

EFFECT OF VERMICOMPOST AND INORGANIC FERTILIZER ON THE YIELD AND QUALITY OF CABBAGE

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Abstract

Vermicompost is an important organic manure for maintaining soil fertility and sustainable crop production. Hence, the present study was conducted to evaluate the effectiveness of vermicompost (VC) with inorganic fertilizer on the yield and quality of cabbage (*Brassica oleracea var. capitata*) during two consecutive years of 2019-2021. There were five treatments: T₁ = 100% RDF (N₁₁₅P₇₀K₁₂₅S₂₀Zn₂ kg ha⁻¹), T₂ = 75% RDF + 4 t ha⁻¹ vermicompost (VC), T₃ = 100% RDF + 3 t ha⁻¹ VC, T₄ = 75% RDF + 3 t ha⁻¹ VC and T₅ = Control. The experiment was laid out in randomized complete block design with three replications. The highest cabbage head yield was found in T₃ (100% RDF + 3 t ha⁻¹ VC), which was 409% higher over the control. The maximum protein content (10.6%), vitamin- C (40.0 mg 100g⁻¹) and firmness (1.93 kgf) were recorded in the same treatment. The treatment T₃ also showed the highest gross margin while the maximum BCR (5.33), soil organic matter and total-N were recorded in T₄. Therefore, 100% RDF + 3 t VC ha⁻¹ can be recommended for quality cabbage production.

Keywords: Vermicompost, cabbage yield, quality, nutrient requirement, profitability

Introduction

Improper and continuous use of chemical fertilizers reduce soil fertility, increase of planting cost, hamper sustainable practices of agriculture as well as cause health hazard of consumers (Bisht and Chauhan, 2020; Chuan *et al.*, 2019; Rahman and Debnath, 2015). Combined application of organic and inorganic fertilizers is necessary to improve soil health and increases sustainable crop production. Organic fertilizer is ensured healthy and safe crop production by recycling of organic matter. In this context, farmer are gradually increasing to use of organic fertilizers in their crop field for sustaining productivity, keeping good soil health (Pozza and Field, 2020; Chatterjee *et al.*, 2012). Vermicompost is the good source of organic fertilizer which is processed by the utilization of earthworms with organic waste made from livestock product (Chowdhury *et al.* 2020). Vermicompost is rich in essential plant nutrients (Korav *et al.*, 2021; Olle, 2017) and influences the plant growth by improving the physical and chemical properties of soil (Ceritoğlu *et al.*, 2018).

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Cabbage (*Brassica oleracea var. capitata L.*) is one of the most common important winter vegetables (Ray *et al.*, 2018) in Bangladesh occupied by 18.6 thousand hectares of land with the production of 323 thousand metric tons fresh cabbage (BBS, 2020). It is an excellent source of vitamin C, vitamin B, minerals and provides fibers to our diet. The average yield of cabbage 17.4 t ha⁻¹ in Bangladesh is much below than the potential yield (BBS, 2020). The cultivation of cabbage requires proper supply of plant nutrients from inorganic and organic sources like vermicompost. Vermicompost is rich in plant nutrient elements, various hormones, enzymes, humic substances and especially organic matter (Ceritoğlu *et al.*, 2018). The organic matter content in Bangladesh soil is less than 1 to 1.5% (Islam *et al.*, 2018). Depletion of soil organic matter is the major barrier to produce higher yield. Increased sustainable production of crops cannot be maintained by using chemical fertilizer alone because of deterioration of soil physical and chemical properties. So, integrated use of both organic manure and chemical fertilizer is the best approach. However, it is utmost necessary to improve the yield of cabbage through judicious use of inorganic fertilizer and organic manure. Therefore, the present investigation was initiated to find out the suitable combination of vermicompost and inorganic fertilizer for increasing sustainable cabbage production and investigate the post-harvest soil properties.

Materials and Methods

Description of the study area

The experiment was conducted at Horticulture Research Centre (HRC) in Bangladesh Agricultural Research Institute (BARI), Gazipur during winter season (October to March) of 2019-2020 and 2020-2021. Geographically, it is located at 23.99° N latitude and 90.41° E longitude and elevated of 8.4 m above sea level. The soil was terrace and the texture was clay loam belonging to the *Chhiata* soil series (Aeric Haplaquepts) under the Madhupur Tract (AEZ-28) (Shil *et al.*, 2016). The particle and bulk density of the soil was 2.50 g/cm³ and 1.35 g/cm³, respectively and the field capacity (FC) was 26%. Soil samples (0 to 15 cm depth) collected before beginning of the experiment was analyzed by the standard methods and the results are presented in Table 1.

Table 1. Fertility status of initial soil of the experimental plot

Soil	pH	OM ^a	Total N	K	P	S	B	Zn
		%		meq. 100 g ⁻¹	mg kg ⁻¹			
Initial	6.5	1.24	0.060	0.12	11.0	14.5	0.17	0.83
Critical level	5.5-6.5	3-5	0.12	0.12	8	10	0.20	0.60
	Slightly ^b acidic	Low	Very low	Low	Low	Low	Low	Low

^a OM = organic matter, ^b Interpretation source: Anonymous (2018).

The environment was subtropical, humid, and subjected to monsoons. The daily average temperatures was 13.0 to 36.1°C and yearly mean rainfall varied from 1500 to 2200 mm. Maximum and minimum monthly average temperature and average humidity, and monthly rainfall data of the experimental period of 2019-20 and 2020-21 were recorded from a meteorological station located about 351 m from the experimental field (Figures 1a, b, c).

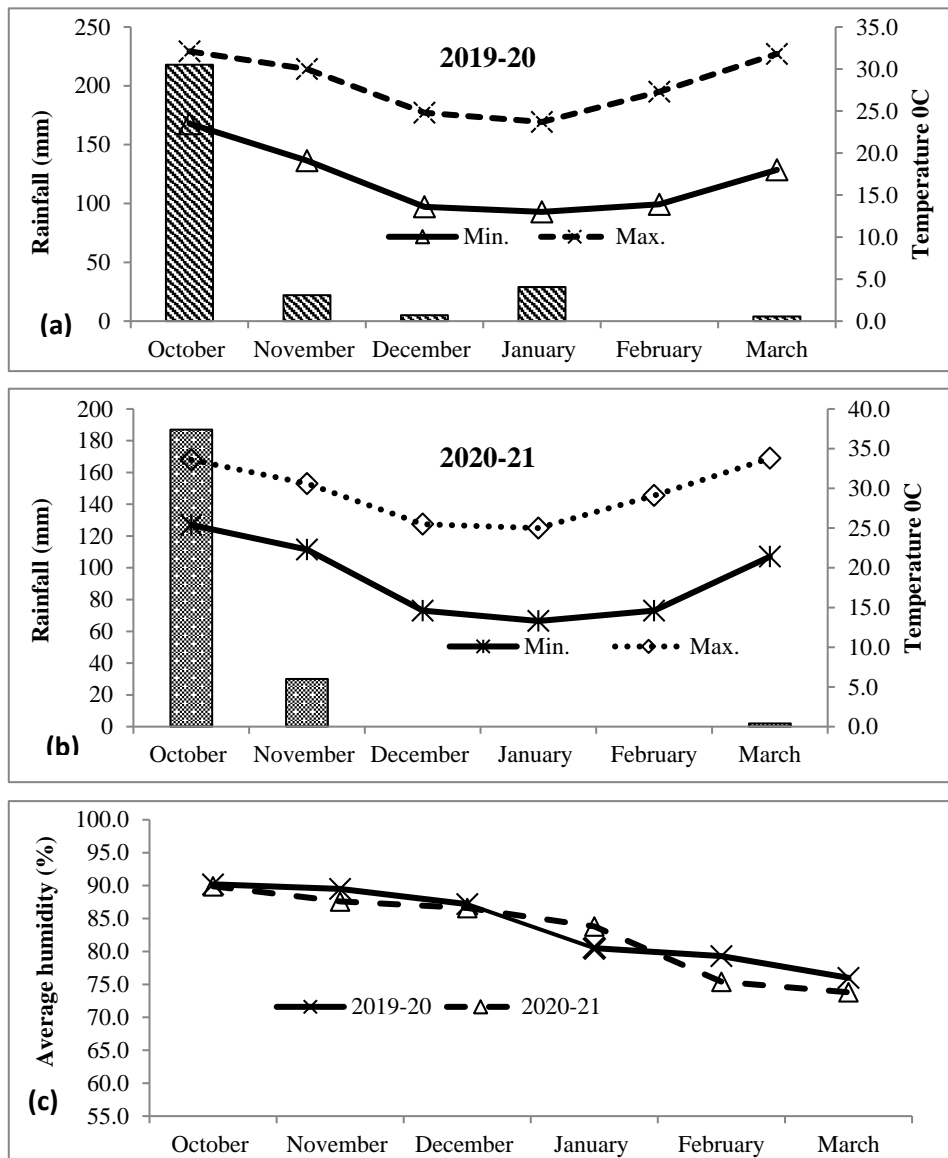


Fig. 1 Monthly average minimum and maximum temperature and rainfall (a, b) and monthly average humidity (c) during the experimental period of 2019-20 and 2020-21.

Chemical properties of vermicompost

The chemical properties of vermicompost were analyzed by standard methods and the properties are presented in Table 2.

Table 2. Nutrient status of vermicompost used in the experimental field

Name of the manure	pH	OC	K	Total N	P	S	B	Zn
		%						
Vermicompost	7.1	19.2	1.00	1.08	1.8	0.96	0.01	0.018

Cabbage seedling arising and land preparation

Cabbage seeds (cv. Atlas 70) were sown on 30 October 2019 and 31 October 2020 in raised seed bed which had been prepared manually. Irrigation was provided immediately after seed sowing. After emergence, developing seedlings were watered twice weekly. Seedlings were saved from infestation of disease (damping off) and insects using the fungicide Bavistin® and insecticide Sevin®. The soil was prepared by 4 passes with a tractor driven plough and leveled with a tractor driven rotavator. Weeds and stubbles were removed and cleaned manually.

Treatment details, manure and fertilizer application

The experimental treatments were: T₁=100% recommended dose of chemical fertilizer (RDF: N₂₀₀P₅₀K₈₀S₂₀Zn₃B_{1.5}), T₂ = 75% RDF + VC 4 t ha⁻¹, T₃ = 100% RDF+ VC 3 t ha⁻¹, T₄= 75% RDF+ VC 3 t ha⁻¹ and T₅ = Control. The experiment was laid out in a randomized complete block design with 3 replications. The unit plot size was 2.4 m × 2 m. Plots were separated by 50 cm width. Urea, triple super phosphate (TSP), muriate of potash (MoP), gypsum, zinc sulphate heptahydrate and boric acid were used as sources of N, P, K, S, Zn and B, respectively.

Entire quantity of compost and full of TSP, gypsum, zinc sulphate, boric acid and half of MoP were applied manually during the final land preparation at two days before transplanting. The total amount of urea and rest half of MoP was applied in two equal installments as ring method under moist soil condition and mixed with soil immediately by hand at 15 and 35 days after transplanting.

Planting, harvesting and intercultural operation

Thirty-day-old healthy and uniform sized cabbage seedlings were transplanted maintaining spacing row to row 60 cm and plant to plant 40 cm on 29 November 2019 and 30 November 2020, respectively. Irrigation water was applied immediately to transplanted seedlings. The second, third, fourth, fifth, sixth and seventh irrigations were provided at 2, 5, 8, 12, 16 and 20 days, respectively, to enable establishment of transplants and cabbage plants were earthen up. Irrigation water was applied

uniformly in all plots using a hose pipe, 2 to 3 times in a week. Weeding was done manually at 20 and 50 days after transplanting (DAT). Imitaf 20 SL® was applied @ 0.5 mL⁻¹ at 40 and 50 days after transplanting to control insect pest like cutworm. The mature cabbage head was harvested from each plot at different days started on 20 February to first week of March 2020 and 2021.

Data collection

The field data viz. plant height (cm), leaf length (cm), leaf breadth (cm), head thickness (cm), head diameter (cm) and individual head weight (kg) were recorded from 5 randomly selected plants with tag in inner row. Cabbage head yield (t ha⁻¹) was measured from the whole plot technique which was calculated from the head weight of randomly selected 5 cabbage plants and head weight of rest cabbage plants in plot. Fresh cabbage samples were collected from each plot and brought to the laboratory and preserved by freezing at -30°C and held for cabbage head quality analysis. Cabbage head samples were removed from the freezer to determine total soluble solid (TSS), titratable acidity, pH and vitamin C. Firmness of cabbage head was measured in ambient conditions (25±1°C). Each head sample was sliced and squeezed to extract juice. The TSS was measured by placing about 0.4 mL of juice on the prism surface of a hand refractometer (Atago Ltd., PAL-1, Tokyo, Japan) and results expressed in °Brix according to an accepted method (932.12; Anon., 1994). Titratable acidity was determined by diluting a 2 mL aliquot of juice to 10 mL with 8 mL of distilled water and 2 drops of phenolphthalein with the pH adjusted to 8.2 using 0.1 N (w/v) NaOH. Titratable acidity was estimated according to the method of Rangana (1986). The pH of the juice was determined with a digital pH meter (Metter-Toledo GmbH, CH-8603, Schwerzenbach, Switzerland). Vitamin C (ascorbic acid) was determined according to standard methods (Anon., 1994). A texture analyzer (GUSS, model GS-25, Western Cape, South Africa) was used to determine the cabbage head firmness on fresh samples. The 8 mm diameter flat end probe was inserted to 3 mm depth into cabbage head (same position of each sample) at 5 mm per sec speed. The most penetration force was used as firmness value. Three samples from each treatment were examined and averaged.

Soil and plant samples analysis

Postharvest soil samples at 0-15 cm depth were collected from each treatment for analysis. Plant samples (cabbage biomass) from each treatment were oven-dried at 70 °C for 48 h and finely ground. Each sample was preserved in polythene bags. The initial and postharvest soil samples were analyzed following standard methods. The soil pH was measured by glass electrode pH meter and organic carbon was wet oxidation method outlined by Page *et al.* (1982) and organic matter content calculated by multiplying % organic carbon with the Van Bemmelen factor of 1.73; Total N was determined by Microkjeldahl method (Page *et al.*, 1982),

available P was determined by Bray and Kurtz method (Bray and Kurtz, 1945), exchangeable K by 1N NH₄OAc method (Jackson, 1973), available S by turbidity method using BaCl₂ (Fox *et al.*, 1964); available Zn by DTPA method (Lindsay and Norvell, 1978); available B by azomethine-H method (Page *et al.*, 1982).

Di-acid mixture (HNO₃-HClO₄) (5:1) was used for digestion of plant samples. The following methods were used for the determination of NPKSZnB: N (Micro-Kjeldahl method), P (spectrophotometer method), K (atomic absorption spectrophotometer method), S (turbidity method using BaCl₂ by spectrophotometer), Zn (atomic absorption spectrophotometer method) and B (spectrophotometer following azomethine-H method).

Protein content and nutrient uptake estimation

Protein content in cabbage was estimated considering the nitrogen content as percentage. The protein content was estimated by multiplying the %N content with constant factor 6.25 that means %N × 6.25 (Hiller *et al.*, 1948).

Nutrient (N, P, K, S, Zn and B) uptake by cabbage was calculated from the result of crop biomass dry matter yield and nutrient (N, P, K, S, Zn and B) content in cabbage (Anon., 2018).

Nutrient uptake = Yield in kg ha⁻¹ × nutrient content in %/100

Statistical analysis

Collected data were subjected to analyses by statistical software Statistix-10 (Statistix-10, 1985). The means of all data were compared using the least significant difference (LSD) at a significant level $p \leq 0.05$.

Cost and return analysis

The benefit cost ratio (BCR) was calculated for a hectare of land. Management costs were calculated by adding the cost incurred from labor, ploughing, inputs etc. Cabbage head yield was utilized to calculate gross return. Shadow prices (land rent and others) were not considered. Gross return was measured by multiplying the crop yield by unit price (farm gate). Gross margin was calculated by subtracting management cost from gross return.

Results and Discussion

Plant parameters

The plant height, leaf length and leaf breadth of cabbage were significantly influenced by the application of vermicompost and inorganic fertilizers (Table 3). The maximum plant height (36.2 and 39.4 cm for 2019-20 and 2020-21, respectively) was found in T₃ (100% RD+ VC 3 t ha⁻¹), which was closely followed by T₁ (100% RDF). The lowest plant height (28.1 and 25.1 cm for 2019-20 and

2020-21, respectively) was observed in the control. Similar results were also reported by Alam *et al.* (2017) in cabbage where the maximum plant length was recorded in combination of vermicompost and inorganic fertilizer. The leaf length and leaf breadth were also followed the same trend.

The highest leaf length (31.5 cm in 2019-20 and 35.6 cm in 2020-21) was recorded from T₃ which were statistically similar to the most of the treatment in both years (Table 3). Vermicompost improves the soil structure, soil porosity, water holding capacity and boosts to supply proper nutrient for cabbage leaf length and development (Reza *et al.*, 2016). The maximum leaf breadth (21.3 cm in 2019-20 and 16.6 cm in 2020-21) was also recorded from the same T₃ treatment which was close comparable with T₄ and T₂ treatment in 2019-21 and with T₁ in 2020-21. The lowest leaf length and breadth was noted from control T₅ treatment. The result is in agreement with the findings of Ali and Kashem (2018) who reported that highest leaf length and breadth was achieved in vermicompost with inorganic fertilizer treated plot. Getnet and Raja (2013) corroborated similar that leaf length and breadth was bigger in vermicompost treated plot than others.

Table 3. Effect of vermicompost and inorganic fertilizer on growth characters of cabbage

Treatment	Plant height (cm)			Leaf length (cm)			Leaf breadth (cm)		
	2019-20	2020-21	Mean	2019-20	2020-21	Mean	2019-20	2020-21	Mean
T ₁ = 100% RDF	35.2ab	39.1a	37.2	30.8a	34.7a	32.8	19.1b	15.8ab	17.5
T ₂ = 75% RDF + VC 4 tha ⁻¹	30.9bc	38.2a	34.6	28.8a	34.5a	31.7	19.6ab	15.4b	17.5
T ₃ = 100% RDF+ VC 3 tha ⁻¹	36.2a	39.4a	37.8	31.5a	35.6a	33.6	21.3a	16.6a	19.0
T ₄ = 75% RDF+ VC 3 tha ⁻¹	31.5a-c	32.2b	31.9	29.5a	32.0a	30.8	21.3a	13.4c	17.4
T ₅ = Control (Native nutrient?)	28.1c	25.1c	26.6	17.3b	21.9b	19.6	10.4c	8.96d	9.68
CV (%)	9.88	7.36	-	9.25	6.30	-	6.35	4.06	-

Values within the same column with a common letter do not differ significantly ($P \leq 0.05$).

RDF= Recommended dose of fertilizer, VC= Vermicompost

Yield attributes of cabbage

The yield attributes of cabbage were significantly influenced by the vermicompost and inorganic fertilizer (Table 4). The maximum head thickness (12.3 cm in 2019-20 and 13 cm in 2020-21) was found in T₃, which was followed by T₂. The minimum head thickness (9.40 and 10.7 cm for 2019-20 and 2020-21,

respectively) was recorded in the control (Table 4). Similar result was also reported by Ali and Kashem (2018). The individual head weight also followed the same trend (Table 4). The head diameter was significantly influenced by the integrated nutrient management. The mean head diameter of cabbage ranged from 13.5 to 26.5 cm, having the maximum in T₃ closely followed by T₄ and the lowest in the control (Table 4). The highest yield attributes were recorded in T₃ might be due to organic (vermicompost) amendments enhanced beneficial soil microorganisms, increased soil organic matter, total carbon, and cation exchange capacity (CEC), and lowered bulk density thus improved soil quality resulted higher growth of cabbage (Bulluck *et al.*, 2002). Moreover, inorganic fertilizer supplied readily available essential plant nutrients.

Table 4. Effect of vermicompost and inorganic fertilizer on the yield attributes of cabbage

Treatment	Head thickness (cm)			Head diameter (cm)			Individual head wt. (kg)		
	2019-20	2020-21	Mean	2019-20	2020-21	Mean	2019-20	2020-21	Mean
T ₁ = 100% RDF	11.1b	12.6a	11.9	21.9a	25.5ab	23.7	2.03b	2.34ab	2.19
T ₂ = 75% RDF + VC 4 tha ⁻¹	11.1b	12.8a	12.0	21.8a	24.6b	23.2	2.05b	2.12b	2.09
T ₃ = 100% RDF+ VC 3 tha ⁻¹	12.3a	13.0a	12.7	23.8a	26.5a	25.2	2.37a	2.47a	2.42
T ₄ = 75% RDF+ VC 3 tha ⁻¹	11.7ab	11.7ab	11.7	23.2a	25.8a	24.5	2.16a	2.18b	2.17
T ₅ = Control	9.40c	10.7b	10.1	13.5b	15.3c	14.4	0.24c	0.57c	0.41
CV (%)	5.97	5.66	-	6.49	2.59	-	9.04	7.14	-

Values within the same column with a common letter do not differ significantly ($P \leq 0.05$).

RDF= Recommended dose of fertilizer, VC= Vermicompost

Head yield of cabbage

The head yield of cabbage was significantly variable among the treatments (Figure 2a). The maximum fresh head yield (98.9 and 112 t ha⁻¹ for 2019-20 and 2020-21, respectively) was found in T₃, which was identical with T₁ and T₄. The lowest mean head yield (20.6 t ha⁻¹) was noted in the control (Figure 2c). The similar results were also reported by Alam *et al.* (2017). Addition of vermicompost with inorganic fertilizer in soil enhanced the microbial activities helping nutrient availability to the crop which results higher yield (Alam *et al.*, 2017). Vimala *et al.* (2006) reported that conjunctive use of organic and inorganic sources would improve the soil health and increase yield of cabbage. Reza *et al.* (2016) reported similarly that vermicompost with inorganic fertilizer contributed to attain higher

yield of cabbage. The mean fresh head yield varied from 20.6 to 105 t ha⁻¹, having the maximum in T₃ treatment (Figure 2c). The yield due to different treatments followed the order: T₃>T₁>T₄>T₂>T₅ (Figure 2c). The highest biomass dry matter (DM) yield was found in T₃, which was significantly higher than the other treatments (Figure 2b). The lowest biomass dry matter (DM) yield was recorded in the control (Figure 1b). Karmegam and Daniel (2008) also reported that in hyacinth beans, higher dry matter production was recorded in vermicompost added plot. In the experiment, the highest head yield increment (409%) over control was found in T₃ treatment and lowest increment was in T₂ treatment (Figure 2d).

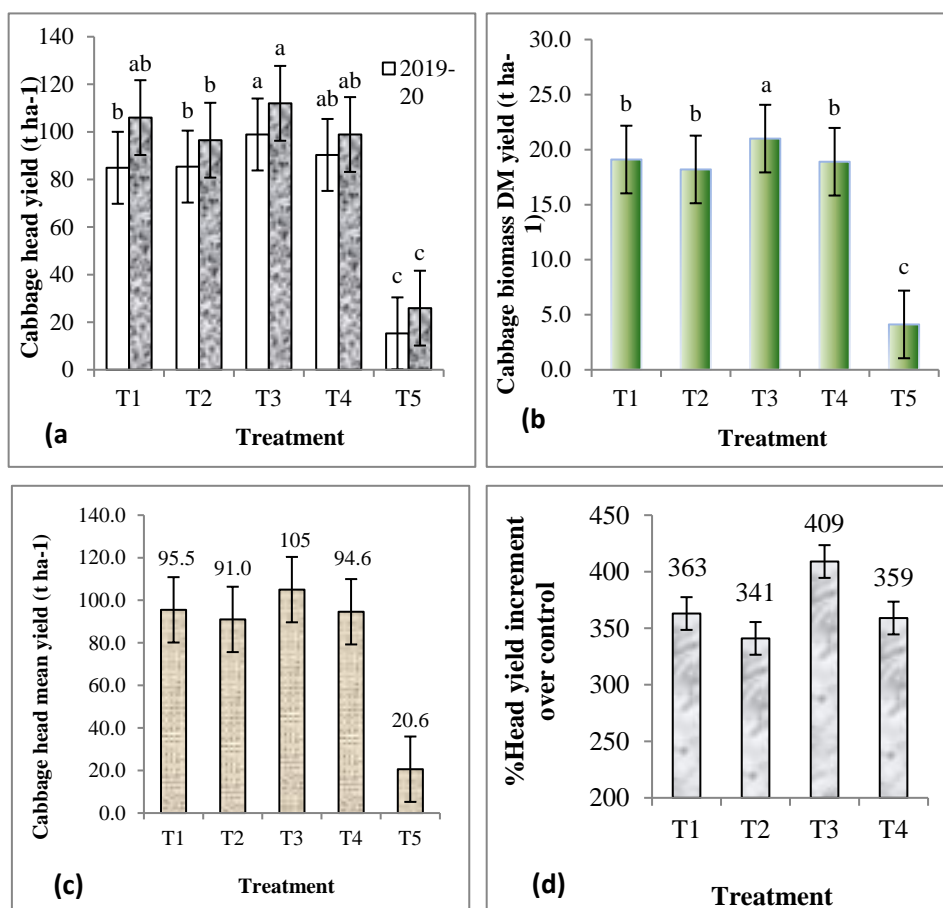


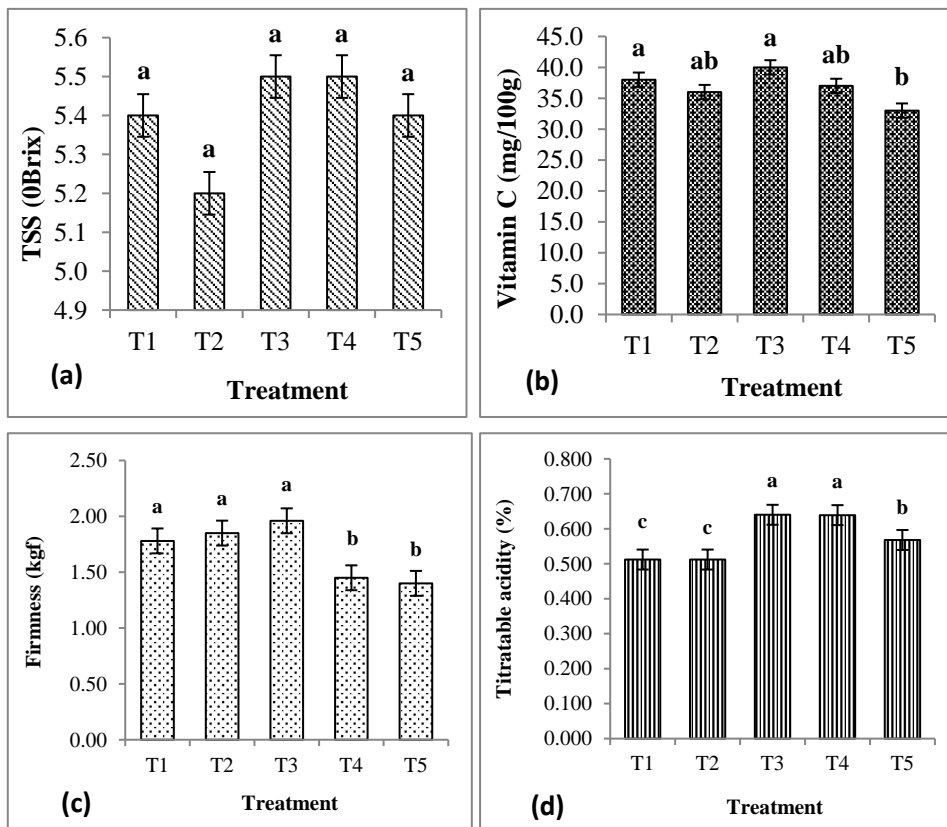
Fig. 2 Effect of vermicompost and inorganic fertilizer on fresh head yield (a), biomass dry matter mean yield (b), mean head yield of cabbage (c) and % head yield increment over control (d).

Notes: T₁ = 100% RDF, T₂ = 75% RDF + VC 4 t ha⁻¹, T₃ = 100% RDF+ VC 3 tha⁻¹, T₄= 75% RDF+ VC 3 tha⁻¹ and T₅ = Control.

Values followed by the same letter are not significantly different according to the least significant difference (LSD) test at $p \leq 0.05$.

Quality attributes of cabbage

The vitamin C, firmness, titratable acidity, pH and protein content in cabbage were significantly influenced by the application of vermicompost and inorganic fertilizer (Figure 3 (a, b, c, d, e, f)). The highest vitamin C content ($40.0 \text{ mg } 100 \text{ g}^{-1}$) was recorded in T₃ which was followed by T₁ and T₄. The lowest vitamin C was noted in the control (Figure 3b). Vitamin C content generally varied based on cultivar, plant nutrition, production practice and maturity (Antonio *et al.*, 2007). Nurhidayati *et al.* (2016) corroborated that vermicompost treated cabbage increased the content of vitamin C 57% over control. The maximum firmness (1.96 kgf) was found in T₃ which was identical to T₁ and T₂ (Figure 3c). The lowest value was recorded in the control. Mean titratable acidity varied from 0.512 to 0.640%, having the maximum (0.640%) in T₃ followed by T₄ and the lowest noted in T₁ (Figure 3d). The maximum cabbage pH (7.42) was recorded in T₁ and the lowest in T₄ treatment (Figure 3e). The protein content of cabbage was significantly variable among the treatments (Figure 3f). The highest protein content (10.6%) was found in T₃ and the lowest noted in the control (Figure 3f). Upadhyay *et al.* (2012) reported that the maximum protein content was recorded in cabbage with vermicompost treated plot.



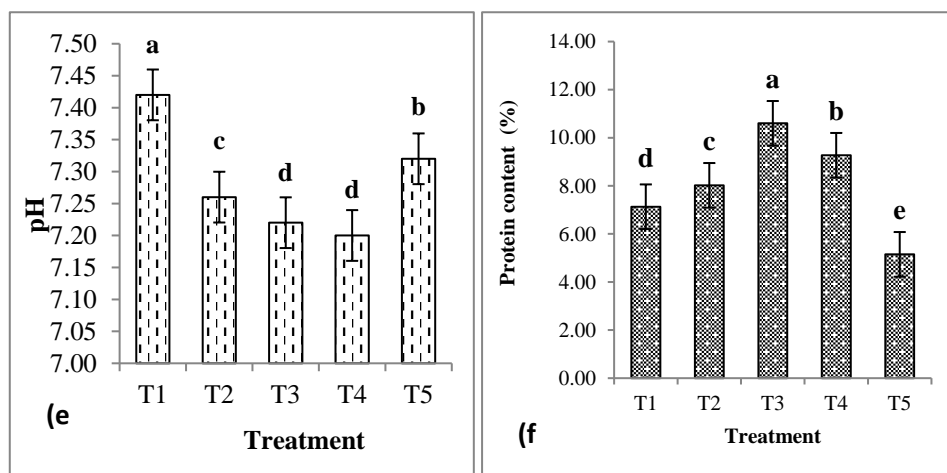


Fig. 3 Effect of vermicompost and inorganic fertilizer on TSS (a), vitamin C (b), firmness (c), titratable acidity (d), pH (e) and protein content of cabbage (f) (mean data of two years).

Notes: T₁ = 100% RDF, T₂ = 75% RDF + VC 4 t ha⁻¹, T₃ = 100% RDF+ VC 3 tha⁻¹, T₄ = 75% RDF+ VC 3 tha⁻¹ and T₅ = Control.

Mean values followed by the same letter are not significantly different at 5% level of LSD

Nutrient content in cabbage

The content of N, P, K, S, Zn, and B in cabbage was significantly influenced by the application of vermicompost and inorganic fertilizer (Table 5). Result revealed that significantly highest N content (17.0 g kg⁻¹) was found in T₃ while the minimum N content (8.23 g kg⁻¹) in the control (Table 5). The Zn and B content also showed the similar trend. The T₄ treatment showed the highest P, K and S content (4.00, 15.6 and 1.53 g kg⁻¹, respectively) in cabbage, which were significantly higher over other treatment (Table 5). The lowest P, K and S content (1.06, 5.67 and 0.47 g kg⁻¹, respectively) was recorded in the control (Table 5). The higher amount of N, Zn and B content in T₃ and P, K and S content in T₄ might be due to application of vermicompost with inorganic fertilizer increased availability of plant nutrients, organic matter content and CEC in resulted higher N, Zn, B, and P, K, S accumulation by the cabbage plant. Similar results were also reported by Reza *et al.* (2016); Maselesele *et al.* (2022); Nguyen *et al.* (2013); Anguria *et al.* (2017) in cabbage.

Table 5. Effect of vermicompost and inorganic fertilizer on nutrient content in cabbage (Pooled data of two years)

Treatment	N	P	K	S	Zn	B
	g kg ⁻¹					
T ₁ = 100% RDF	11.4d	1.07c	11.6c	1.07b	0.19b	0.17b
T ₂ = 75% RDF + VC 4 tha ⁻¹	12.8c	2.27b	11.5c	1.23b	0.23b	0.20b
T ₃ = 100% RDF+ VC 3 tha ⁻¹	17.0a	2.93b	13.8b	1.23b	0.32a	0.30a
T ₄ = 75% RDF+ VC 3 tha ⁻¹	14.8b	4.00a	15.6a	1.53a	0.31a	0.29a
T ₅ = Control	8.23e	1.06c	5.67d	0.47c	0.16b	0.16b
CV (%)	3.80	16.5	5.64	13.7	14.2	15.2

Values within the same column with a common letter do not differ significantly at 5% level of LSD.

Nutrient uptake by cabbage

The uptake of N, P, K, S, Zn and B by the cabbage was significantly influenced by the application of vermicompost and inorganic fertilizer (Figure 4a, b). The highest N uptake (359 kg ha⁻¹) was found in T₃ (100% RDF+ VC 3 t ha⁻¹), and the lowest in the control (Figure 4a). Similarly the maximum Zn and B uptake were observed in T₃, which were identical to T₄ and the minimum was noted in the control (Figure 4b). The T₄ treatment showed the maximum P, K and S uptake by the cabbage (75.6, 295 and 29 kg ha⁻¹, respectively) followed by T₃ and the lowest in the control (Figure 4a). Higher uptake of N, P and K in vegetative parts of cabbage under combined application of vermicompost and inorganic fertilizer might be due to good proliferation of root system, resulting in better absorption of these nutrients. Konyak and Sanjay-Swami (2018) reported that combination of organic (vermicompost) and inorganic fertilizer showed the higher uptake of N, P and K by the cabbage plant. Reza *et al.* (2016) also reported that vermicompost (5 t ha⁻¹) with IPNS based chemical fertilizer exhibited higher uptake of N, P, K, S, Zn and B by cabbage. Similar report corroborated by Singh *et al.* (2011).

Effect of vermicompost and inorganic fertilizer on Postharvest Soil Properties

The post-harvest properties of soil were significantly influenced by the combined application of vermicompost and inorganic fertilizer (Table 6). The soil pH of all treatment was found almost static or slightly decreased with the initial reference status (Table 6). The organic matter (OM) and total N content in soil varied significantly due to the variation of the treatments. The maximum OM (1.30%) was noted in T₂ followed by T₄. The total N content was maximum (0.064%) in T₄ treatment statistically similar to T₂ treatment (Table 6). Similar result was also corroborated by Reza *et al.* (2016) who noted that vermicompost with IPNS based

inorganic fertilizer showed the highest organic matter and total N content in postharvest soil. Kamla *et al.* (2002) reported the similar view. Ali and Kashem (2018) also reported that vermicompost with inorganic fertilizer increased the soil organic matter and total N content. The OM and total N content of all treatments were found slightly increased over the initial status. The K content in postharvest soil varied non-significantly among the treatment but decreasing trend of exchangeable K content was exhibited with the initial soil K status. The variation of post-harvest soil S was also non-significant. The Zn and B content in postharvest soil were maximum in T₃ treatment but statistically similar to T₂ treatment. The Zn and B content were slightly increased from the initial soil Zn and B status (Table 6).

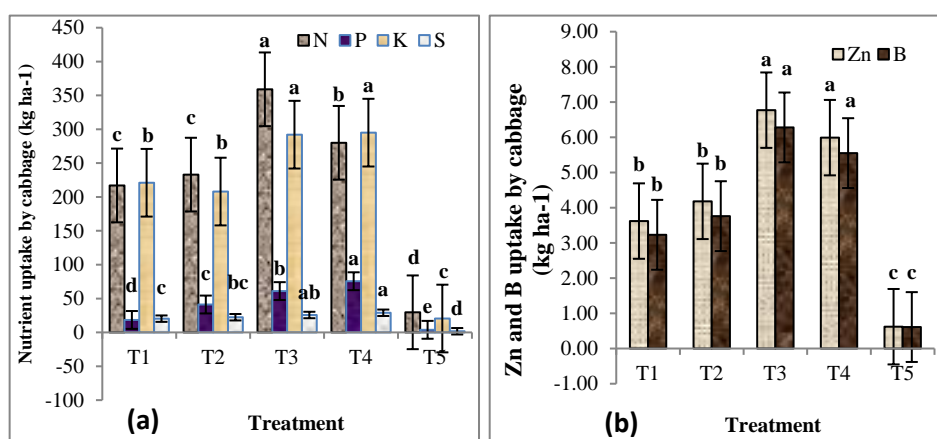


Fig. 4. Effect of vermicompost and inorganic fertilizer on N, P, K, S uptake (a) and Zn, B uptake (b) by cabbage (mean data of two years). Notes: T₁ = 100% RDF, T₂ = 75% RDF + VC 4 tha⁻¹,

T₃ = 100% RDF+ VC 3 tha⁻¹, T₄ = 75% RDF+ VC 3 tha⁻¹ and T₅ = Control.

Values followed by the same letter are not significantly different at 5% level of LSD.

Table 6. Effects of application of vermicompost and inorganic fertilizer on chemical properties of postharvest soil

Treatment	pH	OM	Total N	K	P	S	Zn	B
		----- %-----	meq. 100 g ⁻¹	----- mg kg ⁻¹ -----				
Initial soil	6.5	1.24	0.060	0.12	11.0	14.5	0.83	0.17
T ₁ = 100% RDF	6.4a	1.25b	0.061cd	0.11a	12.0ab	14.5a	0.90bc	0.18a
T ₂ = 75% RDF + VC 4 tha ⁻¹	6.5a	1.30a	0.063ab	0.11a	12.0ab	15.0a	0.91ab	0.17ab
T ₃ = 100% RDF+ VC 3 tha ⁻¹	6.4a	1.28a	0.062bc	0.10a	13.0a	14.5a	0.92a	0.18a
T ₄ = 75% RDF+ VC 3 tha ⁻¹	6.5a	1.30a	0.064a	0.11a	12.0ab	15.0a	0.89c	0.18a
T ₅ = Control	6.5a	1.24b	0.060d	0.10a	11.0b	14.0a	0.80d	0.16b
CV (%)	1.30	0.89	1.44	8.44	7.45	5.63	1.01	5.14

Values within the same column with a common letter do not differ significantly ($P \leq 0.05$)

Cost and Return Analysis

Application of vermicompost with inorganic fertilizer showed positive effect on the cost and return analysis (Table 7). Economic analysis revealed that the highest gross return (Tk.735000 ha⁻¹) and gross margin (Tk. 579340 ha⁻¹) were found in T₃. Similar results were also reported by Ray *et al.* (2018) in cabbage production. Other researchers observed comparable result like highest gross return and gross margin in cabbage by the application of vermicompost with 100% recommended chemical fertilizer (Alam *et al.* 2017). The maximum benefit cost ratio (5.33) was recorded in T₄, which was closely followed by T₁ and the lowest was observed in the control (Table 7). However the highest BCR increment 255% over control was achieved in T₄ treatment.

Table 7. Cost and benefit analysis for cabbage production as influenced by integrated nutrient management

Treatment	TVC (Tk. ha ⁻¹ yr ⁻¹)	Gross return (Tk. ha ⁻¹ yr ⁻¹)	Gross margin (Tk. ha ⁻¹ yr ⁻¹)	BCR
T ₁ = 100% RDF	125660	668500	542840	5.32
T ₂ = 75% RDF + VC 4 tha ⁻¹	134245	637000	502755	4.75
T ₃ = 100% RDF+ VC 3 tha ⁻¹	155660	735000	579340	4.72
T ₄ = 75% RDF+ VC 3 tha ⁻¹	124245	662200	537955	5.33
T ₅ = Control	96000	144200	48200	1.50

Inputs price: Ploughing (single pass) = BDT 3000 ha⁻¹, Wage rate = BDT 400 day⁻¹,

Urea = BDT 16 kg⁻¹, Triple super phosphate = BDT 22 kg⁻¹, Muriate of potash = BDT 17 kg⁻¹, Gypsum = BDT 12 kg⁻¹, Borax = BDT 150 kg⁻¹, Zinc sulphate = BDT 160 kg⁻¹, Vermicompost= BDT 10 kg⁻¹, Cabbage seed = BDT 1000 kg⁻¹, Sevin = BDT 200/100g, Imitaf= BDT 155/100 ml, Irrigation = BDT 100 hour⁻¹. Output price: Fresh cabbage head = BDT 7 kg⁻¹

Conclusion

The yield attributes and head yield of cabbage were significantly influenced by the integrated use of vermicompost and chemical fertilizer. The highest yield and yield attributes of cabbage as well as the maximum vitamin C, protein content, gross return and gross margin were found in T₃ (100% RDF + 3 t VC ha⁻¹) treatment. The maximum nutrient availability and organic matter content were recorded in T₃ and T₄ treatments. Therefore, vermicompost at 3 t ha⁻¹ along with 100% recommended dose of chemical fertilizer can be recommended for sustainable cabbage production.

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