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Yield Performance of Cabbage under Different Combinations of Manures and Fertilizers

Kumazr Sajib, Prosanta Kumar Dash, Bipradas Adhikary and Md. Abdul Mannan

Agrotechnology Discipline, Khulna University, Khullna-9208, Bangladesh

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.

Key words: Fertilizer · Cowdung · Vermicompost · Tricoderma compost · Cabbage · Sustainable

INTRODUCTION

Cabbage (*Brassica oleracea* var. *capitata*) is one of the most important leafy vegetables belongs to the family Cruciferae. It is an 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 [1]. Cabbage is an excellent source of vitamin C, in addition to containing vitamin B complex, cabbage supplies some potassium and calcium to the diet [2]. The leading cabbage growing districts in Bangladesh are Kustia, Meherpur, Jessore, Bogra and Tangail [1]. Cabbage is cultivated in an area of 15.79 thousand hectares with a production of 207 thousand tons [3].

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 [4]. Cowdung compost, vermicompost and *Trichoderma* compost will play a vital role to make soil fertile [5]. Cowdung is a rich source of different nutrients. It provides 0.5 % N, 0.15 % P, 0.5 % K and moisture 60± 6 % [6]. 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 [7, 8]. 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' [9]. Vermicompost contains several

Corresponding Author: Prosanta Kumar Dash, Agrotechnology Discipline, Khulna University, Khullna-9208, Bangladesh.

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 [10]. *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 % [11].

In Bangladesh the productivity of cabbage per unit area is quite low as compared to developed countries of the world [12]. 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} [13].

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 [5]. 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 [14]. Higher synthetic fertilizer inputs may lead to higher herbivore damage [15]. 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. It is hypothesized that organic agricultural practices might be a potential alternative to mitigate the soil health degradation problem and gave the highest yield in terms of BCR. 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.

MATERIALS AND METHODS

Plant Material and Growth Condition: The field experiment was conducted at Hogladanga village under the Batiaghata upazila of Khulna district during November, 2013 to March, 2014. Climate was sub-tropical which was characterized by heavy rainfall, high humidity, high temperature and relatively long day during the Kharif season (April to September) and scanty rainfall, associated with moderately low temperature and short day period during the Rabi season (October to March). Plenty of sunshine and moderately low temperature is suitable for growing tomato, which prevails during Rabi season in Bangladesh.

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. Cabbage cultivar Atlas 70 seeds were used for seedling production in this experiment. 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. Cabbage seedlings were raised on one seedbed with special care (Hogladanga, Khulna). Twenty five days old healthy and uniform size seedlings were transplanted in the experimental plots on 6 December, 2013. In total, there were 21 unit plots in the experiment. The unit plot was 2.4 m ± 1.6 m in area. Thus each unit plot arranged with 16 plants where plant to plant and row to row distance were 40 cm and 60 cm, respectively. Furrow irrigation methods was followed for irrigation of cabbage crops. Chemical analysis of soil sample was done after fertilization and after harvesting

(SRDI, Daulatpur, Khulna). Different intercultural was done such as gap filling, earthing up, weeding and crop protection (Sinocord @ 1 ml litre^{-1} was used) etc. Harvesting was started from 3rd March and completed end of March. Before harvesting, head compactness of the cabbage was tested by pressing with thumb. The compact mature head showed comparatively hard feelings. During harvesting marketable and unmarketable heads were divided.

Treatments and Design: The single factor experiment was laid out in the Randomized Complete Block Design (RCBD) with three replications which consisted of seven treatments such as 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.

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

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).

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).

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.

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).

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).

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.

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.

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:

$$\%\ \text{Head formation plot}^{-1} = \frac{\text{Number of head developed plant} \times 10}{\text{Total number of plants}}$$

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.

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.

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.

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).

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.

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).

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).

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

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).

Benefit Cost Ratio of Cabbage: To find out the BCR the following formula was used.

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

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 [16].

RESULTS AND DISCUSSION

Plant Height: Plant height was significantly influenced by different organic manures and inorganic fertilizers. It is evident that plant height was the highest with the treatment T_6 (50 % Vermicompost + 50 % Recommended doses of fertilizer) at different growth stages of cabbage. The tallest plants were 12.70, 18.77, 25.17, 31.27, 33.27, 36.97 and 37.07 cm at 10, 20, 30, 40, 50, 60 and 70 DAT, respectively. On the other hand, the shortest plants varied on different treatment combinations at different growth stages. Such as, 10.37 and 16.40 cm at 10 and 20 DAT were observed from T_1 treatment (Urea 350 kg ha^{-1}, TSP 250 kg ha^{-1}, MoP 300 kg ha^{-1}) and T_2 treatment (cowdung @10 t ha^{-1}). 20.57, 25.93, 28.33 and 33.67 cm at 30, 40, 50 and 70 DAT were observed from *Trichoderma* compost @ 10 t ha^{-1} (T_4) treatment (Table 1). Vermicompost had significant effect on plant height [17]. Vermicompost and inorganic fertilizer combination helps to grow plant vigorously. It is because vermicompost is reservoir of many nutrients and it facilitate plant growth. As a result plant height increased day by day at different treatment combination.

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. 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 1). 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.

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}. 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 2). 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.

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. 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 2).

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,

Table 1: Effect of different of organic manures, inorganic fertilizers and their combinations on plant height and plant spread at different days after transplanting

	Plant height (cm) at							Plant spread (cm) at						
Treatments	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, T7= 50 % *Trichoderma* compost + 50 % recommended doses of fertilizer

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

Table 2: 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

	Number of loose leaves plant^{-1} at							Length of the unfolded leaves (cm) at						
Treatments	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, T7= 50 % *Trichoderma* compost + 50 % recommended doses of fertilizer

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

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 combined 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.

Breadth of the Unfolded Leaves: Breadth of the unfolded leaves was also influenced significantly due to the effect of different organic and inorganic fertilizers. It was 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 3). Islam [10] 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.

Days Required for 80 % Head Formation: The use of different organic and inorganic fertilizers showed significant influence on days required for 80 % head formation. 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

Table 3: Breadth of the unfolded leaves of cabbage at different days after transplanting

	Breadth of the unfolded leaves (cm) at						
Treatments	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

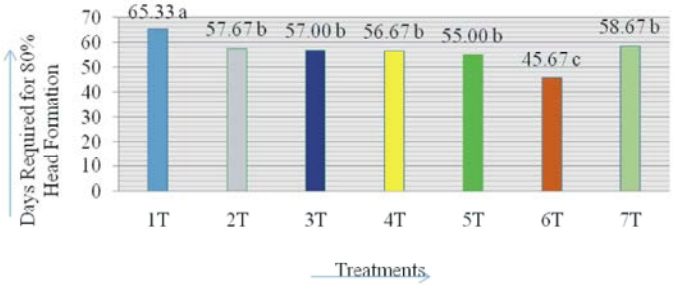

Fig. 1: Days required for 80 % head formation influenced by cowdung, vermicompost, *Trichoderma* compost and NPK fertilizers

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}, T3= Vermicompost @ 10 t ha^{-1}, T4= *Trichoderma* compost @10 t ha^{-1}, T5= 50 % Cowdung + 50 % Recommended doses of fertilizer, T6= 50 % Vermicompost + 50 % Recommended doses of fertilizer, T7= 50 % *Trichoderma* compost + 50 % Recommended doses of fertilizer, Different letter indicate mean difference by DMRT test

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 [10] 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.

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. The cabbage grown with the treatment T_6 (50 % vermicompost + 50 % recommended doses of fertilizer) matured earlier (78.33 DAT).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).

These findings are in agreement with the observation of Subhan [18], reported that application of manure reduced the number of days for cabbage head maturity. Islam [5] 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.

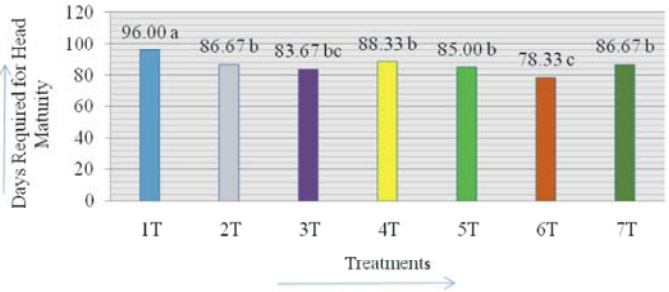

Fig. 2: Days required for head maturity influenced by cowdung, vermicompost, *Trichoderma* compost and NPK fertilizers
T_1 = Recommended doses of NPK (Urea @ 350 kg ha^{-1}, TSP @ 250 kg ha^{-1}, MoP @ 300 kg ha^{-1})
T_2= Cowdung @10 t ha^{-1}, T_3= Vermicompost @ 10 t ha^{-1}, T_4= *Trichoderma* compost @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, Different letter indicate mean difference by DMRT test

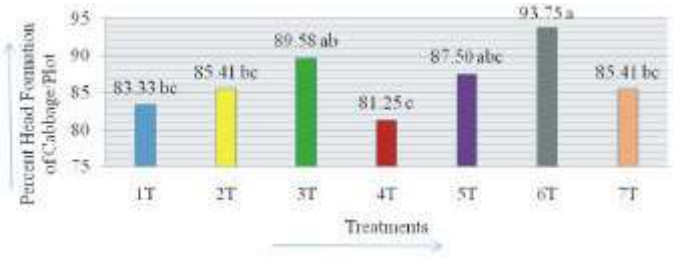

Fig. 3: Per-cent head formation of cabbage plot^{-1} as influenced by cowdung, vermicompost, *Trichoderma* compost and NPK fertilizers
T_1 = Recommended doses of NPK (Urea @ 350 kg ha^{-1}, TSP @ 250 kg ha^{-1}, MoP @ 300 kg ha^{-1}), T_2= Cowdung @10 t ha^{-1}, T_3= Vermicompost @ 10 t ha^{-1}, T_4= *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, Different letter indicate mean difference by DMRT test

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. 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).

It was found that different combinations of organic and inorganic fertilizers combined supplied adequate available plant nutrients and provide better growing conditions which helps to form head. The author [5] 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.

Number of Lateral Roots Plant^{-1}: Different organic and inorganic fertilizers caused significant variation in relation to number of lateral roots plant^{-1}. 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.

Length of Stem: There was significant variation in relation to the length of stem among the treatments due to different organic and inorganic fertilizers. 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 4). Islam [5] 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,

Table 4: 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

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.

Diameter of Stem: Different organic and inorganic fertilizers significantly influenced in stem diameter of cabbage. 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 4). 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.

Gross Weight of Cabbage Plant^{-1}: Different organic and inorganic fertilizers significantly influenced the gross weight of cabbage plant^{-1}. 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).

Islam [5] 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.

Weight of Marketable Head of Cabbage: Weight of marketable head of cabbage varied significantly among the treatments due to different organic and inorganic fertilizers. 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 results showed that organic and inorganic fertilizers performed better when used combined 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.

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. 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

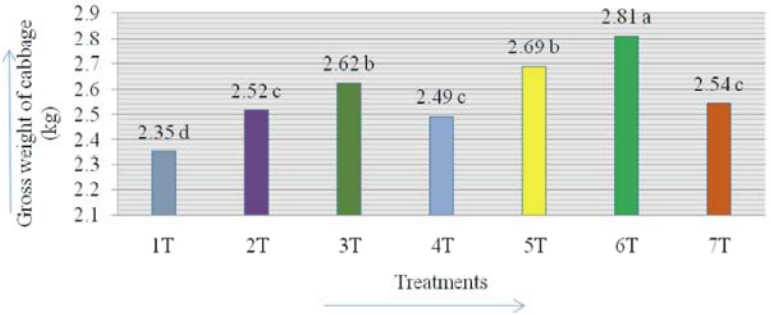

Fig. 4: Gross weight of cabbage plant^{-1} as influenced by cowdung, vermicompost, *Trichoderma* compost , NPK fertilizers and their combinations

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, Different letter indicate mean difference by DMRT test

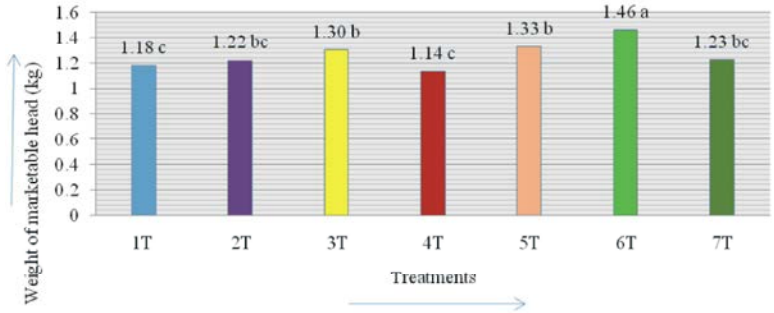

Fig. 5: Weight of marketable head of cabbage as influenced by cowdung, vermicompost, *Trichoderma* compost, NPK fertilizers and their combinations

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, Different letter indicate mean difference by DMRT test

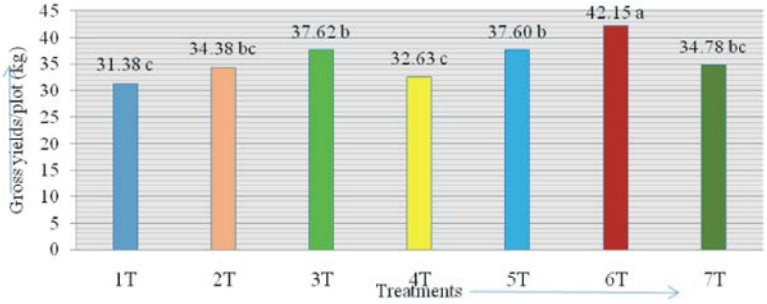

Fig. 6: Gross yield of cabbage plot^{-1} as influenced by cowdung, vermicompost, *Trichoderma* compost, NPK fertilizers and their combinations

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, Different letter indicate mean difference by DMRT test

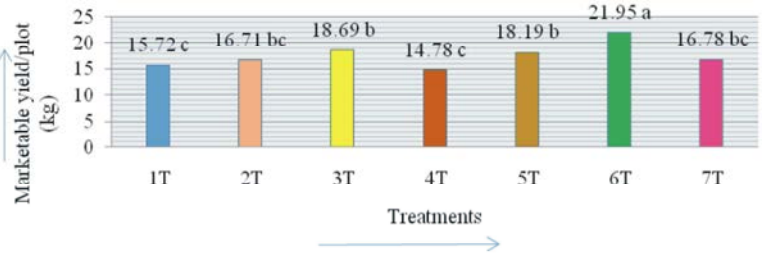

Fig. 7: Marketable yield of cabbage plot^{-1} as influenced by cowdung, vermicompost, *Trichoderma* compost, NPK fertilizers and their combinations

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, Different letter indicate mean difference by DMRT test

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}.

These results are partially supported by the findings of Islam [10], 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 combined 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.

Marketable Yield Plot^{-1}: The variation among marketable yields of cabbage obtained from different plots was highly significant due to the different organic and inorganic fertilizers. 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 the author [5] 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 combined 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.

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. 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.

These results are partially supported by the findings of the author [5] 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.

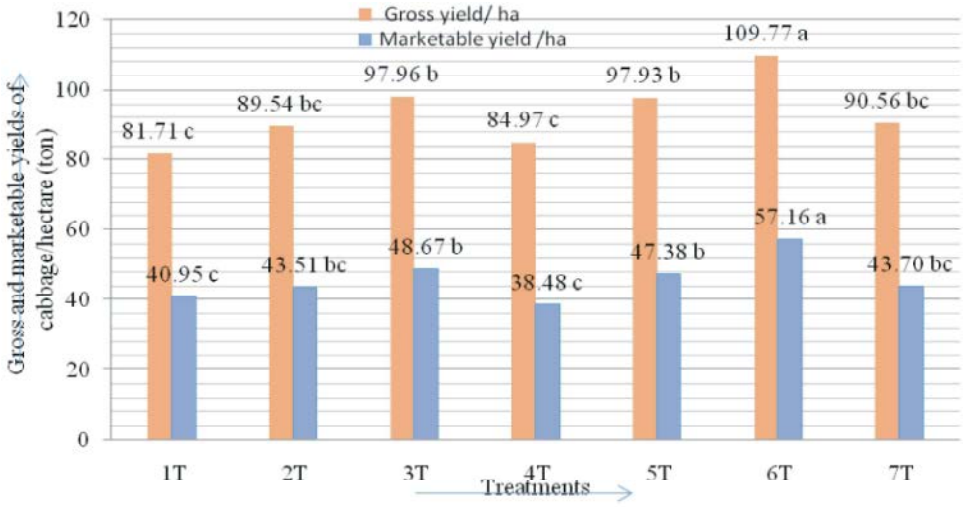

Fig. 8: Gross and marketable yields of cabbage hectare^{-1} as influenced by cowdung, vermicompost, *Trichoderma* compost, NPK fertilizers and their combinations

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, Different letter indicate mean difference by DMRT test

Marketable Yield Hectare^{-1}: There was a significant effect of different organic and inorganic fertilizers on the marketable yield of cabbage hectare^{-1}. 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.

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.

CONCLUSION

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.

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