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Growth and yield performance of cabbage under different combinations of vermicompost and fertilizers

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Abstract

The field experiment was conducted at On-Farm Research Division, Bangladesh Agricultural Research Institute (BARI), Rangpur, Bangladesh during the Rabi season of 2014-15 and 2015-16 to evaluate the effects of vermicompost on the growth and yield of cabbage. The experiment was laid out in RCB design with seven treatments viz; T_1 = 100% recommended chemical fertilizer (RCF), T_2 = 80% RCF, T_3 = 60% RCF, T_4= 100% RCF+ Vermicompost (VC) @ 1.5 t ha^{-1}, T_5= 80% RCF+ VC @ 3 t ha^{-1}, T_6 = 60% RCF+ VC @ 6 t ha^{-1} and T_7 = Absolute control. The highest head yield was recorded from T_4 during 2014-15 and 2015-16 (59.21t ha^{-1}& 72.61t ha^{-1}respectively) where the lowest yield was obtained from T_7 (27.11 t ha^{-1}& 24.05 t ha^{-1} respectively). The total soluble solids were higher in T_7 treatment. The highest gross margin was calculated in T_4 (203060 & 270060 Tk. ha^{-1}in 2014-15& 2015-16, respectively) and the lowest was in T_7 (74300 & 59000 Tk.ha^{-1}in 2014-15 & 2015-16, respectively).

Keywords: Cabbage, chemical fertilizer, vermicompost and TSS.

Introduction

In Bangladesh winter vegetable cabbage (*Brassica oleracea* L. var. capitata L.) is the most widely cultivated. There are 0.75 million hectares of land under cabbage cultivation in Bangladesh with the production of 217 thousand metric tons fresh cabbage (BBS, 2014).It is an excellent source of vitamins, minerals and dietary fibers. The crop demands higher amount of plant nutrients particularly nitrogen for head (edible part of cabbage) production. However, excess supply of nitrogen through inorganic fertilizers although increases the total dry weight but adversely affects the head quality by producing coarse and loose head, reducing keeping quality and enhancing the nitrate nitrogen content of head (Ojetayo*et al.*,2011). Some study suggests that application of higher amount of organic manure along with reduced levels of inorganic nitrogen fertilizer can improve the nutritional and keeping quality of cabbage head (Londhe, 2002; Yadav*et al.*, 2001). Therefore global movement for the second "Green revolution" ought to emphasize on composting, particularly vermicomposting (Buchanan *et al.*, 1988). Vermicompost have many outstanding biological properties. They are rich in bacteria, actinomycetes,

fungi (Werner and Cuevas, 1996) and cellulose-degrading bacteria (Werner and Cuevas, 1996). Earthworms excreta is a rich nutritive organic fertilizer due to rich in humus, NPK, micronutrients, beneficial soil microbes- 'nitrogen fixing and phosphate solubilizing bacteria' and actinomycetes and growth hormones 'auxins', 'gibberlins and 'cytokinins'.The vermicompost promote growth from 50-100% over conventional compost and 30-40% over chemical fertilizers (Sinha*et al.*, 2010). The application of vermicompost showed maximum yield in potato (Patil, 1995; Saikia and Rajkhowa, 1998); positive effect on the yield of okra(Ushakumari*et al.*, 1996); improve all plant characters and greater number of fruits per plant in chilli (Abburi and Haripriya, 2003); increased dry pod yield in ByadagiChilli (Sashidhara,1999); green pod per plants, green grain weight per plant, percentage of protein and carbohydrates content and green pod yield was higher in vermicompost applied garden pea, compared to chemical fertilizer (Meena*et al.*, 2007); total chlorophyll contents in leaves, dry matter production, flower appearance, length of fruits and fruits per plant, dry weight of 100 seeds, yield per plot was significantly higher in hyacinth beans(Karmegam and Daniel, 2008). Since information regarding the effect of vermicompost on cabbage is not available, the study was conducted to assess its effect on the growth and yield of cabbage.

Materials and Methods

Experiment site and design: The experiment was carried out at On Farm Research Division, BARI, Alamnagar, Rangpur (Longitude $089^0$15.697N, Latitude $25^0$43.233E, Altitude 29m) during the period of October to March of 2014-15 and 2015-16. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications and seven treatments. Autumn Queen variety of cabbage was used in the experiment. The seeds were treated with Thiram @ 2.0 g kg^{-1} seed to protect the damping off and other seed borne diseases. Seeds @10 g bed^{-1} were sown in shallow furrows prepared at 10-12 cm apart by dropping the seeds at 5-7 cm apart and at 1.5-2 cm depth. Five weeks old seedlings of cabbage were transplanted on last week of October when average height of seedlings was about 10 cm. The distance between plants to plant as well as row to row was kept at 45 cm. Vermicompost was used as organic manure in the experiment. However, the seven treatments of the experiment were as follows, T_1 = 100% Recommended Chemical Fertilizer (RCF), T_2 = 80% RCF, T_3 = 60% RCF, T_4 = 100% RCF+ (VC) @ 1.5 t ha^{-1}, T_5 = 80% RCF+ VC @ 3 t ha^{-1}, T_6 = 60% RCF+ VC @ 6 t ha^{-1} and T_7 = Absolute control. Recommended dose of chemical fertilizer for the crop was @ 180-66-50-24-1.5-1 kg ha^{-1}, N-P-K-S-Zn-Brespectively and these were used in the form of Urea, TSP (Triple Super Phosphate), MoP (Muriateof Potash), Gypsum, Zinc sulphate and Boron. The whole amount of P, K, S, B and 1/3 N were broadcast and thoroughly incorporated into the soil at the time of final land preparation and the remaining 2/3 N was top dressed in two equal installation at 25 and 45 days after transplanting. Vermicompost was applied in the field during final land preparation. The unit plot size was 3m × 3m.The randomization of treatment was done with the help of random number table (Fisher, 1950). Weeding was done twice. The field was irrigated three times at 25 DAP, 35 DAP and 45DAP. Basal dose of fertilizer was added in the field during final land preparation. Total soluble solids (%TSS) was measured with the help of Brix Refractometer. Crop harvesting was started in second week of February and continued till second week of March. Crop growth rate was measured from the above ground plant biomass harvested at 15 days interval up to first crop cut.

Soil sampling and analysis

Soil samples to a depth of 0-15 cm were collected before initiation of the experiment. The collected samples were then air dried and ground to pass through a 2 mm (10 meshes) sieve and stored in a clean plastic container for physical and chemical analyses. After removal of all debris, composite soil sample was made by treatment wise and the soil was labeled as post soil. The soil was air dried in room temperature in the laboratory. Then pH, organic carbon (%), total N (%), available P (ppm), exchangeable K (meq/100g soil), Ca, Mg, S, Zn, B and all other physical and chemical properties were analyzed of initial soil as presented in Table 01 by the standard methods of Jackson (1973); Nelsons and Sommers (1982); Black(1965); Olsen andSommers (1982); Thomas (1982).(Table 1).

Table 01. Initial physical and chemical soil properties of the experimental site

Soil characteristics	Analytical value	Interpretation
Physical properties		
Sand	17.2%	
Silt	47.2%	
Clay	35.6%	
Textural class	Silt clay loam	
Bulk density	1.4 g/cm3	
Particle density	2.6 g/cm3	
Chemical properties		
Soil pH	5.54	Highly acidic
Organic Matter (%)	1.24	Low
Total N (%)	0.06	Very Low
Available P (ppm)	80.50	Very High
Exchangeable K (meq/100 g)	0.14	Low
Exchangeable Mg (meq/100g)	0.32	Very Low
Available S (ppm)	5.43	Low
Available B (ppm)	0.10	Very Low
Zinc (ppm)	1.0	Medium

Organic Manure (vermicompost) analysis for P, K, S, Zn determination

Vermicompost was collected from Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur Bangladesh.The sample weighing 1 g was transferred into a dry clean 100 ml beaker, then 10 ml HNO_3 was added, boiled gently till the content became almost dry. After cooling the content, 5 ml $HClO_4$ was added, boiled gently until the solution became colorless or nearly so and dense white fumes fill the beaker. The contents of the flask were boiled until they became sufficiently clean and colorless. The contents were then transferred to a 100 ml volumetric flask by washing with distilled water through a Whatman filter paper no. 1. A blank was also digested without chemicals. The P, K, S and Zn contents were determined from this digest by the standard method of Olsen and Sommers (1982).

Organic manures (Vermicompost) analysis for nitrogen determination

An amount of 1 g vermicompost sample was taken into a 100 ml Micro-Kjeldahl digestion flask. Into the flask, 10 ml H_2O and 15 ml conc. H_2SO_4 were added and heated for 10 minutes. Then 5 g digestion mixture (K_2SO_4:$CuSO_4$.H_2O, Se = 100:10:5.1) was added in it after cooling the flask was swirled and allowed to stand for about 10 minutes, followed by continuous heating till the digest was clean and colorless. After cooling, the contents were transferred into a 100 ml volumetric flask and the volume was made with distilled water. A reagent blank was prepared in a similar manner by the standard method of Black (1965).

Table 02. Nutrient status of the organic manure (vermicompost)

Organic Manure	Contents (%)			
	N	P	K	S
Vermicompost	0.90	0.66	1.80	0.60

Collection of data and analysis

The data pertaining to plant height (cm), number of unfolded leaves per plant, head circumferences (cm), head height (cm), total weight (kg plant^{-1}), marketable weight (kg plant^{-1}), total yield (t ha^{-1}) and marketable yield (t ha^{-1}) characters were recorded from randomly selected 5 cabbage plants. After harvest, plant samples from each plot were collected and divided into stalk and head. Data on yield and yield contributing characters were taken and analysis was done statistically analyzed following 'R' software package (R Core Team, 2017).The mean differences of the treatments were observed by least significant difference (LSD) test at 5% level of probability for the interpretation of results (Gomez and Gomez, 1984).

Results

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

Plant height

The combined effect of inorganic fertilizer with vermicompost on cabbage plant height has been presented in Table 03and Table 04. Significant variation ($P \leq 0.05$) was observed among the treatments.In 2014-15 T_4 treatment produced the highest plant height (19.87 cm) of cabbage whereasthe lowest plant height (15.17 cm) was observed in T_7 (Absolute control). In 2015-16 there was no statistical difference among the treatments except absolute control regarding plant height. Numerically highest plant height was recorded in T_4 (21.66 cm) and lower exhibited in absolute control (17.11 cm).

Table 3.Yield and yield contributing characters of cabbage with different doses of fertilizer in OFRD, BARI, Rangpur during 2014-15

Treatment	Plant height (cm)	Whole plant fresh wt. (g plant^{-1})	Whole plant dry wt. (g plant^{-1})	Head length (cm)	Head circumference (cm)	Fresh head wt. (g)	Yield (t ha^{-1})
T_1 = 100% RCF	19.07 ab	3671 a	350.5 ab	14.22 a	120.20 a	2096ab	54.76 ab
T_2 = 80% RCF	18.67 ab	3446 ab	338.9 ab	13.22 a	120.89 a	1938 b	52.38 b
T_3 = 60% RCF	18.20 ab	3078 b	311.8 bc	12.78 ab	111.15 a	1908 b	51.8 b
T_4 = 100% RCF+ VC @ 1.5 t ha^{-1}	19.87 a	3846 a	371.8 a	14.66 a	127.86 a	2431a	59.21 a
T_5 = 80% RCF+ VC @ 3 t ha^{-1}	18.40 ab	3549 ab	341.5 ab	14.44 a	123.03 a	2338 a	57.91 ab
T_6 = 60% RCF+ VC @ 6 t ha^{-1}	18.40 ab	3487 ab	303.5 bc	14.11 a	122.96 a	2172 ab	53.72 ab
T_7 = Absolute control.	15.17 b	1894 c	270.5 c	10.44 b	72.63 b	1417 c	27.11 c
CV(%)	13.08	8.14	9.81	10.70	16.15	7.36	7.07

Whole plant fresh weight

Whole plant fresh weight was measured from the above ground part. The maximum fresh weight of whole plant was recorded from T_4 (3846 g) which was statistically similar with T_1 (3671 g) and the minimum fresh weight of whole plant was recorded from T_7 (1894 g) i.e. control exhibit lowest weight during 2014-15. In 2015-16, maximum fresh plant weight was found in T_4 (4033 g) and the lowest was found in T_7 (1578 g).

Whole plant Dry weight

Whole plant dry weight wasmeasured from oven dry of whole plant sample. In 2014-15 the maximum dry weight of total plant was found in T_4 (371.8 g) and the minimum was found in T_7(270.5 g) (Table 3). Similar trend was observed in 2015-16 wherethe maximum dry plant weight was found in T_4 (387.2 g) and the minimum was found in T_7 (145.2 g) (Table 4).

Table 4.Yield and yield contributing characters of cabbage with different doses of fertilizer in OFRD, BARI, Rangpur during 2015-16

Treatment	Plant height (cm)	Whole plant fresh wt. (g plant^{-1})	Whole plant dry wt. (g plant^{-1})	Head length (cm)	Head circumference (cm)	Fresh head wt. (g)	Head Yield (t ha^{-1})
T_1 = 100% RCF	21.22 a	3822 ab	365.9 ab	15.44ab	134.71ab	2228ab	63.13b
T_2 = 80% RCF	21.44a	3578bc	354.3 abc	14.44 bc	135.4ab	2070bc	58.65b
T_3 = 60% RCF	20.55a	3233 c	327.2bc	14.00c	125.66 b	2040c	57.57b
T_4 = 100% RCF+ VC @ 1.5 t ha^{-1}	21.66 a	4033 a	387.2 a	15.88a	142.38 a	2563a	72.61a
T_5 = 80% RCF+ VC @ 3 t ha^{-1}	21.11 a	3667 abc	356.9 abc	15.66a	137.54ab	2470ab	69.97a
T_6 = 60% RCF+ VC @ 6 t ha^{-1}	21.00 a	3578 bc	318.9 c	15.33ab	137.48ab	2304ab	65.28ab
T_7 = Absolute control.	17.11b	1578 d	145.2 d	11.66d	87.15 c	849d	24.05c
CV(%)	3.76	6.91	7.37	4.01	6.03	6.32	8.49

DAP: Day After Planting, **RCF:** Recommended Chemical Fertilizer, **VC**: Vermicompost

Head length of cabbage

Head length of cabbage was significantly varied among the treatments for the different doses of organic and inorganic fertilizer combinations (Table 3 & 4). Inorganic fertilizer with vermicompost had positive impacton cabbage head length.Numerically the highest head length (14.66 cm) was observed in $T_4$and the lowest head length (10.44 cm) was recorded from T_7during 2014-15.In 2015-16 the highest head length was recorded in T_4 (15.88 cm) which was statistically similar with T_5 (15.66 cm) and followed by T_1 (15.44 cm) and T_6 (15.33 cm). The lowest head length (11.66 cm) was found in control treatment.

Head circumference of cabbage

Numerically Significant (P≤0.05) variation was observed among treatments regarding head circumference of cabbage.In the first year the highest head circumference (127.86 cm) was observed in T_4treatment which was statistically similar with rest treatments except control which was appeared (72.63 cm). In second year the similar trend was appeared.The highest head circumference (142.38 cm) was recorded in T_4i.e100% recommended fertilizer with additional 1.5 t vermicompost and the lowest was found in T_7 (87.15 cm) i.e absolute control treatment. A similar result was found by Blatt (1991).

Fresh Head weight

Marketable fresh head weight of cabbage was varied among the treatments for their combinations. The maximum fresh head weight (2431 g) was recorded in T_4 treatment which was statistically similar with T_5 (2338 g) followed by T_6 (2172 g) and the lowest was recorded in T_7 (1417 g) during 2014-15.In 2015-16 the highest fresh head weight was recorded from T_4 (2563 g) which was followed by T_5 (2470 g), T_6 (2304 g) and T_1 (2228 g) and the lowest weight (849 g) was obtained in T_7.

Head Yield of cabbage (t ha^{-1})

Yield of cabbage differed significantly due to application of different level of inorganic and organic fertilizer. Among the treatments the highest yield was observed in T_4(59.21 tha^{-1}) followed by T_5 (57.91 tha^{-1}), T_1 (54.76 tha^{-1}) and T_6 (53.72 tha^{-1}) during 2014-15. The lowest yield was observed in T_7 (27.11 tha^{-1}). In 2015-16 the highest yield was obtained from T_4 (72.61 tha^{-1}) which was statistically similar with T_5 (69.97 tha^{-1}) and the lowest yield was obtained from T_7 (24.05 tha^{-1}).

TSS value

Total soluble solids were measured by Brix Refractometer. The absolute treatment control fertilizer level appears highest level of total soluble solids (%TSS) (8.47%& 8.50%) during 2014-15 and 2015-16 and the lowest was obtained from T_4 (7.40 %) during 2014-15 and in T_5 (7.41%) during 2015-16 (figure 1).

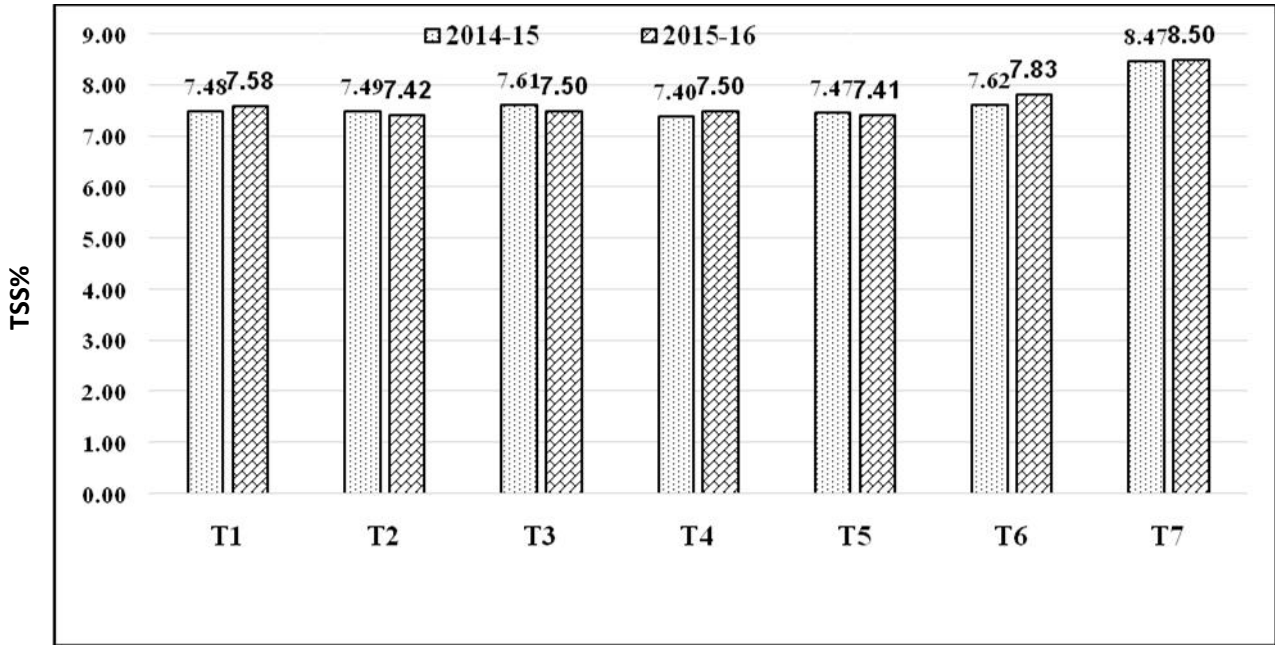

Fig. 1: Total Soluble Solids

Cost and return analysis

At harvest cabbage from field after data collection rest was sell in the local market. The Cost and return of cabbage calculated from the farmgate price both the year. In 2014-15 highest gross return (296500 Tk. ha^{-1}) was recorded from T_4 due to its highest yield 59.21 tha^{-1}. There was variation among the treatments total variable cost due to type and amounts of inputs variation. Total variable cost was the higher in T_6 and lowest in T_7 due to use of vermicompost and other input variability. The lowest return (135550 Tk. ha^{-1}) was recorded in T_7. The highest gross margin was found in T_4 (203060 Tk ha^{-1}) and the lowest was in T_7 (Tk. 74300 ha^{-1}). Similar return trend was found in first and second year appeared during second year trial. The highest gross margin was recorded in T_4 (270060 Tk. ha^{-1}) and the lowest was in T_7 (Tk. 59000 ha^{-1}) (Table 4 and 5).

Table 5. Cost and return analysis of cabbage as influenced by chemical fertilizers and vermicompost, at OFRD, Rangpur during 2014-15

Treatments	Final head yield (t ha^{-1})	Gross return (Tk. ha^{-1})	Total Variable cost (Tk. ha^{-1})	Gross Margin (Tk. ha^{-1})	BCR (on variable cost basis)
T_1=100% RCF	54.76	273800	77990	195810	3.51
T_2 = 80% RCF	52.38	261900	74672	187228	3.51
T_3 = 60% RCF	51.8	259000	71294	187706	3.63
T_4 = 100% RCF+ VC @	59.21	296050	92990	203060	3.18
T_5 = 80% RCF+ VC @ 3 t	57.91	289550	104642	184908	2.77
T_6 = 60% RCF+ VC @ 6 t	53.72	268600	131294	137306	2.05
T_7 = Absolute control	27.11	135550	61250	74300	2.21

Table 6. Cost and return analysis of cabbage as influenced by chemical fertilizers and vermicompost, at OFRD, Rangpur during 2015-16

Treatments	Final head yield (t ha^{-1})	Gross return (Tk. ha^{-1})	Total Variable cost (Tk. ha^{-1})	Gross Margin (Tk. ha^{-1})	BCR (on variable cost basis)
T_1=100% RCF	63.13	315650	77990	237660	4.05
T_2 = 80% RCF	58.65	293250	74672	218578	3.93
T_3 = 60% RCF	57.57	287850	71294	216556	4.04
T_4 = 100% RCF+ VC @ 1.5 t ha^{-}	72.61	363050	92990	270060	3.90
T_5 = 80% RCF+ VC @ 3 t ha^{-1}	69.97	349850	104642	245208	3.34
T_6 = 60% RCF+ VC @ 6 t ha^{-1}	65.28	326400	131294	195106	2.49
T_7 = Absolute control	24.05	120250	61250	59000	1.96

*BCR= Benefit and Cost ratio, 1US$=85 .00 Tk

Input price: Urea=16,TSP=22, MoP=15, Gypsum=10, Zinc Sulphate=150, Boric Acid=130, Vermicompost=7 Tk. kg^{-1},

Output price: Cabbage= 5 Tk. kg^{-1}

Discussion

Higher plant height in vermicompost treated plot might be accelerated with the improvement of soil properties likewise soil nutrient status, water holding capacity and structure which was also supported by Walker and Bernel, 2004. Higher plant height may be contributed to higher fresh weight in T_4 treatment. Vermicompost may enhance the plant growth which might be encouraged by the prevailing auxins, cytokinins and gibberelins of vermicompost. Kargam and Daniel (2008) also reported in hyacinth beans that higher dry matter produced in vermicompost treated plot. Use of only inorganic fertilizers is harmful for soil health. So, we should try to supplement a part of chemical fertilizer by organic fertilizers and application of vermicompost gave better performance for increased head height of cabbage. Organic fertilizers can serve as alternative practice to mineral fertilizers for improving soil structure and microbial biomass (Dauda*et al*., 2008). Addition of vermicompost in soil develops soil microbial activity resulting more addition of nutrients for crop growth which ultimately results more yield. Similar results were observed in experiment of Noor *et al*. (2005) and Das *et al*., 2002. In both year T_7 treatment exhibit lowest yield i.e control treatment where no fertilizer was applied. Treatments having vermicompost along with organic feritlizer showed better yield than other fertilizers in increasing the yield of cabbage. But it was notable that, without chemical fertilizers vermicompost or other organic fertilizers could not give better yield. (*Yadav et al., 2001*)

Conclusion

Cabbage production with addition of vermicompost not only supportive for increasing yield but also has an opportunity to improve the status of soil organic matter. The result revealed that when vermicompost was applied in combination with integrated plant nutrient system along with recommended doses chemical fertilizers, the effect showed better performance on yield rather than applying chemical fertilizers alone. Thus vermicompost can be used in combination with fertilizers for satisfactory yield of cabbage.

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