EFFECT OF DIFFERENT SOURCES OF ORGANIC NUTRIENTS IN COMBINATION WITH FERTILIZERS ON THE PRODUCTION OF CABBAGE

M Islam[1] * MK Islam[2] MJ Alam[1] TS Munmun[2] MA Islam[1] and S Mondal[1]

Present address
[1]Scientific Officer [2]Senior Scientific Officer, Bangladesh Agricultural Research Institute

Correspondence*
monirbdku@gmail.com

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Abstract

It is well known that, excessive use of chemical fertilizers deteriorates soil health but integrated nutrient management of organic and inorganic fertilizers not only boost up crop yield but also can improve soil quality. To explore the options an experiment was conducted at Horticulture Research Center of Regional Agricultural Research Station, Bangladesh Agricultural Research Institute (BARI), Jessore during 2015-16 to evaluate the effect of different sources of organic nutrients in combination with fertilizers on cabbage production. Six treatments viz. T_1 = 100% Recommended dose of chemical fertilizers (RDCF), T_2 = Cowdung 10 t/ha + 75% of RDCF, T_3 = Poultry manure 3 t/ha + 75% of RDCF, T_4 = Vermi compost 1.5 t/ha + 75% of RDCF, T_5 = Tricho-compost 3.0 t/ha + 75% of RDCF and T_6 = Native fertility (control) were used in the experiment. The experiment was laid out in a randomized complete block design with three replications. The treatments showed significant effect on yield and yield components. Individual marketable head weight was significantly highest (1.71 kg) in the treatment T_3 (Poultry Manure @ 3 t/ha+75% RDCF) followed by T_5 (1.67 kg) and T_6 (1.65 kg) while, the minimum (1.25 kg) was observed in T_6 (control). Similarly, the significant highest head yield (85.75 t/ha) was also obtained from the treatment T_3 (Poultry Manure @ 3 t/ha+75% RDCF) consistent with more profitability (MBCR 19.68) followed by the treatment T_5 (83.58 t/ha) and T_4 (82.90 t/ha) and the lowest yield (52.50 t/ha) in treatment T_6 (control). Therefore, combined use of organic and inorganic fertilizer (T_3 = Poultry manure @ 3 t/ha + 75% RDCF) could be the best option to increase the productivity (marketable head yield) and profitability of cabbage cultivation maintaining good soil health.

Key words: Cabbage, Organic fertilizer, inorganic fertilizer, productivity, profitability, sustainability.

Introduction

Cabbage (*Brassica oleracea* var. *capitata* L.) is a cole crop, belongs to the *cruciferae* family. It is an important fresh and processing vegetable crop in most of the countries of the world. Cabbage is believed to have originated in Western Europe and it was the first cole crop to be cultivated (Chauhan, 1986). The marketable head of cabbage is an excellent source of vitamins, minerals and dietary fibers and consumed fresh as salad and cooked as vegetable or utilized as processed product. It contains a range of essential vitamins (Vitamin C & B) and minerals such as potassium and calcium to the diet, as well as small amount of protein and good caloric value, which was 250 mL of raw cabbage contains 21 kilocalories and cooked, 58 kilocalories (Haque, 2006). Cabbage is one of the main cash crops and generally grown in *rabi* season in Bangladesh. Currently, about 295744 MT cabbages is being produced from 9,920 ha of land with an average yield of 29.81 t/ha in 2015-16 season (BBS, 2017). It indicates a very poor yield per unit area. Growth and yield of this vegetable crop is remarkably influenced by organic and inorganic nutrients management. It is an established fact that use of inorganic fertilizer for the crops is not so good for health because of residual effect but in the case of organic fertilizer such problem does not arise and on the other hand it increases the productivity of soil as well as crop quality and yield (Tindall, 2000). In Bangladesh, most of the cultivated soils have less than 1.5% organic matter, while a good agricultural soil should contain at least 2% organic matter (Haque *et al*., 2015). So, more attention is needed for increasing organic matter

content in the soil which is possible only by using more organic manures. Organic fertilizers enrich the soil organic matter, which improves soil structure or workability (soil tilth), making the soil easier to plough (sand and clay soils). Therefore, the application of organic fertilizers assist structuring of soil to open and admit air penetration to roots and water drainage, both conditions necessary for satisfactory plant growth (Eimhoit *et al*., 2005). Most vegetable crops return small amounts of crop residue to the soil, so manure, compost, and other organic amendments help maintain soil organic matter levels. In Bangladesh, the farmers use mostly the chemical fertilizers for their crop production and they are used to do it, even many of them don't use organic manures in their farm at all. Besides, the excess application of inorganic fertilizers causes hazard to public health and the environment. As a result, the soil health is deteriorating day by day. So, the combined application of both organic and inorganic fertilizers can increase the yield and keep the environment sound (Hsieh *et al*., 1996). Therefore, it is a crucial need to use more organic manures with reduced amount of inorganic fertilizers. However, there are many sources of organic manures in Bangladesh but among them cow dung, poultry manure, vermi-compost, tricho-compost are the most common. Therefore, the study was undertaken to know the effect of different sources of organic nutrients in combination with reduced amount of chemical fertilizers on the growth and yield of cabbage.

Materials and Methods

Site description

The experiment was conducted at Horticulture Research Center (HRC), Regional Agricultural Research Station (RARS), Bangladesh Agricultural Research Institute (BARI), Jessore, Bangladesh (23 ° 11′ N, 89° 14′ E and 16 m ASL) in 2015/16 *rabi* season. The soil of the experimental site is silt loam to silty clay loam, calcareous brown flood plain of the High Ganges River Floodplain (BARC, 2012). The climate in this region is subtropical monsoon with average annual rainfall of 1590 mm (Alam *et al*., 2017). Maximum temperature was 32.53 ^{0}C in 2nd week of September and minimum temperature was 9.90 ^{0}C last week of January (Figure 1). The total rainfall during experiment (September /15 to January/16) of the area was 231.57 mm and relative humidity (RH) was 77.35 to 85.64 % during the experimental period (Figure 2). The topsoil (0-15 cm) was slightly alkaline (pH 7.6) and had low soil organic C content (0.70%). Organic matter content was 1.44 g kg^{-1} (Table 1).

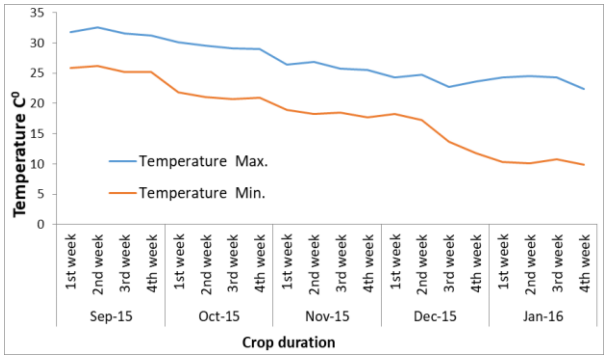

Fig. 1. Temperature data of the experimental area during the whole crop period (September/15 to January/16)

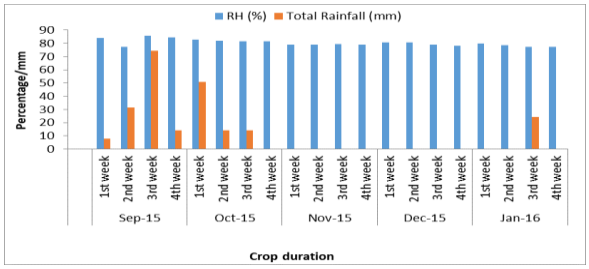

Fig. 2. Relative humidity (RH %) and rainfall data of the experimental area during the whole crop period (September/15 to January/16)

Pre-cropping soil sampling and analysis

Ten core samples were collected from 0 to 15 cm depth, bulked together, air-dried, sieved with 2 mm and ready for routine analysis. Soil pH was measured in a 1: 2.5 suspension of soil and water using pH meter with a combined glass/calomel electrode (Jackson, 1962). The electrode was calibrated using standard buffer solutions at pH 4.0 and 7.0., while organic matter was determined using wet digestion method (Nelson and Sommers, 1982). Phosphorus was extracted by shaking the soil with 0.5 M sodium bicarbonate solution of pH 8.5. The concentration of P in the extract was determined calorimetrically at 882 nm wavelength after developing a blue colour using molybdate-ascorbic acid (Olsen and Sommers, 1982). Soil K was extracted with 1 M NH40AC pH7, and their content K was read on the flame photometer (Jackson 1958). The soil nitrogen was determined using the micro-kjeldahl method

(Jackson 1964), while the micronutrient (Zn) were extracted with 0.1 M, HCl and read on atomic absorption spectrophotometer. Soil N content was 0.07 % which is lower than 0.15 % N critical level for crops recommended by Sobulo and Osiname (1981). The soil 'P' 15.71 mg/kg is medium for crop production in Jessore region. However, the K content 0.29 mmh/ 100 gram soil is optimum. The organic matter was below 3 % critical level for crop production (FRG, 2012). The soil pH 7.60 showed that the soil is slightly alkaline (Table 1).

Sources and processing of organic fertilizers used in the experiments

Cowdung was obtained from the large-scale dairy farm of Cantonment Board, Jessore, while the poultry manure was collected from Afil Poultry Feed Ltd., a renowned commercial poultry and hatchery farm in Jessore, where are more than 15,000 poultry birds in the farm. Vermi-compost was obtained from Kaligonj Vermi-compost plant, Jhinadah and Tricho-compost was collected from the Tricho-compost plant established in Abdulpur, Jessore by a project funded by Krishi Gobesona Foundation (KGF) in 2013. NPK in the form of Urea, TSP and MoP were purchased from Government authorized fertilizer and seeds selling outlet Sornali Krishi Vander, Palbari, Jessore. The Cabbage seed (variety: Green 60) was purchased from a certified seed company Syngenta, Jessore Branch. The organic materials were processed and sieved to remove pebbles and only well decomposed cowdung, poultry manure were used for application.

Chemical analysis of the organic materials

Three samples each of the processed forms of the organic materials was analyzed (Table 2). The N content was determined by the micro kjeldahl method (Jackson 1964), while the determination of other nutrients such as P, K, Ca, Mg was done using the wet digestion method based on 25-5-5 ml of HNO3-H2SO4-HClO4 acids (AOAC, 1970). The micronutrients (Fe, Cu, Zn and Mn) were extracted with 0.1 M, HCl and read on atomic absorption spectrophotometer. pH was read on pH meter (Crockford and Nowel, 1956). Table 2 shows the chemical analysis of the organic fertilizers used for the experiment. Poultry manure and tricho-compost are highly alkaline and vermi-compost and cowdung are moderately alkaline. Poultry manure had the highest values of N and K followed by vermi-compost. Tricho-compost had the highest values of P and S followed by poultry manure. Cowdung contained the highest values of Ca and Mg closely followed by poultry manure and lowest value of C/N ratio. However, vermi-compost had the highest value of C/N ratio compared to others.

Raising seedlings

Seedlings were raised in the permanent nursery established in Horticulture Research Center, Regional Agricultural Research Station, Jessore. The size of nursery bed was 3 m x 1 m. The soil of the nursery was prepared well then it was watered and covered with the white polythene tightly and kept it for 10 days to make heat inside the soil for killing the soil born pathogen. Then seeds were sown in 11 September 2015 manually into rows spaced at 20 cm apart, irrigated twice a day (morning and evening) and also shaded with black polythene on the frame made by iron wire to ensure good germination and establishment. Germination of the seeds occurred 8 days after sowing (DAS), after12 DAS the crowded seedling were then transplanted in second seed bed for hardening of the seedlings and seedlings were nursed for 2 weeks before transplanting. The seedlings were transplanted in the main field after 32 DAS. The nursery establishment is important because directly sown seeds will not germinate; hence, the erection of shade structure in the experiment was to control the prevailing temperature of the environment for seed's germination (Moyin-jesu, 2015). Before transplanting in the main field, the leaves of seedlings were clipped for better establishment.

Table 1. Initial soil (0-15 cm) chemical properties

Item	Soil test results								
	pH (soil:water=1:2.5)	OC %	OM g kg^{-1}	Total N (%)	K mmh 100 g $soil^{-1}$	P mg kg^{-1}	S (mg kg^{-1})	B (mg kg^{-1})	Zn (mg kg^{-1})
Initial soil	7.60	0.7	1.44	0.07	0.29	15.71	2.02	0.06	0.85

Table 2. Elemental composition of following organic manures

Sl No.	Specification	Test Result			
		Vermi-compost	Poultry manure	Cowdung	Tricho-compost
01.	Physical condition	Dust	Dust	Dust	Dust
02.	Colour	Black	Black	Black	Black
03.	Moisture (%)	11.81	9.55	10.49	9.30
04.	pH	7.6	8.5	7.1	8.1
05.	OC (%)	19.95	14.60	12.40	20.1
06.	Ca (%)	2.45	2.76	2.89	1.71
07.	Mg (%)	1.44	1.62	1.70	0.40
08.	N (%)	1.73	2.10	1.34	1.20
10.	P (%)	0.34	0.57	0.41	1.41
11.	K (%)	0.96	1.12	0.88	0.93
12.	S (%)	0.14	0.17	0.10	0.24
13.	B (%)	0.0072	0.0080	0.010	0.02
14.	Cu (%)	0.12	0.13	0.11	0.01
15.	Fe (%)	0.301	0.346	0.358	0.12
16.	Mn (%)	1.18	0.19	0.17	0.01
17.	Zn (%)	0.017	0.018	0.027	0.026

Experimental design

The experiment was laid out in randomized complete block design (RCB) with three replications. There were six treatments in the experiment as follows-

T_1 = 100% Recommended dose of chemical fertilizers (RDCF)
T_2 = Cowdung 10 t/ha + 75% of RDCF
T_3 = Poultry manure 3 t/ha + 75% of RDCF
T_4 = Vermi compost 1.5 t/ha + 75% of RDCF
T_5 = Tricho-compost 3 t/ha + 75% of RDCF
T_6 = Native fertility (Control)

*Recommended dose of chemical fertilizers (RDCF) by Bangladesh Agricultural Research Institute is Urea = 350 kg/ha, TSP = 250 kg/ha and MoP = 300 kg/ha.

*Organic manures were followed by following the Fertilizer Recommendation Guide, Bangladesh Agricultural Research Council, Farmgate, Dhaka, Bangladesh (2012).

The experimental site was cleared, ploughed, harrowed and divided into different plots. Each plot size was 4.8 m x 3.6 m (17.28 m^2).

Site and crop management

Thirty two-day-old seedlings were transplanted to the experimental plots on 13 October 2015 by maintaining 60 cm x 40 cm plant spacing. The seedlings were transplanted at evening for escaping the shock from the direct sun light. After transplanting, irrigation was done every mornings and evenings until the full establishment of seedlings and also 2-3 times after 20-30 days of transplanting. The chemical fertilizers such as Urea, TSP and MoP, were applied @ 350, 250, 300 kg/ha respectively. Entire amount of TSP and one third of MoP were applied in the final land preparation. Rest of urea and MoP were applied in three equal installments at 10, 20 and during head initiation (BARI, 2017). All of the organic manures were applied at the final land preparation including TSP and other chemical fertilizers accept Urea and MoP. Urea and MoP were applied in four installments starting from 10 days after transplanting. Weeding was done manually 10 days after transplanting and continued at 2 weeks interval until harvesting. There were no significant attack of diseases and pest. However, some of the plants were attacked by the Aphid, white fly and spodoptera caterpillar, in that case for controlling aphid and white fly Malatheone® was sprayed @ 2 ml/litre of water 10 days interval for 3 times and for reducing the population of caterpillar sex pheromone trap of Ispahani brand was used @ one trap/10 m^2 and the detergent water of the trap was changed @ 7 days interval. Nevertheless, the experiment field was visited every day to avoid or to take necessary measures for any circumstances. Harvesting of the crop started from 82 DAT (Days After Transplanting) and onward at optimum maturity stage.

Crop monitoring

Days required heading initiation

Days were counted from the date of transplanting to start of head formation averaged on ten plants i.e. when any one plant in the plot started to head formation that date was counted.

Plant Height

The plant height was measured during harvest at 82 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).

Individual plant weight

Individual plant weight was measured by uprooting the plant including roots, stem, leaves and matured head during harvest at 82 days after transplanting and then weighted by using digital measuring balance. Mean value of the ten selected plants was calculated for each unit plot and expressed in kilogram (kg).

Head length

Head length was measured after harvest of matured head by using meter scale. The measurement was taken from the base to the tip of an individual plant. Mean value of the ten selected heads was calculated for each unit plot and expressed in centimeter (cm).

Head girth

Head girth was measured after harvest of matured head by using measuring wire. It was measured by placing the measuring wire from one starting point of the periphery and by rounding the periphery to end at the starting point. Mean value of the ten selected heads was calculated for each unit plot and expressed in centimeter (cm).

Marketable head weight

The weight was taken after harvesting of matured head by using digital measuring balance. First of all, the older or faded leaves were removed from the head and cut at the base of the head as prepared for market then weighted individually. Mean value of the ten selected heads was calculated for each unit plot and expressed in gram (gm).

Head Yield (t/ha)

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

Economic performance

Total production cost was calculated as the sum of variable (operating) and fixed costs. Prices of inputs and outputs were determined in BDT based on prices in the local (Jessore) market in 2016. The variable costs used in the analysis were the costs of tillage, seed, sowing, seedling raising, transplanting, fertilizers, pesticide, irrigation, and harvesting. Fixed costs are those costs which do not change with change in the volume and type of production, such as the rental value of land, depreciation of machinery and interest on operating capital. Gross return was calculated from the amount of marketable head harvested (t ha^{-1}) and their farm gate prices. The price of marketable head of cabbage was 10 Tk/kg. Net return was calculated from the deviation of gross return and total cost. Finally, marginal benefit cost ratio (MBCR) was calculated by using the following formula-

$$\text{MBCR} = \frac{\text{Gross return of the treatment A - Gross return of the control treatment}}{\text{Total cost of the treatment A - Total cost of the control treatment}}$$

Statistical analysis:

Data were analyzed by ANOVA (using MSTAT-C) to evaluate differences between treatments and the means were separated using least significant difference (LSD) at the 5% level of significance ($p<0.05$).

Results

Effect of different treatments on the growth parameters of cabbage

Growth parameters (head initiation, plant height and individual plant weight) were significantly varied by the treatments (Table 3). In case of days to head initiation, the significant lowest days to head initiation (33 days) was found in the treatment T_4 (Vermi-compost 1.5 t/ha + 75% of RDCF) closely followed by T_3 (34 days) and maximum days required in control treatment (T_6). The significant highest plant height was observed in the treatment T_3 (29.17 cm) which was closely followed by the treatment T_1 (28.58 cm) and T_5 (28.53 cm).

The treatment T_3 increased plant height by 2.1 % and 2.2 % compared to T_1 and T_5 respectively and when compared to T_2 and T_4 the treatment T_3 also increased plant height by 5% each. The significant highest individual plant weight (2.68 kg) was obtained in T_3 treatment and was at par with other treatments except control. In all the cases of growth parameters (head initiation, plant height and individual plant weight) the lowest values were recorded from the control treatment.

Effect of different treatments on yield and yield components of cabbage

There were significant effect ($P < 0.05$) on yield and yield components of cabbage due to different combinations of nutrient managements (Table 5). The head length was found highest (14.56 cm) in the treatment T_3 (Poultry manure 3 t/ha + 75% of RDCF) which was similar with T_2 and T_5. The treatment T_5 increased the head length by 2.4 and 3.9 % compared to T_2 and T_5 respectively. The highest head girth (15.96 cm) was recorded from the treatment T_3 followed by T_1 (15.31 cm) and T_5 (15.25 cm) where, T_3 maximized the head girth by 4.2 and 4.7 %, when compared to T_1 and T_5, respectively. In case of individual marketable head weight and head yield, the highest values were obtained from the treatment T_3 followed by T_5 and T_4. The treatment T_3 increased marketable head weight by 2.4, 3.5, 8.9 and 14.8 % in comparison with the treatment T_5, T_4, T_2 and T_1 respectively. Finally, the highest crop yield (head yield) was noticed in T_3 treatment (85.75 t/ha), closely followed by the treatment T_5 (83.58 t/ha) and T_4 (82.92 t/ha). The treatment T_3 boosted up the head yield by 2.6 and 3.4 % compared to T_5 and T_4 respectively and by 8.9 and 15.4 % when compared to T_2 and T_1 respectively. The least values of yield and any other yield component was observed in the control treatment (T_6).

Economics

The highest gross return (8, 57,500 BDT) was observed in T_3 treatment, where as it was slightly lower in T_5 and T_4 treatment. The net return and MBCR was found maximum in the treatment T_3 (Poultry manure

Table 3. Effect of different treatments on the growth of cabbage

Treatments	Days to Head initiation	Plant height at harvest (cm)	Indivudal plant wt. (kg)
T_1 (100% RDCF)	36	28.58	2.46
T_2 (Cowdung 10 t/ha + 75% of RDCF)	37	27.80	2.46
T_3 (Poultry manure 3 t/ha + 75% of RDCF)	34	29.17	2.68
T_4 (Vermi compost 1.5 t/ha + 75% of RDCF)	33	27.80	2.39
T_5 (Tricho-compost 3 t/ha + 75% of RDCF)	36	28.53	2.47
T_6 (Control)	38	24.67	1.83
CV (%)	4.09	5.95	9.21
$LSD_{0.05}$	2.51	2.958	0.394

Table 4. Effect of different treatments on yield and yield components of cabbage

Treatments	Head length (cm)	Head girth (cm)	Marketable head wt. (kg)	Head yield (t/ha)
T_1 (100% RDCF)	13.95	15.31	1.49	74.33
T_2 (Cowdung 10 t/ha + 75% of RDCF)	14.22	15.12	1.57	78.67
T_3 (Poultry manure 3 t/ha + 75% of RDCF)	14.56	15.96	1.71	85.75
T_4 (Vermi compost 1.5 t/ha + 75% of RDCF)	13.57	15.07	1.65	82.90
T_5 (Tricho-compost 3 t/ha + 75% of RDCF)	14.01	15.25	1.67	83.58
T_6 (Control)	12.39	13.80	1.25	52.50
CV (%)	5.28	4.39	11.99	11.12
$LSD_{0.05}$	1.30	1.185	0.337	15.30

Table 5. Economic analysis under different treatments

Treatments	Gross return (Tk/ha)	Total cost (Tk/ha) (fixed cost + variable cost)	Net return (Tk/ha)	MBCR
T_1 (100% RDCF)	7,43,300/-	1,94,749/-	5,48,551/-	13.23
T_2 (Cowdung 10 t/ha + 75% of RDCF)	7,86,700/-	2,00,644/-	5,86,056/-	11.69
T_3 (Poultry manure 3 t/ha + 75% of RDCF)	8,57,500/-	1,95,144/-	6,62,356/-	19.68
T_4 (Vermi compost 1.5 t/ha + 75% of RDCF)	8,29,000/-	2,05,644/-	6,23,356/-	11.10
T_5 (Tricho-compost 3 t/ha + 75% of RDCF)	8,35,800/-	2,20,644/-	6,15,156/-	7.33
T_6 (Control)	5,25,000/-	1,78,249/-	3,46,751/-	1

Here, Market price of cabbage, Urea, TSP and MoP, cowdung, poultry manure, vermicompost and tricho-compost were 10, 17, 23, 16, 1, 1.5, 10 and 10 tk/kg respectively.

3 t/ha + 75% of RDCF) compared to other treatments (table 5). The treatment T_3 increased net return by 91 % more compared to T_6 (control) as because T_3 boosted up yield by 63 % from the control treatment. The highest MBCR was obtained from the treatment T_3 (19.68) closely followed by T_1 (13.23). Treatment T_3 increased MBCR by 48.8 % when compared to T_1 and 68.3, 77.3 and 168.5 % compared to T_2, T_4 and T_5 respectively. The least value of MBCR and also net return was recorded from the control treatment.

Discussion

Effect of organic and inorganic fertilizers on growth and yield of cabbage production

The lowest values of plant growth and yield contributing components of cabbage (Days to head initiation, plant height, individual plant weight, head length, head girth, marketable head weight and head yield) were recorded from the control treatment compared to other treatments, mainly due to the low soil nutrients status and no fertilization during cropping period at all. This finding was supported by Mohammed and Solaiman (2012) who reported that nutrients supply was an important input for realizing higher cabbage yield. Hence, the application of fertilizers, especially organic fertilizers enhanced both soil and crop productivity in the tropics.

The highest values in respect of growth and head yield parameters were obtained from the treatment T_3 (Poultry manure 3 t/ha + 75% of RDCF) as the nutrient content of poultry manure is much more than other organic source such as cow dung, vermi-compost and tricho-compost. Poultry manure was rich in major nutrients such as N, P and K by 56.7, 39 and 27.3 % more from cow dung, 21.4, 67.6 and 16.7 % more from vermin-compost respectively and in case of tricho-compost, poultry manure was rich in N and K by 75 and 20 % more but tricho-compost was rich in Phosphorus by 147, 315 and 244 % more compared to poultry manure, vermi-compost and cow dung respectively. Haque *et al*., (2015) reported that application of different organic manures on cabbage showed significant disparities in almost all the growth and yield characteristics, where poultry manure gave the better results regarding crop yield compared to the control and other organic manure treatments, similar to our results.

Conclusion

Considering the yield and yield attributes and from the above mentioned discussions it can be concluded that the treatment T_3 (Poultry manure 3 t/ha + 75% of RDCF) performed better than the treatment T_1 where only chemical fertilizers were used and also better than that of other treatment combinations in respect of growth and head yield of cabbage in the experiment. Therefore, 25% reduction of chemical fertilizer as replaced by 3 t/ha poultry manure as organic fertilizer could be a good option in cabbage production as well as maintaining soil health for enhancing sustainable crop production.

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