum square					
		% head formation of cabbage $plot^{-1}$	Number of lateral roots $plant^{-1}$	Length of the stem (mm)	Diameter of stem (mm)	Gross weight of cabbage $plant^{-1}$ (kg)	Weight of marketable head of cabbage $plant^{-1}$ (kg)
Replication	2	0.14	18.89	14.49	2.40	0.56	0.97
Treatment	6	1.32^{*}	5.27^{*}	6.68^{**}	4.75^{**}	1.7^{**}	1.62^{**}
Error	12	0.38	0.78	0.98	0.55	0.37	0.29

** Significant at 1% level of probability
* Significant at 5% level of probability
ns = non-significant.