EFFECT OF VERMICOMPOST AND PLANT VITALIZER (HB-101) ON GROWTH AND YIELD OF RED CABBAGE

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EFFECT OF VERMICOMPOST AND PLANT VITALIZER (HB-101) ON GROWTH AND YIELD OF RED CABBAGE

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CERTIFICATE

This is to certify that the thesis entitled '**Effect of Vermicompost and Plant Vitalizer (HB-101) on Growth and Yield of Red Cabbage**' submitted to the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in HORTICULTURE**, embodies the results of a piece of bona fide research work carried out by **MANNA SALWA**, Registration No. **12-04839** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that any help or source of information, received during the course of this investigation has been duly acknowledged.

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TO

MY BELOVED PARENTS

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The Author

EFFECT OF VERMICOMPOST AND PLANT VITALIZER (HB-101) ON GROWTH AND YIELD OF RED CABBAGE

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ABSTRACT

The experiment was conducted during October 2017 to February 2018 in the Horticultural farm of Sher-e-Bangla Agricultural University. The experiment consisted of two factors: Factor A: Vermicompost (3 levels) as- Vr_0: No vermicompost (control condition); Vr_1: 4 ton vermicompost/ha, Vr_2: 8 ton vermicompost/ha; and Factor B: Plant vitalizer (4 levels) as- Vi_0: No vitalizer (control condition), Vi_1: 2 ml vitalizer/*l* water, Vi_2: 4 ml vitalizer/*l* water and Vi_3: 6 ml vitalizer/*l* water. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Different levels of vermicompost and plant vitalizer influenced significantly on most of the recorded parameters. In case of different levels of vermicompost, the highest marketable yield (52.30 t/ha) was observed from Vr_2 treatment, while the lowest (38.47 t/ha) from Vr_0 treatment. For different levels of plant vitalizer, the highest marketable yield (51.62 t/ha) was found from Vi_3, whereas the lowest (39.62 t/ha) from Vi_0 treatment. The highest marketable yield (33.83 t/ha) was observed from Vr_2Vi_3, while the lowest (58.77 t/ha) from Vr_0Vi_0 treatment combination. The highest benefit cost ratio (2.64) was found from Vr_2Vi_3 and the lowest (1.67) was obtained from Vr_0Vi_0. So, combination of 8 ton vermicompost/ha and foliar application of 6 ml vitalizer/*l* water may be used for red cabbage cultivation.

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CHAPTER I

INTRODUCTION

Red cabbage (*Brassica oleraceae* L. var *capitata*) is one of the most important crops grown throughout the world. It is a member of Cole crops and important fresh and processing vegetable crop. Cole crops are biennials, but are generally grown as annuals. It is used as salad, boiled vegetable, cooked in curries, used in pickling as well as dehydrated vegetable (Manasa *et al*., 2017). Red cabbage is excellent source of vitamin C and in addition it contains anthocyanins some B vitamins, supplies some potassium and calcium to the diet 250 ml of raw cabbage contains 21 kilocalories and cooked 58 kilocalories (Haque, 2006). Among the three different forms of cabbage, the red one had highest vitamin C, tocopherol and phenolic content (Singh *et al*., 2006). So, prior to cultivation and use as food, red cabbage mainly used for medicinal purposes (Silva, 1986).

Red cabbage distinguished by exceptional health-enhancing properties and many beneficial sensory traits, has become more and more important in recent years (Wojciechowska *et al*., 2007). Chemical compounds contained in red cabbage prevent oxidative damage of DNA and also take part in the process of angiogenesis inhibition (Bast and Haenen, 2002). These processes support neoplasm diseases control, while inhibition of angiogenesis alone brings about the reduction of tumors development (Hagivara *et al*., 2002). Substances contained in red cabbage have a beneficial influence on insulin excretion in pancreas cells and anti-inflamatory properties as well (McDougall *et al*., 2007). The latter ones are attributed to active antioxidants contained in red cabbage leaves. Generally, red cabbage to vegetables characterizing the highest antioxidant properties, even stronger than those featuring spinach, broccoli, onion or tomato (Proteggente *et al*., 2002). The quantity of biologically active compounds in plants depends both on their genotype and cultivation conditions, as well as on environmental conditions. A significant role is also played by the stage of plant development and genetic factors (Pourmorad *et al*., 2006).

Manures was reffered the fertilizers that derive from animal matter, animal excreta, human excreta, and different plant matter (Dittmar *et al*., 2009). Manures improves soil structure, facilitates aeration in soil as well as increase water holding capacity by increasing regular and irregular pores and causes a priming effect of native soil organic matter. Recently organic farming is appreciated by vegetable consumers as it enhances quality of the produce. Now a days the peoples are willing to get the vegetable without the inorganic fertilizer, because the peoples are suffering with some serious disease which are due to the affect of inorganic fertilizers (Relf *et al*., 2002). Increased consumer awareness of food safety issues and environmental concerns has contributed to the development of organic farming over the last few years (Worthington, 2001). In particular, the vegetable crops respond positively to the application of different organic supplements, although the recommendations on application rates vary between different researchers and type of fertilizers that used for crop production (Polat *et al*., 2004; Jae-Jung *et al*., 2004; Mastouri *et al*., 2005).

In global movement for the second 'Green Revolution' ought to emphasize on composting, particularly vermicomposting. Vermicomposting can be done indoors and outdoors around the year in relatively less time, which are physically, nutritionally and biochemically improved over composts. Vermicomposting is defined as a low cost technology system for processing or treatment of organic waste (Abul-Soud *et al*., 2014). Vermicompost is produced through the interactions between earthworms and microorganism in the breakdown of organic wastes and to convert into nutritional rich humas (Dominguez *et al*., 1997). Earthworms speed up the composting process, aerate the organic material in the bin, and enhance the finished compost with nutrients and enzymes from their digestive tracts. Integration of vermicompost and other nutrients elements may facilitate the utilization of different nutrients for crop growth and productivity and help replenish the organic matter status in the soil (Rai *et al*. (2013). Among the sources of organic manures, vermicompost is a potential source due to the presence of readily available plant nutrient and number of beneficial micro-organisms such as N fixing, P solubilizing and cellulose decomposing organisms. It increases macropore space that improved air-water relationship in the soil which favorably affects plant growth and development. Vermicompost favorably affects soil pH, microbial population and soil enzyme activities (Maheswarappa *et al*., 1999).

Vitalizer (HB-101) is an organic plant growth enhancer, a unique blend of the essences of Japanese cedar, pine, cypress and plantain grass (Anon., 2019). HB-101 is neither an agricultural chemical nor a plant fertilizer. The use of vitalizer has been started in European countries for the last few years and getting remarkable responses in regards of attained more yield. As vitalizer HB-101 is a purely natural extract derived from the portion of plant that is important growth nutrient for plants, flowers and crop production. It is 100% organic product, safe for plants and animals and designated to benefit the earth environment. It is an all-natural solution that supports healthy plants by strengthening the cells and increasing photosynthetic efficiency. HB-101 plant vitalizer, which itself contains ionized minerals that enhanced the activity of the micro-organisms, insuring that the necessary balance of plant nutrients. Continuous application of HB-101 improves soil fertility and contributes to the higher marketable yield and superior corps in the upcoming and future years. Hence, HB-101 is referred to as a plant “vitalizer”, or plant growth enhancer (Anon., 2019).

Considering the above mentioned facts this experiment will satisfy the following objectives:

- To determine the influence of vermicompost levels on growth and yield of red cabbage.
- To study the effect of plant vitalizer levels on growth and yield of red cabbage.
- To find out the combined effect of vermicompost and plant vitalizer level on growth and yield of red cabbage.

Chapter II

Review of Literature

CHAPTER II

REVIEW OF LITERATURE

Red cabbage one of the most important herbaceous short duration cool season vegetables distinguished by a short stem upon which is crown with a mass of red colored leaves (head) and newly introduced in Bangladesh agriculture. The potential yield of red cabbage is determined by appropriate husbandry practices and the surrounding environment that was provided to the cultivation of this crop. Among the husbandry practices, organic culture especially vermicompost and vitalizer HB-101 may play an important role but a very few studies on the growth and yield of red cabbage have been carried out in our at home and also abroad. The research work so far done in this aspects is not adequate and conclusive. However, some of the important and informative works and research findings related to vermicompost and vitalizer HB-101 on red cabbage or cabbge or other crops of this family so far been done at home and abroad have been reviewed in this chapter under the following headings-

2.1 Effect of vermicompost

An experiment was conducted by Ismail *et al*. (2017) to investigate the effect of vermicompost application in red cabbage cultivation under the field conditions. The treatments included in the study were: U-0 (control), U-1 (0 kg da^{-1} vermicompost + N:P:K), U-2 (100 kg da^{-1} vermicompost + N:P:K), U-3 (200 kg da^{-1} vermicompost + N:P:K), U-4 (400 kg da^{-1} vermicompost + N:P:K) and U-5 (800 kg da^{-1} vermicompost + N:P:K). The results indicated that quality parameters, mineral nutrient status and yield were positively affected by vermicompost applied in increasing doses. Vermicompost applications appeared to be effective in achieving sufficient levels in foliar N, P, Fe, Zn, and Mn contents and yield of red cabbage was found to be 52.65% higher than the control. Based on these results and economic factors, it was concluded that, in addition to mineral fertilizers, application of vermicompost in the rate of 400 kg da^{-1} may be recommended for red cabbage cultivation.

Ahmed *et al*. (2017) was carried out a study during two successive winter seasons of 2014/2015 and 2015/2016 under green roof system condition at the Central Laboratory for Agricultural Climate, Agricultural Research Center, Egypt with aimed to optimize the use of local substrates (sand and rice husk) and provide vermicomposting technique for recycling the urban organic wastes through investigate different vermicompost rates (10, 20 and 30%) as a substrate amendment mixed with sand: rice husk (1:1V/V) compared to peat moss : perlite (1:1V/V) (control) combined with three different volume of pots (4, 6, and 8 L) on vegetative growth, yield and quality of celery and red cabbage. The obtained results indicated that increasing pot volume from 4 to 8 L of substrate led to increase the vegetative and yield of red cabbage in reverse to the economic efficiency. The medium pot volume of substrate gave the highest economic yield of red cabbage compared to the other volumes. Increasing the rate of vermicompost from 10 to 20% led to increase the vegetative and yield characteristics of red cabbage while increasing up to 30% had a negative impact.

The field experiment was conducted by Alam *et al*. (2017) 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 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 (59.21 t ha^{-1} and 72.61 t ha^{-1}, respectively) where the lowest yield was obtained from T_7 (27.11 t ha^{-1} and 24.05 t ha^{-1}, respectively). The highest gross margin was calculated in T_4 (203,060 and 270,060 Tk. ha^{-1} in 2014-15 and 2015-16, respectively) and the lowest was in T_7 (74,300 and 59,000 Tk. ha^{-1} in 2014-15 and 2015-16, respectively).

Reza *et al.* (2016) carried out an experiment to investigate nutrient uptake, growth and yield of the cabbage (*Brassica oleracea* var. capitata) variety'Atlas-70'as influenced by the application of different organic fertilizers. Treatments were T_1= Soil Test Based 100% Recommended Dose of Chemical Fertilizer (RDCF), T_2= 5 t/ha Cow dung (CD) + integrated plant nutrient system (IPNS) based Chemical fertilizers (CF), T_3=5 t/ha Poultry Manure (PM) + integrated plant nutrient system (IPNS) based Chemical fertilizers (CF), T_4= 5 t/ha vermicompost (VC) + integrated plant nutrient system (IPNS) based Chemical fertilizers (CF), T_5= Absolute control. Results of the experiment showed that the same amount of N, P, K and S from cowdung, poultry manure and vermicompost showed significant differences on plant height, unfolded leaves, head circumference, marketable yield, total yield and nutrient content in cabbage.

A pot experiment was conducted by Nurhidayati *et al.* (2016) to assess the effect of three kinds of vermicompost materials and *P. corethrurus* population on plant yield and quality of cabbage under organic growing media compared with inorganic treatment. The first factor is the kind of vermicompost material which consists of three levels (the mixture of mushrooms media waste, cow manure, and vegetable wastes (V_1), mushrooms media waste, cow manure and leaf litter (V_2), mushrooms media waste, cow manure, vegetable wastes and leaf litter (V_3). The results showed that the application of various vermicompost had significantly higher yields than the inorganic treatment. Vermicompost V_1 and V_2 gave the highest yield. The results suggest that the application of vermicompostcan increase the yield and quality of cabbage.

An investigation was made by Sajib *et al.* (2015) on yield performance of cabbage under different combinations of manures and fertilizers at Hogladanga village under Botiaghata upazila, Khulna. 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.

Getnet and Raja (2013) conducted an experiment with aim to produce vermicompost from organic solid wastes by using red earthworm, *Eisenia fetida* and to check growth promoting and pest suppression properties on cabbage, *Brassica oleracea*. Vermicompost was applied at the rate of 25, 50, 100 and 200gm/plant individually. Each application 10 plants were selected and vermicompost application was continued on bimonthly basis. Total number of leaves per plant; leaf length and width; plant stand height and root length; cabbage head round distance and weight were the parameters studied. The number of plant stand height, cabbage head, leaves of cabbage were also significantly different in experimental cabbage compared to control. In conclusion vermicompost have significant impact on cabbage growth promotion.

Chatterjee *et al*. (2013) conducted a field experiments at UBKV, Pundi bari, West Bengal, India to access the influence of different organic amendments on growth, head yield and nitrogen use efficiency in cabbage. The experiment comprised of 15 different nutrients source combining inorganic fertilizers, organic manures (farmyard manure and vermicompost) and Azophos biofertilizers. Growth and head attributes of cabbage were significantly influenced by different nutrient combination and vermicompost emerged as better organic nutrient source over farmyard manure. The nutrient schedule comprising of higher amount of vermicompost (5 t/ha) along with 75% of recommended inorganic fertilizers in presence of biofertilizer inoculation emerged as potential nutrient source and resulted in many fold improvement in the form of vigorous growth, advanced head maturity, maximum curding percent and highest head yield as compared other nutrient combination.

An experiment conducted by Pour *et al*. (2013) to evaluate the possible effects of different concentrations of vermicompost on the growth and physiology of cabbage seedling. Vermicompost were used at five different levels (0, 10%, 20%, 40% and 80%). The seeds were planted in five different prepared soil mixtures with vermicompost and grouped in five different treatment groups including control (C), vermicompost of 10% (V_{10}), vermicompost of 20% (V_{20}), vermicompost of 40% (V_{40}) and vermicompost of 80% (V_{80}). Findings revealed that the applied vermicompost affected the leaf characteristics i.e. number of produced leaves, leaf area, fresh and dry mass. These findings indicated that the effects of vermicompost on plant growth and development not only were nutritional but also hormonal and biochemical and the utilization of high levels of vermicompost, especially at seedling stage, neither is not only economic but also may have adverse effects on the plant growth and development.

Rai *et al*. (2013) carried out an experiment to assess the effect of vermicompost, integrated with different rates of recommended doses of NPK for growth, yield and quality of cabbage. The investigation was laid out in RCBD with ten treatments viz., T_1: 100% NPK (RR), T_2: 75% NPK (RR) + VC 3 t/ha, T_3: 75% NPK (RR) + VC 2 t/ha, T_4: 75% NPK (RR) + VC 1 t/ha, T_5: 75% NPK (RR), T_6: 50% NPK (RR) + VC 3 t/ha, T_7: 50% NPK (RR) + VC 2 t/ha, T_8: 50% NPK (RR) + VC 1 t/ha, T_9: 50% NPK (RR) and T_{10}: VC 5 t/ha. The results revealed that combined use of vermicompost and recommended dose of NPK were statistically significant towards the growth and yield of cabbage. The combined use of recommended dose of 75% NPK (RR) +VC 3 ton/ha, had recorded the maximum gross weight of the plant and net weight of head. Application of vermicompost along with inorganic fertilizers reduced the days taken to maturity. It was concluded that application of vermicompost in combination with inorganic NPK fertilizers increased the productivity of cabbage.

An experiment was conducted by Zhenyu and Yongliang (2005) to test efficiency of vermicompost, and two crops were produced. The results showed that employing vermicompost could increase available nutrients, promote the growth of leaf area, accelerate accumulation of dry matter, when the first and second crops were finished, compared to the treatment of no fertilizer, only applying vermicompost increased yield of cabbage by 45.5% and 77.5%, applying vermicompost with inorganic fertilizer increased yield by 76.1% and 103.9%, the differene was great significant.

Ghuge *et al*. (2007) conducted a field experiment during in Parbhani, Maharashtra, India to assess the effect of combined use of organic and inorganic nutrients sources on the growth and yield of cabbage. The experiment was consisted of 10 treatments. Among the treatments 50% RDF + 50% vermicompost gave the maximum plant spread, head circumference and head weight and total marketable yield of cabbage.

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

2.2 Effect of vitalizer on crops

Flora Co., Ltd. developed the organic plant growth enhancer vitalizer HB-101, a unique blend of the essences of Japanese cedar, pine, Japanese cypress and plantain grass (Anonymous, 2019). HB-101 is a liquid plant growth enhancer formula, specially processed by blending the extracts of cedars, pines, cypress trees and plantains. Cedars, pines and cypresses are long-lived trees with powerful deodorizing power. The saps and secondary metabolites of these trees are responsible for maintaining the health and longevity of the trees. Plantains are known to have medicinal qualities and have long been used for various human medications. HB-101 plant vitalizer is a purely natural extract derived from the portion of a plant that is most important in its development process. HB-101 is a growth nutrient for plants, flowers and crop production and is not a chemical fertilizer. HB-101 is a 100% organic product, safe for plants and animals, and designed to benefit the earth's environment while reducing the demand for costly fertilizers. HB-101 is formulated and bottled in a ready-to-dilute solution for easy and immediate use. Highly concentrated, it's a cost-efficient way to achieve healthier, more vibrant plants.

Anonymous (2019) stated that HB-101 is an OMRI listed plant growth enhancer, which

- Improves the efficiency of the plant's metabolism to induce increased yield and higher crop quality,
- Facilitates nutrient uptake,
- Enhances crop quality attributes including sugar content and color,
- Enhances soil fertility by fostering the development of soil micro-organisms,
- Enhances plant's vigor and increase plant's tolerance to and recovery from abiotic stresses, and
- Decreases transplant shock.

HB-101 treated cops maintain longer shelf life and tolerate to long shipment, which reduces shipping markdowns and expands market to overseas. Continuous application of HB-101 improves soil fertility and contributes to the higher marketable yield and superior corps in the upcoming and future years (Anonymous, 2019).

Plants need the sunlight, air (carbon dioxide and oxygen), water and soil (minerals and micro-organisms) to grow. If the delicate balance of these elements is not maintained, growth is slowed or stopped. Sunlight and carbon dioxide are absorbed into the plant's system through its leaves, where photosynthesis produces glucose and other nutrients necessary for survival. When HB-101 solution is sprayed onto foliage and applied to the soil, the plant absorbs necessary nutrients from the soil. These plant nutrients are combined with ionized calcium and sodium from HB-101 and absorbed into the leaves' cells, thereby strengthening the cells and increasing photosynthetic efficiency. This results in greener leaves and stronger, healthier plants (Anonymous, 2019).

Water and nutrients, especially calcium, are necessary for the development of leaves and roots, but many minerals cannot be absorbed into the plant's system in their solid form. These minerals have to be converted to an ionic state in order to be easily absorbed through the roots, and this is done by micro-organisms living in the soil. By applying HB-101 plant vitalizer, which itself contains ionized minerals, the activity of these micro-organisms is enhanced, insuring that the necessary balance of plant nutrients is maintained. In addition, HB-101 contains significant quantities of saponin, a metabolite which replenishes micro-organisms with oxygen. The stem is the pathway by which nutrients are transported to and from the leaves and roots, and it is also the backbone of the plant. Healthy cells and sufficient nourishment result in the smooth distribution of carbohydrates, which are necessary for strengthening cell membranes. With the introduction of HB-101, nutrient flow from the leaves and roots is maximized, contributing to the development of the stem (Anonymous, 2019).

Soil should be soft and contain a good balance of water and air, and should allow good drainage after rain or irrigation. It should also maintain proper moisture even during sunny weather and should be neutral to mildly acidic. In such conditions, the balance of micro-organisms in the soil will be favorable. However, factors such as acidic rain, agricultural chemicals, and repeated cultivation can harm the soil and stunt the growth of the essential microorganisms. With HB-101 plant vitalizer, the propagation and proper balance of these micro-organisms can be maintained. It is ideal for both the home gardener and use in sustainable farming practices (Anonymous, 2019).

An experiment was conducted by Mohammadi *et al*. (2013) to investigate the effects of natural and chemical fertilizers on yield and quality of potato at the Agricultural Research Farm of Razi University, Kermanshah, Iran. The first factor was tuber inoculation with Nitragin biofertilizer at two levels: non inoculated and inoculated. The second factor was HB-101 (a completely organic natural extract) with three levels: non sprayed, one time and two times sprayed onto the potato foliage during the growing season. The third factor was chemical urea fertilizer. The results showed that the factors had significant effects on tuber yield, tuber weight, and number of tuber per plant, biological yield and harvest index. The highest tuber yield and the number of tuber per plant were obtained when the tubers were inoculated with nitragin; and HB-101 was sprayed two times. It is concluded that integrated application of natural and biological fertilizers along with urea can be useful to enhance potato yield and quality.

Above cited reviews revealed that vermicompost and vitalizer greatly influences the growth and as well as yield. The literature revealed that the effects of vermicompost is more or less conclusive but vitalizer in red cabbage have not been yet studied well and have no definite conclusion for the production of red cabbage under the agro climatic condition of Bangladesh.

Chapter III

Materials and Methods

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted to find out effect of vermicompost and plant vitalizer (HB-101) on growth and yield of red cabbage. The materials and methods that were used for conducting the experiment have been presented in this chapter. It includes a short description of the location of experimental site, soil and climate condition of the experimental plot, materials used and design of the experiment, data collection procedure and data analysis.

3.1 Experimental site

3.1.1 Experimental period

The field experiment was conducted during the period of October 2017 to February 2018.

3.1.2 Experimental location

The present study was conducted in the Horticultural farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207. The location of the site is $23^0 74^/$N latitude and $90^0 35^/$E longitude with an elevation of 8.2 meter from sea level. A map of the experimental location presented in Appendix I.

3.1.3 Soil characteristics

The soil of the experimental field belongs to the Tejgaon series under the Agroecological Zone, Madhupur Tract (AEZ-28) and the General Soil Type is Deep Red Brown Terrace Soils. A composite sample was made by collecting soil from several spots of the field at a depth of 0-15 cm before the initiation of the study. The collected soil was air-dried, grind and passed through 2 mm sieve and analyzed at Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka for some important physical and chemical properties. The soil was having a texture of sandy loam with pH and organic matter capacity 5.9 and 0.78%, respectively and the the soil composed of 26% sand, 43% silt, 31% clay. Details descriptions have been presented in Appendix II.

3.1.4 Climatic condition of the experimental site

Experimental area is situated in the sub-tropical climate zone, which is characterized by heavy rainfall during the month of April to September and scanty rainfall during the rest of the year. The monthly average temperature, humidity, rainfall and sunshine hour during the crop growing period were collected from Weather Yard, Bangladesh Meteorological Department, and presented in Appendix III. During the experimental period the maximum temperature (27.7^{0}C) was recorded in the month of February 2018, whereas the minimum temperature was (12.2^{0}C) in January 2018. The highest humidity (81%) was recorded in the month of October, 2017, while the highest rainfall (30 mm) in February 2018 and the highest sunshine hour (6.9 hr) in October, 2017.

3.2 Experimental details

3.2.1 Planting materials

The test crop used in the experiment was red cabbage hybrid variety Ruby King and the seeds were collected from Siddique Bazar, Dhaka.

3.2.2 Treatment of the experiment

The experiment consisted of two factors:

Factor A: Vermicompost (3 levels) as

- i Vr_0: No vermicompost (control condition)
- ii. Vr_1: 4 ton vermicompost/ha
- iii. Vr_2: 8 ton vermicompost/ha

Factor B: Plant vitalizer (4 levels) as

- i. Vi_0: No vitalizer (control condition)
- ii. Vi_1: 2 ml vitalizer/*l* water
- iii. Vi_2: 4 ml vitalizer/*l* water
- iv. Vi_3: 6 ml vitalizer/*l* water

There were 12 (3×4) treatments combination such as Vr_0Vi_0, Vr_0Vi_1, Vr_0Vi_2, Vr_0Vi_3, Vr_1Vi_0, Vr_1Vi_1, Vr_1Vi_2, Vr_1Vi_3, Vr_2Vi_0, Vr_2Vi_1, Vr_2Vi_2 and Vr_2Vi_3.

3.2.3 Design and layout of the experiment

The two factorial experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The total area of the experimental plot was 167.2 m^2 with length 20.9 m and width 8.0 m which were divided into three equal blocks. Each block was divided into 12 plots where 12 treatments combination allotted at random. There were 36 unit plots and the size of each plot was 2.0 m × 1.2 m. The distance between two blocks and two plots were 0.5 m and 0.5 m, respectively. The layout of the experiment is shown in Figure 1.

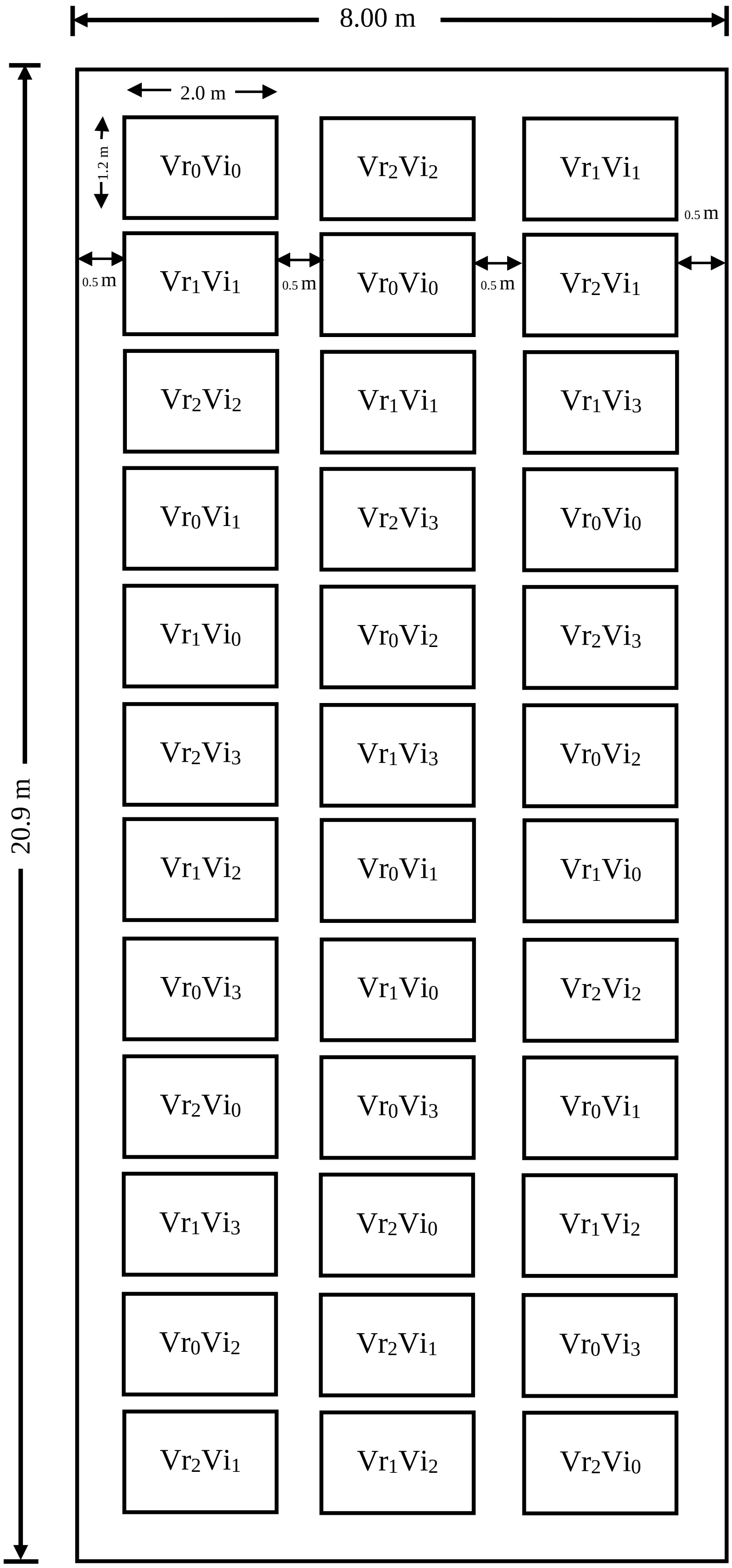
3.3 Growing of crops

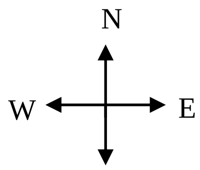
3.3.1 Raising of seedlings

The seedlings of red cabbage were raised at the Horticultural Farm, SAU, Dhaka in a 3 m × 1 m size seed bed. The soil of the seed bed was well ploughed and prepared into loose friable dried masses and to obtain good tilth. Weeds, stubbles and dead roots of the any previous crop were removed. To control damping off disease cupravit fungicide were applied. Ten (10) grams of seeds were sown in each seedbed on October 20, 2017. After sowing, the seeds were covered with finished light soil. At the end of germination shading was done by bamboo mat (chati) over the seedbed to protect the young seedlings from scorching sunshine and heavy rainfall. Light watering, weeding done as and when necessary to provide seedlings with ideal condition for better growth.

3.3.2 Preparation of the main field

The selected plot of the experiment was opened in the 5th September 2017 with a power tiller and left exposed to the sun for a week. Subsequently cross ploughing was done five times with a country plough followed by laddering to make the land suitable for transplanting the seedlings. All weeds, stubbles and residues were eliminated from the field. Finally, a good tilth was achieved.





Plot size: 2.0 m × 1.2 m

Plot spacing: 0.50 m

Between block: 0.50 m

Factor A: Vermicompost
(3 levels) as

i. Vr$_0$: No vermicompost (control condition)

ii. Vr$_1$: 4 ton vermicompost/ha

iii. Vr$_2$: 8 ton vermicompost/ha

Factor B: Plant Vitalizer
(4 levels) as

i. Vi$_0$: No vitalizer water (control condition)

ii. Vi$_1$: 2 ml vitalizer/*l* water

iii. Vi$_2$: 4 ml vitalizer/*l* water

iv. Vi$_3$: 6 ml vitalizer/*l* water

Figure 1. Layout of the experimental plot

3.3.3 Application of manure and fertilizer

It was completely a organic culture of red cabbge and no chemical fertilizer were used in this experiment. Accoding to the treatment of the experiment vermicompost and vitalizer HB-101 were used as a source of nutrients for this experiment in red cabbage cultivation.

3.3.4 Preparation and use of vitalizer

Before the foliar apllication of vitalizer it's soluation was prepared and for the preparation of 2, 4 and 6 ml vitalizer soluation 2, 4 and 6 ml of vitalizer were dissolved in 1 litre of water. As per treatment vitalizer was applied by a hand sprayer at 15 and 45 DAT (Days after transplanting) as foliar application.

3.3.5 Transplanting of seedlings

Healthy and uniform seedlings of red cabbage of 25 days old were transplanted in the experimental plots on 15 November, 2017. The seedlings were uploaded carefully from the seed bed to avoid damage to the root system. To minimize the damage to the roots of seedlings, the seed beds were watered on hour before uprooting the seedlings. Transplanting was done in the afternoon. The seedlings were watered immediately after transplanting. Seedlings were sown in the plot with maintaining distance between row to row and plant to plant was 50 cm and 40 cm, respectively. The young transplants were shaded by banana leaf sheath during day time to protect them from scorching sunshine up to 7 days until they were set in the soil. They (transplants) were kept open at night to allow them receiving dew. A number of seedlings were also planted in the border if the experimental plots for gap filling.

3.3.6 Intercultural operation

After raising seedlings, various intercultural operations such as gap filling, weeding, earthing up, irrigation pest and disease control etc. were accomplished for better growth and development of the red cabbage seedlings.

3.3.6.1 Gap filling

The transplanted seedlings in the experimental plot were kept under careful observation. Very few seedlings were damaged after transplanting and such seedling were replaced by new seedlings from the same stock. Replacement was done with healthy seedling having a boll of earth which was also planted by the side of the unit plot. The transplants were given shading and watering for 5 days for their proper establishment.

3.3.6.2 Weeding

The hand weeding was done 20 and 40 days after transplanting to keep the plots free from weeds.

3.3.6.3 Earthing up

Earthing up was done at 20 and 40 days after transplanting by taking the soil from the space between the rows by a small spade.

3.3.6.4 Irrigation

Light watering was given by a watering cane at every morning and afternoon. Following transplanting and it was continued for a week for rapid and well establishment of the transplanted seedlings. Iriigation was also provided at 20 and 40 days after transplanting followed by weeding and earthing up.

Plate 1. Photograph showing experimental field

3.4 Harvesting

Harvesting of the red cabbage was not possible on a certain or particular date because head initiation as well as head at marketable size in different plants were not uniform or similar probably due to different management practices and other factors. Only the compact marketable heads were harvested with 15 cm long fleshy stalk by using as sharp knife. Before harvesting of the cabbage head, compactness of the head was tested by pressing with thumbs.

Plate 2. Photograph showing mature harvested red cabbage

3.5 Data collection

Five plants were randomly selected from the middle rows of each unit plot for data collection and also for avoiding border effect. Head yield of red cabbage was recorded plot wise for estimating hectare yield of red cabbage. Data were collected in respect of the following parameters to assess plant growth; yield attributes and yields as affected by different treatments of the experiment. Data on plant height, number of leaves/plant and length and bredth of longest leaf were collected and recorded at 20, 30, 40 and 50 days after transplanting (DAT) and at harvest. All other yield contributing characters and yield parameters were recorded during harvest and after harvest accordingly.

3.5.1 Plant height

Plant height of red cabbge was measured from sample plants in centimeter from the ground level to the tip of the longest leaf and mean value was calculated. Plant height was also recorded at 10 days interval starting from 20 days after Transplanting (DAT) upto 50 days and at harvest to observe the growth rate of the red cabbage plants.

3.5.2 Number of leaves/plant

The total number of leaves/plant was counted from each selected plant. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot at 10 days interval starting from 20 days after transplanting (DAT) upto 50 days and at harvest.

3.5.3 Length of largest leaf

The distance from the base of the petiole to the tip of largest leaf was considered length of leaf. It was measured with a meter scale and was recorded in centimeter (cm). Data were recorded as the average of 5 leaves selected at random from the inner rows plant of each plot at 10 days interval starting from 20 days after transplanting (DAT) upto 50 days and at harvest.

3.5.4 Breadth of largest leaf

The breadth of largest leaf was recorded as the average of 5 leaves selected at random from the inner rows plant of each plot at 10 days interval starting from 20 days after transplanting (DAT) upto 50 days and at harvest.

3.5.5 Days from transplanting to head formation

Each plant of the experiment plot was kept under close observation to count days required for head formation. Total number of days from the date of transplanting to the visible head formation was recorded.

3.5.6 Length of stem

The length of stem was taken from the ground level to base of the head during harvesting. A meter scale used for this and was expressed centimeter (cm).

3.5.7 Diameter of stem

The diameter of the stem was measured at the point where the central head was cut off. The diameter of the stem was recorded in three dimensions with scale and the average of three figures was taken into account in centimeter (cm).

3.5.8 Fresh weight of stem per plant

The fresh weight of stem per plant was recorded at the time of harvest cabbage from the average of five (5) selected plants in grams (gm) with a beam balance.

3.5.9 Dry matter content of stem

At first selected stem were collected, cut into pieces and was dried under sunshine for a 3 days and then dried in an oven at 70^0C for 72 hours. The sample was then transferred into desiccators and allowed to cool down at room temperature. The final weight of the sample was taken. The dry matter contents in stem of red cabbage were computed by simple calculation from the weight recorded using the following formula:

$$\text{Dry matter content in stem (\%)} = \frac{\text{Dry weight of stem}}{\text{Fresh weight of plant}} \times 100$$

3.5.10 Length of root

The length of root was considered from the base of the tip of the root. It was measured in centimeter (cm) with a meter scale after harvesting.

3.5.11 Thickness of head

The thickness of head was measured in centimeter (cm) with a meter scale as the vertical distance from the lower to the upper most leaves of the head after sectioning the head vertically at middle position and mean value was calculated.

3.5.12 Diameter of head

The heads from sample plants were sectioned vertically at the middle position with a sharp knife. The diameter of the head was measured in centimeter (cm) with a meter scale as the horizontal distance from one side to another side of the widest part of the sectioned head and mean value was recorded.

3.5.13 Gross weight of head

The heads from sample plants were cleaned by removing unfolded leaves. The weight of every head were taken by a weighing machine and recorded.

3.5.14 Dry matter content of head

At first selected head were collected, cut into pieces and was dried under sunshine for a 3 days and then dried in an oven at 70^0C for 72 hours. The sample was then transferred into desiccators and allowed to cool down at room temperature. The final weight of the sample was taken. The dry matter contents in head of red cabbage were computed by simple calculation from the weight recorded using the following formula:

$$\text{Dry matter content in stem (\%)} = \frac{\text{Dry weight of stem}}{\text{Fresh weight of plant}} \times 100$$

3.5.15 Marketable yield per plant

The fresh weight of compact head at harvest after removing the loose leaves, stem and root was recorded as the average of 5 plants selected at random from each unit plot. The weight of the total head of red cabbage was recorded immediately after harvest the harvest of the crop.

3.5.16 Marketable yield per hectare

The weight of all compact head excluding leaves, stem and root that produced in a plot was taken and converted into yield per hectare of head of red red cabbage and was expressed in ton. The weight of the total head was recorded immediately after the harvest of the crop.

3.6 Statistical analysis

The data obtained for different characters were statistically analyzed to find out effect and the significance of the difference for using vermicompost and plant vitalizer on yield and yield contributing characters of red cabbage. The mean values of all the recorded parameters were evaluated and analysis of variance was performed by the ‘F’ (variance ratio) test using MSTAT-C software. The significance of the difference among the treatment and treatment combinations of means under the experiment was estimated by Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

3.7 Economic analysis

The cost of production was analyzed in order to find out the most economic combination of vermicompost and plant vitalizer. All input cost included the cost for lease of land and interests on running capital in computing the cost of production. The interests were calculated @ 13% in simple rate. The market price of red cabbage as per super shop of Dhaka was considered for estimating the cost and return. Analyses were done according to the procedure of Alam *et al.* (1989). The benefit cost ratio (BCR) was calculated as follows:

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

Chapter IV

Results and Discussion

CHAPTER IV

RESULTS AND DISCUSSION

The study was conducted to find out effect of vermicompost and plant vitalizer (HB-101) on growth and yield of red cabbage. Analyses of variance (ANOVA) of the data on different growth, yield parameters and yield of red cabbage are presented in Appendix IV-IX. The results have been presented and discusses with the help of table and graphs and possible interpretations given under the following headings:

4.1 Plant height

Plant height of red cabbage at 20, 30, 40, 50 DAT (days after transplanting) and at harvest showed statistically significant variation due to different levels of vermicompost (Table 1). At 20, 30, 40, 50 DAT and harvest, the tallest plant (18.28, 27.24, 33.76, 37.47 and 38.34 cm, respectively) was observed from Vr_2 (8 ton vermicompost/ha) treatment which was statistically similar (17.61, 26.32, 32.12, 36.79 and 37.72 cm, respectively) to Vr_1 (4 ton vermicompost/ha) treatment, whereas the shortest plant (15.14, 20.76, 27.96, 30.97 and 31.96 cm, respectively) was found from Vr_0 (No vermicompost i.e. control condition) treatment. Plant height is a genetical character but it may differ due to prevailing different biotic and abiotic factors. Ahmed *et al*. (2017) reported that increasing the rate of vermicompost from led to increase plant height of red cabbage.

Statistically significant differences was recorded due to different levels of plant vitalizer on plant height of red cabbage at 20, 30, 40, 50 DAT and harvest (Table 1). At 20, 30, 40, 50 DAT and harvest, the tallest plant (18.55, 26.60, 34.36, 38.17 and 38.81 cm, respectively) was recorded from Vi_3 (6 ml vitalizer/*l* water) treatment which was statistically similar (18.05, 26.45, 33.28, 37.07 and 37.97 cm, respectively) to Vi_2 (4 ml vitalizer/*l* water) and closely followed (17.03, 24.38, 31.32, 35.03 and 36.29 cm, respectively) by Vi_1 (2 ml vitalizer/*l* water), while the shortest plant (14.41, 21.68, 26.16, 30.04 and 30.96 cm, respectively) was observed from Vi_0 (No vitalizer i.e. control condition) treatment.

Table 1. Effect of vermicompost and plant vitalizer on plant height at different days after transplanting (DAT) and at harvest of red cabbage

Treatments	Plant height (cm) at				
	20 DAT	30 DAT	40 DAT	50 DAT	Harvest
Levels of vermicompost					
Vr_0	15.14 b	20.76 b	27.96 b	30.97 b	31.96 b
Vr_1	17.61 a	26.32 a	32.12 a	36.79 a	37.72 a
Vr_2	18.28 a	27.24 a	33.76 a	37.47 a	38.34 a
$LSD_{(0.05)}$	0.968	1.297	1.185	1.593	1.465
Level of significance	0.01	0.01	0.01	0.01	0.01
Levels of plant vitalizer					
Vi_0	14.41 c	21.68 c	26.16 c	30.04 c	30.96 c
Vi_1	17.03 b	24.38 b	31.32 b	35.03 b	36.29 b
Vi_2	18.05 ab	26.45 ab	33.28 ab	37.07 ab	37.97 ab
Vi_3	18.55 a	26.60 a	34.36 a	38.17 a	38.81 a
$LSD_{(0.05)}$	1.117	1.497	1.368	1.840	1.692
Level of significance	0.01	0.01	0.01	0.01	0.01
CV(%)	6.72	6.18	4.47	5.36	4.81

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

Vr_0: No vermicompost (control condition)

Vr_1: 4 ton vermicompost/ha

Vr_2: 8 ton vermicompost/ha

Vi_0: No vitalizer (control condition)

Vi_1: 2 ml vitalizer/*l* water

Vi_2: 4 ml vitalizer/*l* water

Vi_3: 6 ml vitalizer/*l* water

Combined effect of different levels of vermicompost and plant vitalizer showed statistically significant variation in terms of plant height of red cabbage at 20, 30, 40, 50 DAT and harvest (Table 2). At 20, 30, 40, 50 DAT and harvest, the tallest plant (20.35, 29.64, 37.71, 41.74 and 42.38 cm, respectively) was observed from Vr_2Vi_3 (8 ton vermicompost/ha and 6 ml vitalizer/*l* water) and the shortest plant (13.19, 17.22, 23.05, 26.55 and 27.51 cm, respectively) was found from Vr_0Vi_0 (No vermicompost and No vitalizer i.e. control condition) treatment combination.

4.2 Number of leaves/plant

Statistically significant variation was observed in terms of number of leaves/plant of red cabbage at 20, 30, 40, 50 DAT and at harvest due to different levels of vermicompost (Figure 2). At 20, 30, 40, 50 DAT and harvest, the highest number of leaves/plant (8.58, 15.15, 20.17, 21.45 and 22.55, respectively) was recorded from Vr_2 which was statistically similar (8.32, 14.73, 19.30, 20.95 and 22.10, respectively) to Vr_1 treatment, while the lowest number (7.08, 12.65, 16.17, 17.42 and 18.33, respectively) from Vr_0 treatment.

Different levels of plant vitalizer showed statistically significant differences in terms of number of leaves/plant of red cabbage at 20, 30, 40, 50 DAT and harvest (Figure 3). At 20, 30, 40, 50 DAT and harvest, the highest number of leaves/plant (8.60, 15.51, 21.00, 22.62 and 23.89, respectively) was found from Vi_3 treatment which was statistically similar (8.47, 15.09, 20.04, 22.00 and 22.73, respectively) to Vi_2 and followed (7.91, 14.02, 18.33, 19.20 and 20.31 respectively) by Vi_1, whereas the lowest number (7.00, 12.09, 14.80, 15.93 and 17.04, respectively) was recorded from Vi_0 treatment.

Number of leaves/plant of red cabbage at 20, 30, 40, 50 DAT and harvest varied significantly due to the combined effect of different levels of vermicompost and plant vitalizer (Table 3). At 20, 30, 40, 50 DAT and harvest, the highest number of leaves/plant (9.60, 17.27, 23.33, 24.93 and 26.67, respectively) was found from Vr_2Vi_3, while the lowest number (6.53, 10.60, 12.13, 13.80 and 14.60, respectively) was recorded from Vr_0Vi_0 treatment combination.

Table 2. Combined effect of vermicompost and plant vitalizer on plant height at different days after transplanting (DAT) and at harvest of red cabbage

Treatments	Plant height (cm) at				
	20 DAT	30 DAT	40 DAT	50 DAT	Harvest
Vr_0Vi_0	13.19 e	17.22 f	23.05 f	26.55 e	27.51 e
Vr_0Vi_1	14.13 e	18.77 f	27.01 e	29.29 e	31.02 d
Vr_0Vi_2	16.29 cd	22.91 e	30.38 cd	33.69 d	34.32 c
Vr_0Vi_3	16.93 cd	24.13 c-e	31.41 bc	34.35 cd	34.97 c
Vr_1Vi_0	15.07 de	24.46 c-e	28.19 de	34.06 cd	34.87 c
Vr_1Vi_1	19.23 ab	26.85 a-c	33.38 b	37.30 bc	38.32 b
Vr_1Vi_2	17.77 bc	27.97 ab	32.96 b	37.39 bc	38.61 b
Vr_1Vi_3	18.36 a-c	26.02 b-d	33.96 b	38.40 ab	39.07 b
Vr_2Vi_0	14.97 de	23.35 de	27.24 e	29.52 e	30.48 d
Vr_2Vi_1	17.72 bc	27.53 ab	33.57 b	38.50 ab	39.53 ab
Vr_2Vi_2	20.09 a	28.46 ab	36.50 a	40.13 ab	40.98 ab
Vr_2Vi_3	20.35 a	29.64 a	37.71 a	41.74 a	42.38 a
$LSD_{(0.05)}$	1.935	2.593	2.369	3.186	2.930
Level of significance	0.05	0.05	0.05	0.01	0.01
CV(%)	6.72	6.18	4.47	5.36	4.81

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

Vr_0: No vermicompost (control condition)

Vr_1: 4 ton vermicompost/ha

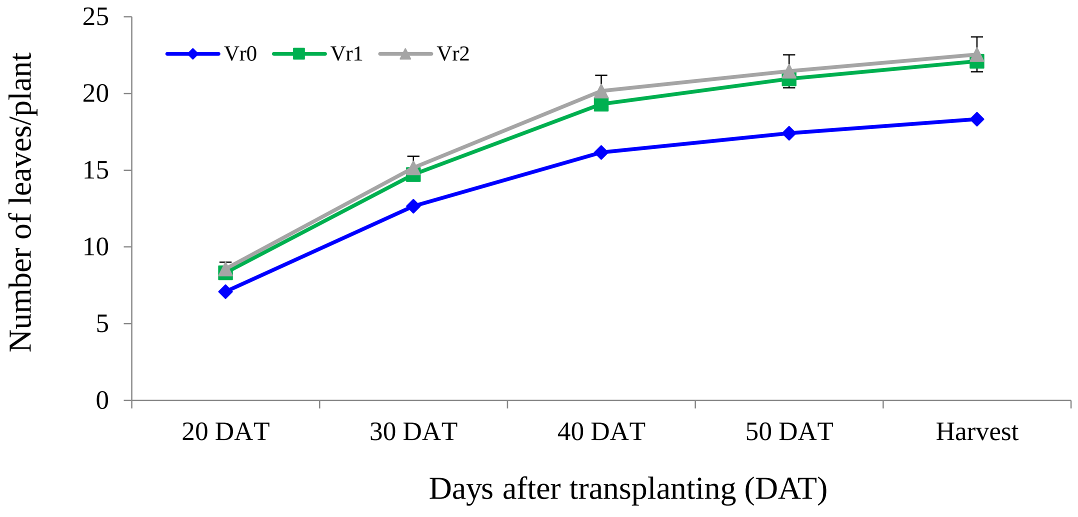
Vr_2: 8 ton vermicompost/ha

Vi_0: No vitalizer (control condition)

Vi_1: 2 ml vitalizer/*l* water

Vi_2: 4 ml vitalizer/*l* water

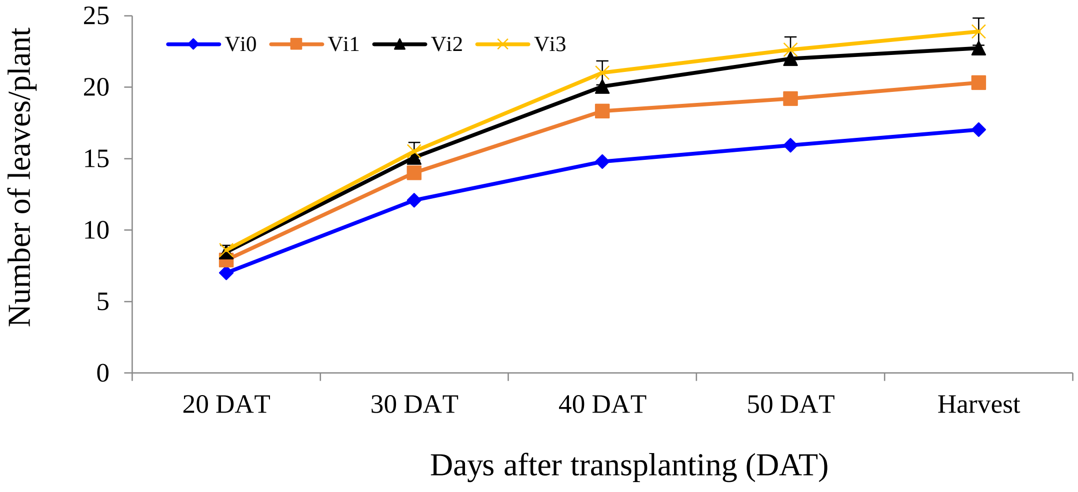
Vi_3: 6 ml vitalizer/*l* water



Vr_0: No vermicompost (control condition) Vr_1: 4 ton vermicompost/ha

Vr_2: 8 ton vermicompost/ha

Figure 2. Effect of different levels of vermicompost on number of leaves/plant of red cabbage. (Vertical bars represent LSD value at 5% level of probability)



Vi_0: No vitalizer (control condition) Vi_1: 2 ml vitalizer/*l* water

Vi_2: 4 ml vitalizer/*l* water Vi_3: 6 ml vitalizer/*l* water

Figure 3. Effect of different levels of plant vitalizer on number of leaves/plant of red cabbage. (Vertical bars represent LSD value at 5% level of probability)

Table 3. Combined effect of vermicompost and plant vitalizer on number of leaves/plant at different days after transplanting (DAT) and at harvest of red cabbage

Treatments	Number of leaves/plant at				
	20 DAT	30 DAT	40 DAT	50 DAT	Harvest
Vr_0Vi_0	6.53 f	10.60 g	12.13 e	13.80 g	14.60 g
Vr_0Vi_1	6.87 ef	13.07 ef	15.80 d	16.73 f	17.93 f
Vr_0Vi_2	7.33 e	12.87 ef	18.33 c	19.87 de	20.73 c-e
Vr_0Vi_3	7.60 de	14.07 c-e	18.40 c	19.27 e	20.07 ef
Vr_1Vi_0	7.53 de	13.47 d-f	16.07 d	16.93 f	18.20 f
Vr_1Vi_1	8.13 cd	14.20 c-e	18.80 c	19.47 e	20.60 de
Vr_1Vi_2	9.00 ab	16.07 ab	21.07 b	23.73 ab	24.67 ab
Vr_1Vi_3	8.60 bc	15.20 bc	21.27 b	23.67 ab	24.93 a
Vr_2Vi_0	6.93 ef	12.20 f	16.20 d	17.07 f	18.33 f
Vr_2Vi_1	8.73 bc	14.80 b-d	20.40 b	21.40 cd	22.40 cd
Vr_2Vi_2	9.07 ab	16.33 ab	20.73 b	22.40 bc	22.80 bc
Vr_2Vi_3	9.60 a	17.27 a	23.33 a	24.93 a	26.67 a
$LSD_{(0.05)}$	0.710	1.460	1.554	1.538	1.992
Level of significance	0.05	0.05	0.05	0.05	0.05
CV(%)	5.25	6.08	4.95	6.55	5.60

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

Vr_0: No vermicompost (control condition)

Vr_1: 4 ton vermicompost/ha

Vr_2: 8 ton vermicompost/ha

Vi_0: No vitalizer (control condition)

Vi_1: 2 ml vitalizer/*l* water

Vi_2: 4 ml vitalizer/*l* water

Vi_3: 6 ml vitalizer/*l* water

4.3 Leaf length

Different levels of vermicompost showed statistically significant differences in terms of leaf length of red cabbage at 20, 30, 40, 50 DAT and at harvest (Table 4). At 20, 30, 40, 50 DAT and harvest, the longest leaf (13.63, 19.08, 26.11, 28.33 and 30.64 cm, respectively) was found from Vr_2 treatment which was statistically similar (13.18, 18.64, 25.77, 27.86 and 30.26 cm, respectively) to Vr_1 treatment, whereas the shortest leaf (11.77, 16.26, 21.79, 24.28 and 26.58 cm, respectively) was recorded from Vr_0 treatment. Leaf length is a genetical character and specific variety produced more or less similar number of leaves at different stage but it may differ due to prevailing different biotic and abiotic factors. Data revealed that all the levels of vermicompost produced significantly higher number of leaves compared to the control condition. Zhenyu and Yongliang. (2005) also reported that applying of vermicompost as nutrient sources increased leaf length of cabbage.

Leaf length of red cabbage at 20, 30, 40, 50 DAT and harvest varied significantly due to different levels of plant vitalizer (Table 4). At 20, 30, 40, 50 DAT and harvest, the longest leaf (14.11, 20.12, 26.58, 28.70 and 31.18 cm, respectively) was recorded from Vi_3 treatment which was statistically similar (13.80, 19.78, 26.06, 28.40 and 30.66 cm, respectively) to Vi_2 and closely followed (12.50, 17.36, 24.15, 26.67 and 29.59 cm, respectively) by Vi_1, while the shortest leaf (11.01, 14.71, 21.43, 23.53 and 25.10 cm, respectively) was found from Vi_0 treatment. Anonymous (2019) stated that HB-101 improves the efficiency of the plant's metabolism and helps to leaf length.

Statistically significant variation was observed due to the combined effect of different levels of vermicompost and plant vitalizer in terms of leaf length of red cabbage at 20, 30, 40, 50 DAT and harvest (Table 5). At 20, 30, 40, 50 DAT and harvest, the longest leaf (15.37, 21.53, 27.44, 30.41 and 33.03 cm, respectively) was recorded from Vr_2Vi_3 and the shortest leaf (10.52, 12.96, 17.77, 19.86 and 21.24 cm, respectively) was observed from Vr_0Vi_0 treatment combination.

Table 4. Effect of vermicompost and plant vitalizer on leaf length at different days after transplanting (DAT) and at harvest of red cabbage

Treatments	Leaf length (cm) at				
	20 DAT	30 DAT	40 DAT	50 DAT	Harvest
Levels of vermicompost					
Vr_0	11.77 c	16.26 b	21.79 b	24.28 b	26.58 b
Vr_1	13.18 a	18.64 a	25.77 a	27.86 a	30.26 a
Vr_2	13.63 a	19.08 a	26.11 a	28.33 a	30.64 a
$LSD_{(0.05)}$	0.454	0.796	0.973	0.912	0.878
Level of significance	0.01	0.01	0.01	0.01	0.01
Levels of plant vitalizer					
Vi_0	11.01 c	14.71 c	21.43 c	23.53 c	25.10 c
Vi_1	12.50 b	17.36 b	24.15 b	26.67 b	29.59 b
Vi_2	13.80 a	19.78 a	26.06 a	28.40 a	30.66 a
Vi_3	14.11 a	20.12 a	26.58 a	28.70 a	31.18 a
$LSD_{(0.05)}$	0.525	0.919	1.123	1.053	1.014
Level of significance	0.01	0.01	0.01	0.01	0.01
CV(%)	4.17	5.22	6.68	4.02	7.55

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

Vr_0: No vermicompost (control condition)

Vr_1: 4 ton vermicompost/ha

Vr_2: 8 ton vermicompost/ha

Vi_0: No vitalizer (control condition)

Vi_1: 2 ml vitalizer/*l* water

Vi_2: 4 ml vitalizer/*l* water

Vi_3: 6 ml vitalizer/*l* water

Table 5. Combined effect of vermicompost and plant vitalizer on leaf length at different days after transplanting (DAT) and at harvest of red cabbage

Treatments	Leaf length (cm) at				
	20 DAT	30 DAT	40 DAT	50 DAT	Harvest
Vr_0Vi_0	10.52 d	12.96 g	17.77 f	19.86 f	21.24 g
Vr_0Vi_1	11.02 d	15.02 ef	21.23 e	23.58 e	27.07 ef
Vr_0Vi_2	12.64 c	18.18 c	22.99 de	26.76 cd	28.83 de
Vr_0Vi_3	12.91 c	18.86 bc	25.16 bc	26.93 cd	29.17 cd
Vr_1Vi_0	11.49 d	16.49 de	23.67 cd	25.78 d	27.57 d-f
Vr_1Vi_1	12.87 c	18.03 cd	24.42 cd	27.93bc	30.88 bc
Vr_1Vi_2	14.24 b	20.05 ab	27.84 a	28.95 ab	31.24 ab
Vr_1Vi_3	14.05 b	19.97 ab	27.15 ab	28.77 a-c	31.35 ab
Vr_2Vi_0	11.01 d	14.68 f	22.85 de	24.95 de	26.48 f
Vr_2Vi_1	13.62 bc	19.03 bc	26.80 ab	28.49 a-c	31.14 ab
Vr_2Vi_2	14.51 ab	21.10 a	27.35 a	29.48 ab	31.91 ab
Vr_2Vi_3	15.37 a	21.53 a	27.44 a	30.41 a	33.03 a
$LSD_{(0.05)}$	0.909	1.591	1.945	1.824	1.756
Level of significance	0.05	0.05	0.05	0.05	0.05
CV(%)	4.17	5.22	6.68	4.02	7.55

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

Vr_0: No vermicompost (control condition)

Vr_1: 4 ton vermicompost/ha

Vr_2: 8 ton vermicompost/ha

Vi_0: No vitalizer (control condition)

Vi_1: 2 ml vitalizer/*l* water

Vi_2: 4 ml vitalizer/*l* water

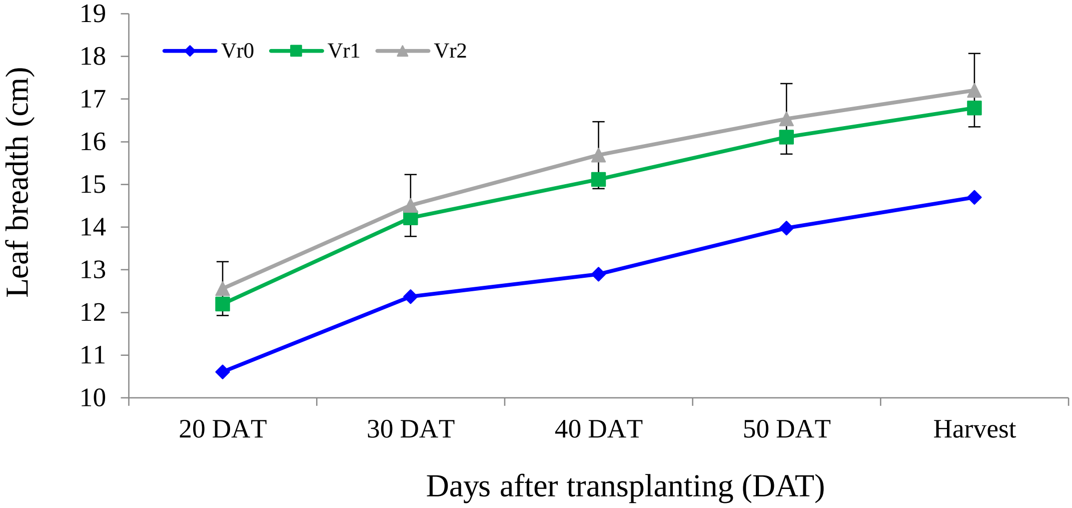
Vi_3: 6 ml vitalizer/*l* water

4.4 Leaf breadth

Statistically significant variation was recorded in terms of leaf breadth of red cabbage at 20, 30, 40, 50 DAT and at harvest due to different levels of vermicompost (Figure 4). Data revealed that at 20, 30, 40, 50 DAT and harvest, the highest leaf breadth leaf (12.56, 14.51, 15.69, 16.54 and 17.21 cm, respectively) was found from Vr_2 treatment which was statistically similar (12.20, 14.22, 15.12, 16.11 and 16.79 cm, respectively) to Vr_1 treatment, while the lowest leaf breadth (10.61, 12.37, 12.90, 13.98 and 14.70 cm, respectively) was found from Vr_0 treatment. Ismail *et al*. (2017) observed that vermicompost applications appeared to be effective in achieving sufficient level growth characters i.e. leaf breadth.

Statistically significant differences was recorded due to different levels of plant vitalizer for leaf breadth of red cabbage at 20, 30, 40, 50 DAT and harvest (Figure 5). At 20, 30, 40, 50 DAT and harvest, the highest leaf breadth (12.64, 14.74, 15.85, 16.69 and 17.23 cm, respectively) was recorded from Vi_3 treatment which was statistically similar (12.35, 14.34, 15.29, 16.31 and 17.16 cm, respectively) to Vi_2 and closely followed (11.75, 13.75, 14.46, 15.57 and 16.36 cm, respectively) by Vi_1. On the other hand, the lowest leaf breadth (10.43, 11.97, 12.67, 13.61 and 14.20 cm, respectively) was observed from Vi_0 treatment. Leaf breadth is a genetical character but it may differ due to prevailing different biotic and abiotic factors. Data revealed that all the levels of plant vitalizer produced significantly higher number of leaves compared to the control condition.

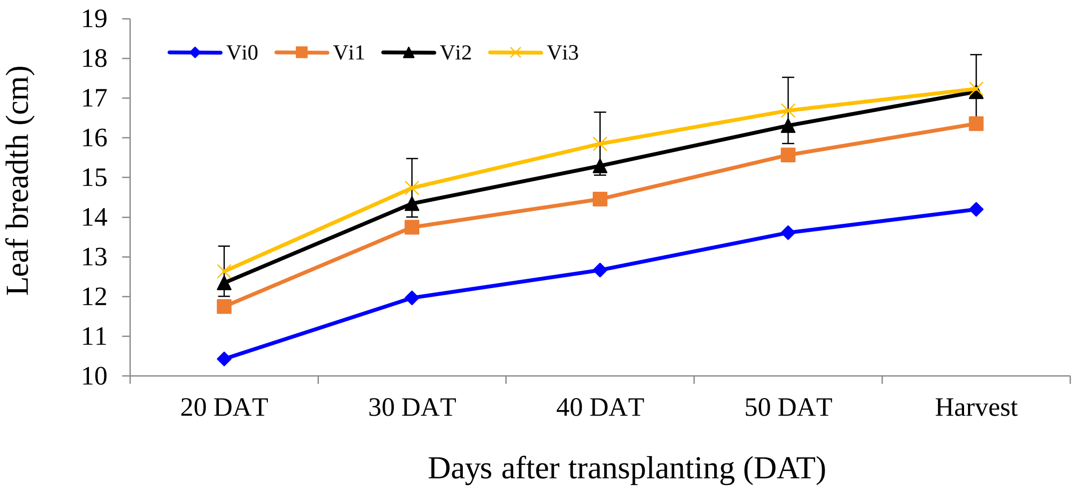
Combined effect of different levels of vermicompost and plant vitalizer showed statistically significant variation in terms of leaf breadth of red cabbage at 20, 30, 40, 50 DAT and harvest (Table 6). At 20, 30, 40, 50 DAT and harvest, the highest leaf breadth (14.09, 16.05, 17.55, 18.39 and 18.79 cm, respectively) was observed from Vr_2Vi_3, while the lowest leaf breadth (10.13, 11.26, 11.84, 12.88 and 13.43 cm, respectively) was recorded from Vr_0Vi_0 treatment combination.



Vr_0: No vermicompost (control condition) Vr_1: 4 ton vermicompost/ha

Vr_2: 8 ton vermicompost/ha

Figure 4. Effect of different levels of vermicompost on leaf breadth of red cabbage. (Vertical bars represent LSD value at 5% level of probability)



Vi_0: No vitalizer (control condition) Vi_1: 2 ml vitalizer/*l* water

Vi_2: 4 ml vitalizer/*l* water Vi_3: 6 ml vitalizer/*l* water

Figure 5. Effect of different levels of plant vitalizer on leaf breadth of red cabbage. (Vertical bars represent LSD value at 5% level of probability)

Table 6. Combined effect of vermicompost and plant vitalizer on leaf breath at different days after transplanting (DAT) and at harvest of red cabbage

Treatments	Leaf breadth (cm) at				
	20 DAT	30 DAT	40 DAT	50 DAT	Harvest
Vr_0Vi_0	10.13 e	11.26 d	11.84 e	12.88 d	13.43 f
Vr_0Vi_1	10.80 de	12.31 c	12.89 de	13.86 cd	14.43 ef
Vr_0Vi_2	10.56 e	13.02 c	13.52 d	14.84 c	15.91 cd
Vr_0Vi_3	10.96 de	12.89 c	13.35 d	14.35 c	15.02 de
Vr_1Vi_0	10.75 de	12.23 c	12.91 de	13.76 cd	14.29 ef
Vr_1Vi_1	12.42 c	14.67 b	15.15 c	16.68 b	17.59 ab
Vr_1Vi_2	12.77 bc	14.70 b	15.74 bc	16.68 b	17.43 b
Vr_1Vi_3	12.88 a-c	15.27 ab	16.66 ab	17.34 ab	17.87 ab
Vr_2Vi_0	10.40 e	12.41 c	13.26 d	14.19 cd	14.87 de
Vr_2Vi_1	12.02 cd	14.29 b	15.34 c	16.18 b	17.06 bc
Vr_2Vi_2	13.73 ab	15.29 ab	16.60 ab	17.40 ab	18.13 ab
Vr_2Vi_3	14.09 a	16.05 a	17.55 a	18.39 a	18.79 a
$LSD_{(0.05)}$	1.185	0.934	1.080	1.212	1.177
Level of significance	0.05	0.05	0.05	0.05	0.05
CV(%)	5.94	7.02	4.38	6.60	4.28

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

Vr_0: No vermicompost (control condition)
Vr_1: 4 ton vermicompost/ha
Vr_2: 8 ton vermicompost/ha

Vi_0: No vitalizer (control condition)
Vi_1: 2 ml vitalizer/*l* water
Vi_2: 4 ml vitalizer/*l* water
Vi_3: 6 ml vitalizer/*l* water

4.5 Days to 1st head initiation

Days to 1st head initiation of red cabbage showed statistically significant variation due to different levels of vermicompost (Table 7). The minimum days to 1st head initiation (35.72) was found from Vr_2 treatment which was statistically similar (36.20) to Vr_1, whereas the maximum days (38.53) from Vr_0 treatment. Rai *et al*. (2013) reported that application of vermicompost along with inorganic fertilizers reduced the days taken to maturity.

Different levels of plant vitalizer varied significantly in terms of days to 1st head initiation of red cabbage (Table 7). The minimum days to 1st head initiation (35.04) was observed from Vi_3 treatment which was statistically similar (36.38 and 37.02) to Vi_2 and Vi_1, respectively, while the maximum days (38.82) was found from Vi_0 treatment.

Statistically significant variation was observed due to the combined effect of different levels of vermicompost and plant vitalizer in terms of days to 1st head initiation of red cabbage (Table 8). The minimum days to 1st head initiation (34.00) was recorded from Vr_2Vi_3, whereas the maximum days (39.73) was observed from Vr_0Vi_0 treatment combination.

4.6 Length of stem

Length of stem of red cabbage showed statistically significant variation due to different levels of vermicompost (Table 7). The highest length of stem (7.70 cm) was observed from Vr_2 treatment which was statistically similar (7.54 cm) to Vr_1 treatment, whereas the lowest length of stem (5.38 cm) was found from Vr_0 treatment. Ahmed *et al*. (2017) reported that increasing the rate of vermicompost from 10 to 20% led to increase the vegetative characteristics of red cabbage.

Statistically significant differences was recorded due to different levels of plant vitalizer for length of stem of red cabbage (Table 7). The highest length of stem (7.62 cm) was recorded from Vi_3 treatment which was statistically similar (7.42 cm and 6.60 cm) to Vi_2 and Vi_1, respectively, whereas the lowest length of stem (5.86 cm) was observed from Vi_0 treatment.

Table 7. Effect of vermicompost and plant vitalizer on yield contributing characters of red cabbage

Treatments	Days to 1st head initiation	Length of stem (cm)	Fresh weight of stem (g)	Dry matter content of stem (%)	Length of roots (cm)
Levels of vermicompost					
Vr_0	38.53 a	5.38 b	51.07 b	11.47 b	13.87 b
Vr_1	36.20 b	7.54 a	57.46 a	13.29 a	16.46 a
Vr_2	35.72 b	7.70 a	58.57 a	13.58 a	16.85 a
$LSD_{(0.05)}$	2.117	0.935	1.235	0.372	0.714
Level of significance	0.05	0.01	0.01	0.01	0.01
Levels of plant vitalizer					
Vi_0	38.82 a	5.86 b	50.08 c	11.19 c	13.11 c
Vi_1	37.02 ab	6.60 ab	55.67 b	12.69 b	15.63 b
Vi_2	36.38 ab	7.42 a	58.11 a	13.46 a	16.88 a
Vi_3	35.04 b	7.62 a	58.95 a	13.79 a	17.29 a
$LSD_{(0.05)}$	2.445	1.079	1.426	0.430	0.825
Level of significance	0.05	0.01	0.01	0.01	0.01
CV(%)	6.79	16.07	5.62	7.44	5.37

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

Vr_0: No vermicompost (control condition)

Vr_1: 4 ton vermicompost/ha

Vr_2: 8 ton vermicompost/ha

Vi_0: No vitalizer (control condition)

Vi_1: 2 ml vitalizer/*l* water

Vi_2: 4 ml vitalizer/*l* water

Vi_3: 6 ml vitalizer/*l* water

Table 8. Combined effect of vermicompost and plant vitalizer on yield contributing characters of red cabbage

Treatments	Days to 1st head initiation	Length of stem (cm)	Fresh weight of stem (g)	Dry matter content of stem (g)	Length of roots (cm)
Vr_0Vi_0	39.73 a	6.27 bc	44.42 f	10.17 f	12.18 e
Vr_0Vi_1	38.93 ab	3.95 d	50.12 e	10.96 e	13.17 de
Vr_0Vi_2	38.40 a-c	5.49 cd	54.46 cd	12.33 d	15.11 c
Vr_0Vi_3	37.07 a-c	5.80 b-d	55.30 c	12.44 d	15.01 c
Vr_1Vi_0	39.07 a	7.30 a-c	53.44 cd	12.12 d	14.05 cd
Vr_1Vi_1	35.93 a-c	7.44 a-c	57.79 b	13.40 c	16.57 b
Vr_1Vi_2	35.73 a-c	7.70 ab	59.72 b	13.68 bc	17.52 b
Vr_1Vi_3	34.07 bc	7.72 ab	58.88 b	13.97 bc	17.71 ab
Vr_2Vi_0	37.67 a-c	4.00 d	52.38 de	11.29 e	13.10 de
Vr_2Vi_1	36.20 a-c	8.39 a	59.10 b	13.72 bc	17.14 b
Vr_2Vi_2	35.00 a-c	9.06 a	60.15 b	14.37 ab	18.00 ab
Vr_2Vi_3	34.00 c	9.34 a	62.67 a	14.95 a	19.15 a
$LSD_{(0.05)}$	4.234	1.870	2.471	0.744	1.429
Level of significance	0.05	0.01	0.05	0.01	0.05
CV(%)	6.79	16.07	5.62	7.44	5.37

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

Vr_0: No vermicompost (control condition)

Vr_1: 4 ton vermicompost/ha

Vr_2: 8 ton vermicompost/ha

Vi_0: No vitalizer (control condition)

Vi_1: 2 ml vitalizer/*l* water

Vi_2: 4 ml vitalizer/*l* water

Vi_3: 6 ml vitalizer/*l* water

Combined effect of different levels of vermicompost and plant vitalizer showed statistically significant variation in terms of length of stem of red cabbage (Table 8). The highest length of stem (9.34 cm) was observed from Vr_2Vi_3 and the lowest length of stem (6.27 cm) was found from Vr_0Vi_0 treatment combination.

4.7 Diameter of stem

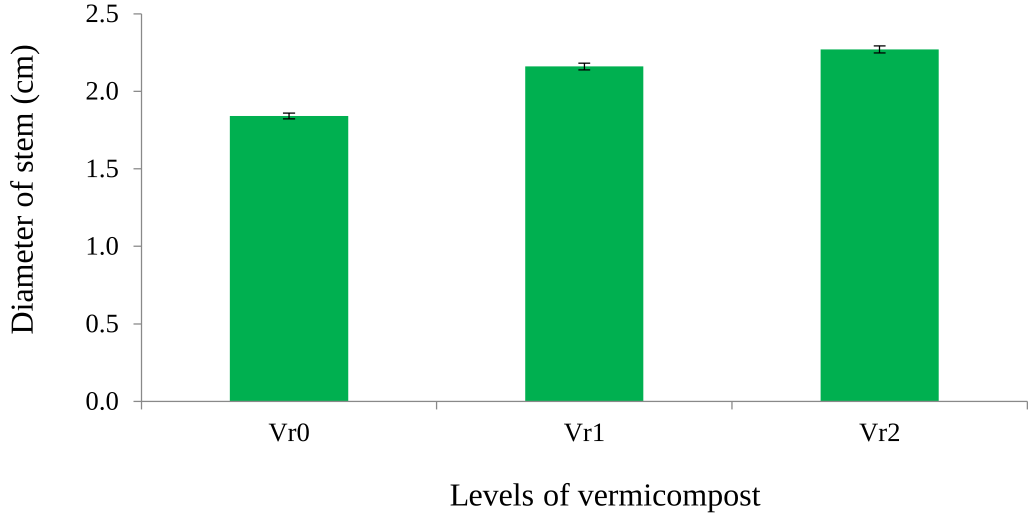
Different levels of vermicompost varied significantly in terms of diameter of stem of red cabbage (Figure 6). The highest diameter of stem (2.27 cm) was observed from Vr_2 treatment which was statistically similar (2.16 cm) to Vr_1 treatment, while the lowest diameter of stem (1.84 cm) was recorded from Vr_0 treatment.

Diameter of stem of red cabbage showed statistically significant differences due to different levels of plant vitalizer (Figure 7). The highest diameter of stem (2.35 cm) was found from Vi_3 treatment which was statistically similar (2.26 cm and 2.04 cm) to Vi_2 and Vi_1, respectively, whereas the lowest diameter of stem (1.70 cm) was recorded from Vi_0 treatment.

Statistically significant variation was observed due to the combined effect of different levels of vermicompost and plant vitalizer in terms of diameter of stem of red cabbage (Figure 8). The highest diameter of stem (2.65 cm) was observed from Vr_2Vi_3, while the lowest diameter of stem (1.65 cm) was found from Vr_0Vi_0 treatment combination.

4.8 Fresh weight of stem

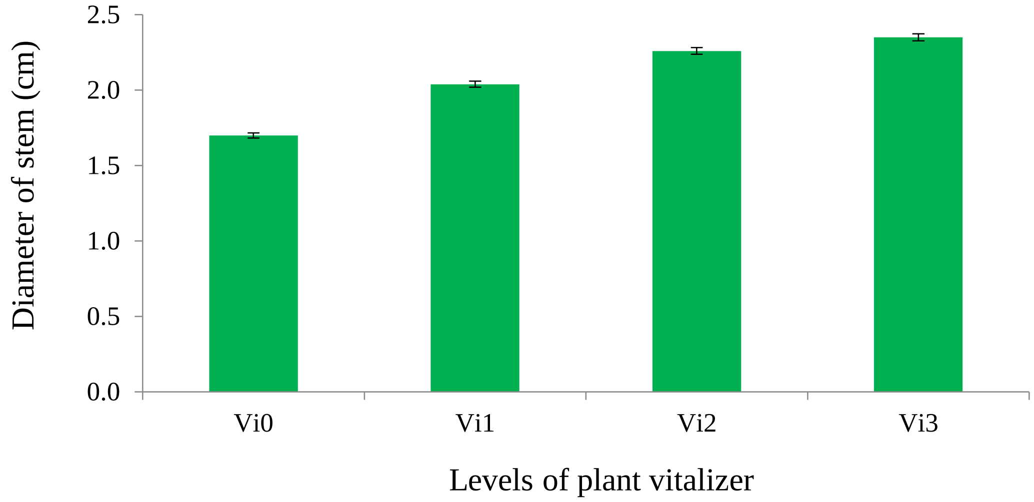
Fresh weight of stem of red cabbage showed statistically significant variation due to different levels of vermicompost (Table 7). The fresh weight of stem (58.57 g) was recorded from Vr_2 treatment which was statistically similar (57.46 g) to Vr_1 treatment, whereas the lowest fresh weight of stem (51.07 cm) was observed from Vr_0 treatment. Ahmed *et al.* (2017) reported that increasing the rate of vermicompost from 10 to 20% led to increase the vegetative characteristics of red cabbage.



Vr_0: No vermicompost (control condition) Vr_1: 4 ton vermicompost/ha

Vr_2: 8 ton vermicompost/ha

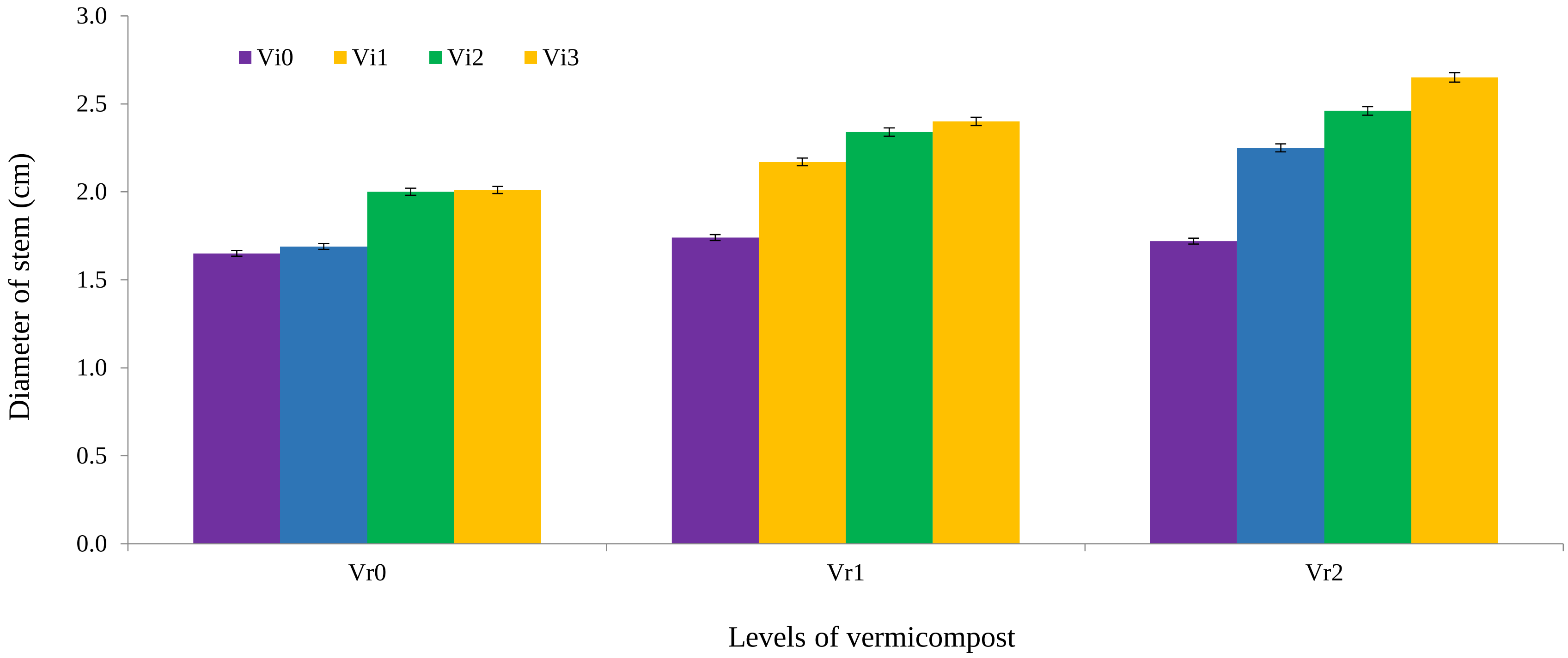
Figure 6. Effect of different levels of vermicompost on diameter of stem of red cabbage. (Vertical bars represent LSD value at 5% level of probability)



Vi_0: No vitalizer (control condition) Vi_1: 2 ml vitalizer/*l* water

Vi_2: 4 ml vitalizer/*l* water Vi_3: 6 ml vitalizer/*l* water

Figure 7. Effect of different levels of plant vitalizer on diameter of stem of red cabbage. (Vertical bars represent LSD value at 5% level of probability)



Vr_0: No vermicompost (control condition) Vr_1: 4 ton vermicompost/ha Vi_0: No vitalizer (control condition) Vi_1: 2 ml vitalizer/*l* water

Vr_2: 8 ton vermicompost/ha Vi_2: 4 ml vitalizer/*l* water Vi_3: 6 ml vitalizer/*l* water

Figure 8. Combined effect of different levels of vermicompost and plant vitalizer on diameter of stem of red cabbage. (Vertical bars represent LSD value at 5% level of probability

Statistically significant differences was recorded due to different levels of plant vitalizer for fresh weight of stem of red cabbage (Table 7). The highest fresh weight of stem (58.95 g) was found from Vi_3 treatment which was statistically similar (58.11 g) to Vi_2 and closely followed (55.67 g) by Vi_1, while the lowest fresh weight of stem (50.08 g) was recorded from Vi_0 treatment.

Combined effect of different levels of vermicompost and plant vitalizer showed statistically significant variation in terms of fresh weight of stem of red cabbage (Table 8). The highest fresh weight of stem (62.67 g) was found from Vr_2Vi_3 and the lowest fresh weight (44.42 g) was observed from Vr_0Vi_0 treatment combination.

4.9 Dry matter content of stem

Statistically significant variation was observed in terms of dry matter content of stem of red cabbage for different levels of vermicompost (Table 7). The highest dry matter content of stem (13.58%) was observed from Vr_2 treatment which was statistically similar (13.29%) to Vr_1 treatment, whereas the lowest (11.47%) was found from Vr_0 treatment.

Dry matter content of stem of red cabbage showed statistically significant variation due to different levels of plant vitalizer for (Table 7). The highest dry matter content of stem (13.79%) was recorded from Vi_3 treatment which was statistically similar (13.46%) to Vi_2 and closely followed (12.69%) by Vi_1, while the lowest (11.19%) was observed from Vi_0 treatment.

Statistically significant variation was observed due to the combined effect of different levels of vermicompost and plant vitalizer in terms of dry matter content of stem of red cabbage (Table 8). The highest dry matter content of stem (14.95%) was observed from Vr_2Vi_3, whereas the lowest (10.17%) was found from Vr_0Vi_0 treatment combination.

4.10 Length of roots

Length of roots of red cabbage showed statistically significant variation due to different levels of vermicompost (Table 7). The highest length of roots (16.85 cm) was found from Vr_2 treatment which was statistically similar (16.46 cm) to Vr_1 treatment and the lowest (13.87 cm) was recorded from Vr_0 treatment.

Statistically significant differences was found recorded for length of roots of red cabbage for different levels of plant vitalizer (Table 7). The highest length of roots (17.29 cm) was recorded from Vi_3 which was similar (16.88 cm) to Vi_2 and followed (15.63 cm) by Vi_1, whereas the lowest (13.11 cm) from Vi_0 treatment.

Combined effect of different levels of vermicompost and plant vitalizer showed statistically significant variation in terms of length of roots of red cabbage (Table 8). The highest length of roots (19.15 cm) was recorded from Vr_2Vi_3 and the lowest (12.18 cm) was found from Vr_0Vi_0 treatment combination.

4.11 Thickness of head

Statistically significant variation was recorded in terms of thickness of head of red cabbage due to different levels of vermicompost (Table 9). The highest thickness of head (14.24 cm) was observed from Vr_2 treatment which was statistically similar (13.88 cm) to Vr_1, whereas the lowest (12.22 cm) was found from Vr_0 treatment. Ahmed *et al*. (2017) reported that increasing the rate of vermicompost led to increase the yield characteristics of red cabbage.

Different levels of plant vitalizer varied significantly due to for thickness of head of red cabbage (Table 9). The highest thickness of head (14.55 cm) was recorded from Vi_3 treatment which was statistically similar (14.11 cm) to Vi_2 and closely followed (13.48 cm) by Vi_1, while the lowest (11.64 cm) from Vi_0 treatment.

Thickness of head of red cabbage showed statistically significant variation due to the combined effect of different levels of vermicompost and plant vitalizer (Table 10). The highest thickness of head (15.90 cm) was observed from Vr_2Vi_3, whereas the lowest (11.28 cm) was found from Vr_0Vi_0 treatment combination.

Table 9. Effect of vermicompost and plant vitalizer on yield contributing characters and yield of red cabbage

Treatments	Thickness of head (cm)	Gross weight of head (kg)	Dry matter content of head (%)	Marketable yield/plant (kg)	Marketable yield/ hectare (ton)
Levels of vermicompost					
Vr_0	12.22 b	1.22 b	6.68 b	0.77 c	38.47 c
Vr_1	13.88 a	1.39 a	7.85 a	0.99 b	49.73 b
Vr_2	14.24 a	1.41 a	8.14 a	1.05 a	52.30 a
$LSD_{(0.05)}$	0.591	0.046	0.337	0.038	2.041
Level of significance	0.01	0.01	0.01	0.01	0.01
Levels of plant vitalizer					
Vi_0	11.64 c	1.16 c	6.23 c	0.79 c	39.62 c
Vi_1	13.48 b	1.33 b	7.38 b	0.92 b	45.85 b
Vi_2	14.11 ab	1.43 a	8.23 a	1.01 a	50.25 a
Vi_3	14.55 a	1.44 a	8.39 a	1.03 a	51.62 a
$LSD_{(0.05)}$	0.683	0.054	0.389	0.044	2.356
Level of significance	0.01	0.01	0.01	0.01	0.01
CV(%)	5.20	6.37	5.26	5.15	5.15

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

Vr_0: No vermicompost (control condition)

Vr_1: 4 ton vermicompost/ha

Vr_2: 8 ton vermicompost/ha

Vi_0: No vitalizer (control condition)

Vi_1: 2 ml vitalizer/*l* water

Vi_2: 4 ml vitalizer/*l* water

Vi_3: 6 ml vitalizer/*l* water

Table 10. Combined effect of vermicompost and plant vitalizer on yield contributing characters and yield of red cabbage

Treatments	Thickness of head (cm)	Gross weight of head (kg)	Dry matter content of head (%)	Marketable yield/plant (kg)	Marketable yield/ hectare (ton)
Vr_0Vi_0	11.28 f	1.12 e	6.02 e	0.68 e	33.83 e
Vr_0Vi_1	12.15 ef	1.16 e	6.13 e	0.71 e	35.49 e
Vr_0Vi_2	12.52 ef	1.29 d	7.24 d	0.84 d	41.97 d
Vr_0Vi_3	12.91 de	1.29 d	7.35 d	0.85 d	42.59 d
Vr_1Vi_0	12.19 ef	1.19 de	6.45 e	0.87 d	43.73 d
Vr_1Vi_1	13.77 cd	1.40 c	7.79 cd	0.97 c	48.53 c
Vr_1Vi_2	14.72 a-c	1.47 a-c	8.54 ab	1.06 b	53.17 b
Vr_1Vi_3	14.83 a-c	1.50 ab	8.63 ab	1.07 b	53.50 b
Vr_2Vi_0	11.44 f	1.17 e	6.22 e	0.83 d	41.29 d
Vr_2Vi_1	14.52 bc	1.42 bc	8.22 bc	1.07 b	53.52 b
Vr_2Vi_2	15.09 ab	1.52 ab	8.91 ab	1.11 ab	55.63 ab
Vr_2Vi_3	15.90 a	1.54 a	9.20 a	1.18 a	58.77 a
$LSD_{(0.05)}$	1.183	0.093	0.673	0.076	4.081
Level of significance	0.05	0.05	0.01	0.05	0.05
CV(%)	5.20	6.37	5.26	5.15	5.15

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

Vr_0: No vermicompost (control condition)

Vr_1: 4 ton vermicompost/ha

Vr_2: 8 ton vermicompost/ha

Vi_0: No vitalizer (control condition)

Vi_1: 2 ml vitalizer/*l* water

Vi_2: 4 ml vitalizer/*l* water

Vi_3: 6 ml vitalizer/*l* water

4.12 Diameter of head

Different levels of vermicompost showed statistically significant differences in terms of diameter of head of red cabbage (Figure 9). The highest diameter of head (8.33 cm) was found from Vr_2 treatment which was statistically similar (8.11 cm) to Vr_1 treatment, while the lowest (6.97 cm) was recorded from Vr_0 treatment.

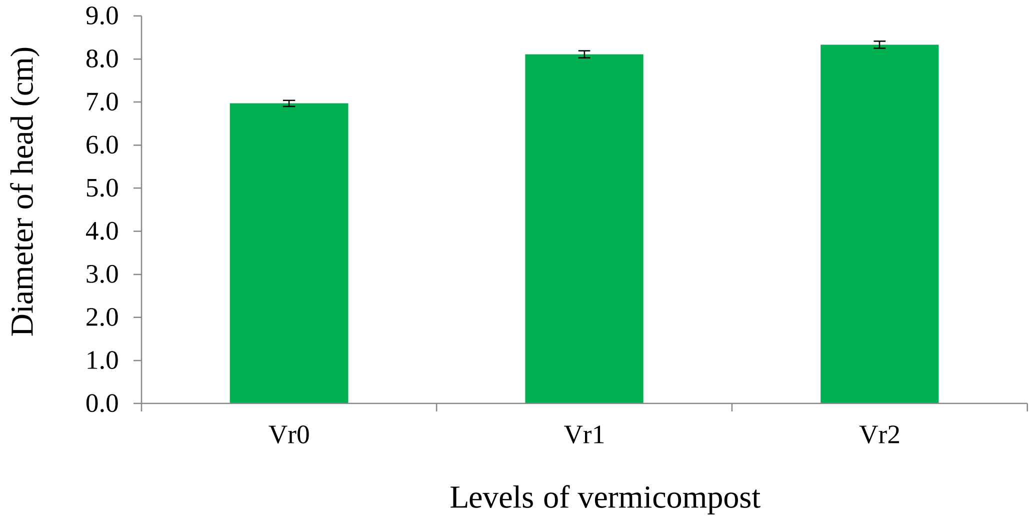
Statistically significant differences was recorded due to different levels of plant vitalizer for diameter of head of red cabbage (Figure 10). The highest diameter of head (8.57 cm) was observed from Vi_3 treatment which was statistically similar (8.29 cm) to Vi_2 and closely followed (7.69 cm) by Vi_1, whereas the lowest (6.66 cm) was found from Vi_0 treatment.

Combined effect of different levels of vermicompost and plant vitalizer showed statistically significant variation in terms of diameter of head of red cabbage (Figure 11). The highest diameter of head (9.47 cm) was observed from Vr_2Vi_3, while the lowest (6.21 cm) was recorded from Vr_0Vi_0 treatment combination.

4.13 Gross weight of head

Gross weight of head of red cabbage showed statistically significant variation due to different levels of vermicompost (Table 9). The highest gross weight of head (1.41 kg) was observed from Vr_2 treatment which was statistically similar (1.39 kg) to Vr_1 treatment, whereas the lowest weight (1.22 kg) was found from Vr_0 treatment. Rai *et al*. (2013) reported that the combined use of recommended dose of 75% NPK (RR) +VC 3 ton/ha, had recorded the maximum gross weight of the plant.

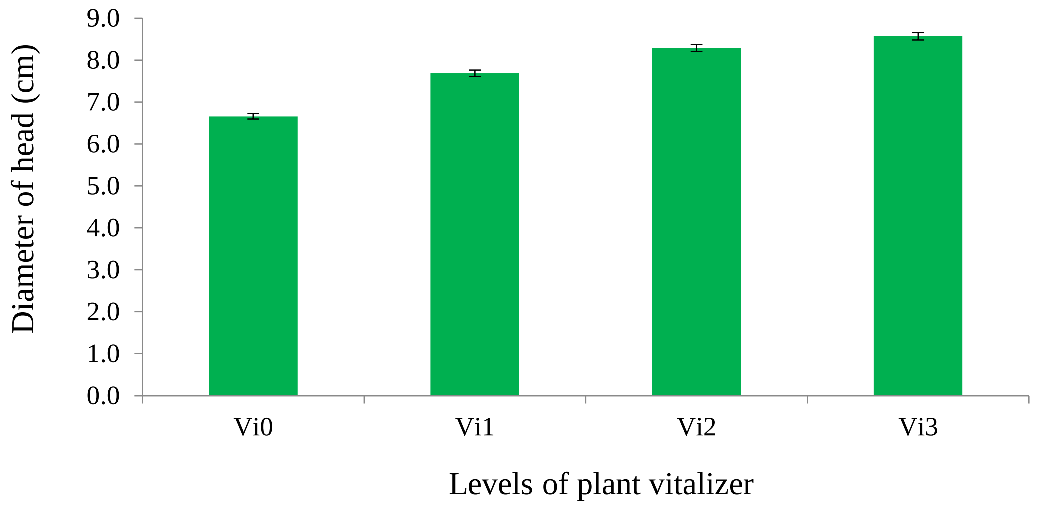
Statistically significant differences was recorded due to different levels of plant vitalizer for gross weight of head of red cabbage (Table 9). The highest gross weight of head (1.44 kg) was recorded from Vi_3 treatment which was statistically similar (1.43 kg) to Vi_2 and closely followed (1.33 kg) by Vi_1, while the lowest weight (1.16 kg) was observed from Vi_0 treatment.



Vr_0: No vermicompost (control condition) Vr_1: 4 ton vermicompost/ha

Vr_2: 8 ton vermicompost/ha

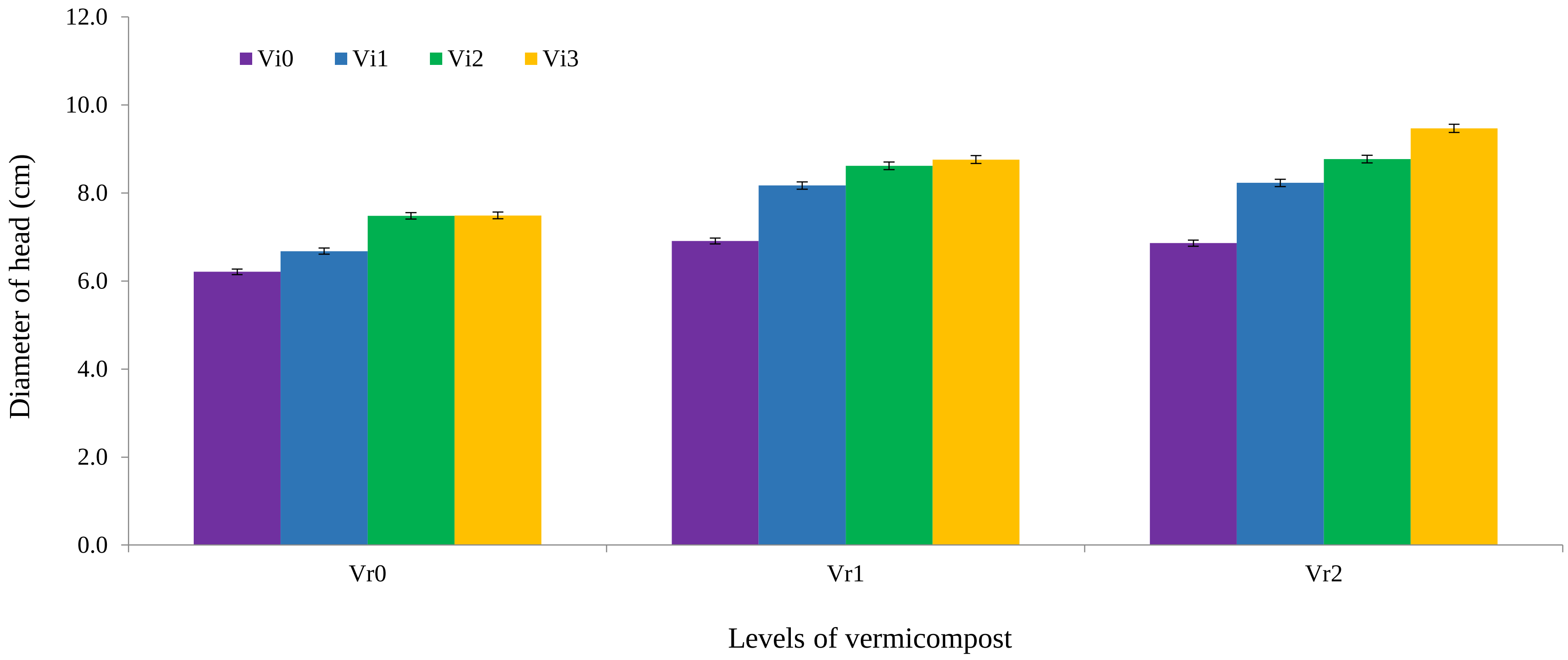
Figure 9. Effect of different levels of vermicompost on diameter of head of red cabbage. (Vertical bars represent LSD value at 5% level of probability)



Vi_0: No vitalizer (control condition) Vi_1: 2 ml vitalizer/*l* water

Vi_2: 4 ml vitalizer/*l* water Vi_3: 6 ml vitalizer/*l* water

Figure 10. Effect of different levels of plant vitalizer on diameter of head of red cabbage (Vertical bars represent LSD value at 5% level of probability)



Vr_0: No vermicompost (control condition) Vr_1: 4 ton vermicompost/ha
Vr_2: 8 ton vermicompost/ha

Vi_0: No vitalizer (control condition) Vi_1: 2 ml vitalizer/*l* water
Vi_2: 4 ml vitalizer/*l* water Vi_3: 6 ml vitalizer/*l* water

Figure 11. Combined effect of different levels of vermicompost and plant vitalizer on diameter of head of red cabbage. (Vertical bars represent LSD value at 5% level of probability

Combined effect of different levels of vermicompost and plant vitalizer showed statistically significant variation in terms of gross weight of head of red cabbage (Table 10). The highest gross weight of head (1.54 kg) was observed from Vr_2Vi_3, whereas the lowest weight (1.12 kg) was found from Vr_0Vi_0 treatment combination.

4.14 Dry matter content of head

Different levels of vermicompost showed statistically significant differences in terms of dry matter content of head of red cabbage (Table 9). The highest dry matter content of head (8.14%) was observed from Vr_2 treatment which was statistically similar (7.85%) to Vr_1 treatment and the lowest (6.68%) was recorded from Vr_0 treatment.

Dry matter content of head of red cabbage showed statistically significant differences due to different levels of plant vitalizer (Table 9). The highest dry matter content of head (8.39%) was recorded from Vi_3 treatment which was statistically similar (8.23%) to Vi_2 and closely followed (7.38%) by Vi_1, whereas the lowest (6.23%) was observed from Vi_0 treatment.

Statistically significant variation was recorded due to the combined effect of different levels of vermicompost and plant vitalizer in terms of dry matter content of head of red cabbage (Table 10). The highest dry matter content of head (9.20%) was found from Vr_2Vi_3 and the lowest (6.02%) was observed from Vr_0Vi_0 treatment combination.

4.15 Marketable yield/plant

Marketable yield/plant of red cabbage showed statistically significant variation due to different levels of vermicompost (Table 9). The highest marketable yield/plant (1.05 kg) was found from Vr_2 treatment which was followed (0.99 kg) to Vr_1 treatment, whereas the lowest (0.77 kg) was observed from Vr_0 treatment. Ahmed *et al*. (2017) reported that increasing the rate of vermicompost from 10 to 20% led to increase the yield characteristics of red cabbage.

Statistically significant differences was recorded due to different levels of plant vitalizer for marketable yield/plant of red cabbage (Table 9). The highest marketable yield/plant (1.03 kg) was observed from Vi_3 treatment which was statistically similar (1.01 kg) to Vi_2 and closely followed (0.92 kg) by Vi_1, while the lowest (0.79 kg) was found from Vi_0 treatment.

Combined effect of different levels of vermicompost and plant vitalizer showed statistically significant variation in terms of marketable yield/plant of red cabbage (Table 10). The highest marketable yield/plant (1.18 kg) was recorded from Vr_2Vi_3 and the lowest (0.68 kg) from Vr_0Vi_0 treatment combination.

4.16 Marketable yield/hectare

Statistically significant variation was observed in terms of marketable yield/hectare of red cabbage due to different levels of vermicompost (Table 9). The highest marketable yield/hectare (52.30 t/ha) was observed from Vr_2 treatment which was followed (49.73 t/ha) to Vr_1 treatment, while the lowest (38.47 t/ha) was found from Vr_0 treatment. Ismail *et al*. (2017) reported that vermicompost applications appeared to be effective in achieving sufficient levels in foliar N, P, Fe, Zn, and Mn contents and yield of red cabbage was found to be 52.65% higher than the control.

Different levels of plant vitalizer showed statistically significant differences due to for marketable yield/hectare of red cabbage (Table 9). The highest marketable yield/hectare (51.62 t/ha) was found from Vi_3 treatment which was statistically similar (50.25 t/ha) to Vi_2 and followed (45.85 t/ha) by Vi_1, whereas the lowest yield (39.62 t/ha) from Vi_0 treatment. Anonymous (2019) stated that HB-101 improves the efficiency of the plant's metabolism and increase yield.

Marketable yield/hectare of red cabbage showed statistically significant differences due to the combined effect of different levels of vermicompost and plant vitalizer (Table 10). The highest marketable yield/hectare (33.83 t/ha) was observed from Vr_2Vi_3, while the lowest yield (58.77 t/ha) was found from Vr_0Vi_0 treatment combination.

4.17 Economic analysis

Cost of production and benefit cost of red cabbage cultivation presented in Table 11 and Appendix X. Price of red cabbage was considered as per present market price. The economic analysis presented under the following heads-

4.17.1 Cost of production

Costs for land preparation, vermicompost, plant vitalizer, seeds, manpower and all operational cost from seeds sowing to harvesting of red cabbage were recorded as per plot and converted into hectare.

4.17.2 Gross return

The combination of different levels of vermicompost and plant vitalizer showed different value in terms of gross return (Table 11). The highest gross return (881,550 Tk./ha) was obtained from the treatment combination Vr_2Vi_3 and the second highest gross return (834,450 Tk./ha) was found in Vr_2Vi_2, whereas the lowest gross return (507,450 Tk./ha) was obtained from Vr_0Vi_0.

4.17.3 Net return

In case of net return, application of different levels of vermicompost and plant vitalizer showed different levels of net return under the present trial (Table 11). The highest net return (547,300 Tk./ha) was found from the treatment combination Vr_2Vi_3 and the second highest net return (501,536 Tk./ha) was obtained from the combination Vr_2Vi_2 and the lowest (203,919 Tk./ha) net return was obtained Vr_0Vi_0.

4.17.4 Benefit cost ratio

Application of different levels of vermicompost and plant vitalizer, the highest benefit cost ratio (2.64) was found from the combination of Vr_2Vi_3 and the second highest (2.51) was estimated from the combination of Vr_2Vi_2. The lowest benefit cost ratio (1.67) was obtained from Vr_0Vi_0 (Table 11). From economic point of view, it is apparent from the above results that the combination of Vr_2Vi_3 was best than rest of the combination in red cabbage cultivation.

Table 11. Cost and return of red cabbage cultivation as influenced by different level of vermicompost and plant vitalizer

Treatments	Cost of production (Tk./ha)	Yield of red cabbage (t/ha)	Gross return (Tk./ha)	Net return (Tk./ha)	Benefit cost ratio
Vr_0Vi_0	303,531	33.83	507,450	203,919	1.67
Vr_0Vi_1	304,867	35.49	532,350	227,483	1.75
Vr_0Vi_2	306,202	41.97	629,550	323,348	2.06
Vr_0Vi_3	307,538	42.59	638,850	331,312	2.08
Vr_1Vi_0	316,887	43.73	655,950	339,063	2.07
Vr_1Vi_1	318,223	48.53	727,950	409,727	2.29
Vr_1Vi_2	319,558	53.17	797,550	477,992	2.50
Vr_1Vi_3	320,894	53.50	802,500	481,606	2.50
Vr_2Vi_0	330,243	41.29	619,350	289,107	1.88
Vr_2Vi_1	331,579	53.52	802,800	471,221	2.42
Vr_2Vi_2	332,914	55.63	834,450	501,536	2.51
Vr_2Vi_3	334,250	58.77	881,550	547,300	2.64

Price of red cabbage @ Tk. 15/kg

Vr_0: No vermicompost (control condition)

Vr_1: 4 ton vermicompost/ha

Vr_2: 8 ton vermicompost/ha

Vi_0: No vitalizer (control condition)

Vi_1: 2 ml vitalizer/*l* water

Vi_2: 4 ml vitalizer/*l* water

Vi_3: 6 ml vitalizer/*l* water

Chapter V

Summary and Conclusion

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted during the period of October 2017 to February 2018 in the Horticultural farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207 to find out effect of vermicompost and plant vitalizer (HB-101) on growth and yield of red cabbage. The test crop used in the experiment was red cabbage hybrid variety Ruby King. The experiment consisted of two factors: Factor A: Vermicompost (3 levels) as- Vr_0: No vermicompost (control condition); Vr_1: 4 ton vermicompost/ha, Vr_2: 8 ton vermicompost/ha; and Factor B: Plant vitalizer (4 levels) as- Vi_0: No vitalizer (control condition), Vi_1: 2 ml vitalizer/*l* water, Vi_2: 4 ml vitalizer/*l* water and Vi_3: 6 ml vitalizer/*l* water. The two factorial experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data on different growth, yield parameters and yield of red cabbage were recorded and statistically significant variation was observed for different recorded parameters.

In case of different levels of vermicompost, at 20, 30, 40, 50 DAT and harvest, the tallest plant (18.28, 27.24, 33.76, 37.47 and 38.34 cm, respectively) was observed from Vr_2, whereas the shortest plant (15.14, 20.76, 27.96, 30.97 and 31.96 cm, respectively) from Vr_0. At 20, 30, 40, 50 DAT and harvest, the highest number of leaves/plant (8.58, 15.15, 20.17, 21.45 and 22.55, respectively) was recorded from Vr_2 treatment, while the lowest number (7.08, 12.65, 16.17, 17.42 and 18.33, respectively) from Vr_0 treatment. At 20, 30, 40, 50 DAT and harvest, the longest leaf (13.63, 19.08, 26.11, 28.33 and 30.64 cm, respectively) was found from Vr_2 treatment, whereas the shortest leaf (11.77, 16.26, 21.79, 24.28 and 26.58 cm, respectively) from Vr_0 treatment. At 20, 30, 40, 50 DAT and harvest, the highest leaf breadth leaf (12.56, 14.51, 15.69, 16.54 and 17.21 cm, respectively) was found from Vr_2 treatment, while the lowest leaf breadth (10.61, 12.37, 12.90, 13.98 and 14.70 cm, respectively) from Vr_0 treatment.

The minimum days to 1st head initiation (35.72) was found from Vr_2, whereas the maximum days (38.53) from Vr_0 treatment. The highest length of stem (7.70 cm) was observed from Vr_2, whereas the lowest (5.38 cm) from Vr_0 treatment. The highest diameter of stem (2.27 cm) was observed from Vr_2, while the lowest (1.84 cm) from Vr_0 treatment. The fresh weight of stem (58.57 g) was recorded from Vr_2, whereas the lowest (51.07 cm) from Vr_0 treatment. The highest dry matter content of stem (13.58%) was observed from Vr_2, whereas the lowest (11.47%) from Vr_0 treatment. The highest length of roots (16.85 cm) was found from Vr_2 and the lowest (13.87 cm) from Vr_0 treatment. The highest thickness of head (14.24 cm) was observed from Vr_2 treatment, whereas the lowest (12.22 cm) from Vr_0 treatment. The highest diameter of head (8.33 cm) was found from Vr_2, while the lowest (6.97 cm) from Vr_0 treatment. The highest gross weight of head (1.41 kg) was observed from Vr_2, whereas the lowest weight (1.22 kg) from Vr_0 treatment. The highest dry matter content of head (8.14%) was observed from Vr_2 and the lowest (6.68%) from Vr_0 treatment. The highest marketable yield/plant (1.05 kg) was found from Vr_2 and the lowest (0.77 kg) from Vr_0. The highest marketable yield/hectare (52.30 t/ha) was observed from Vr_2 treatment, while the lowest (38.47 t/ha) from Vr_0 treatment.

For different levels of plant vitalizer, at 20, 30, 40, 50 DAT and harvest, the tallest plant (18.55, 26.60, 34.36, 38.17 and 38.81 cm, respectively) was recorded from Vi_3, while the shortest plant (14.41, 21.68, 26.16, 30.04 and 30.96 cm, respectively) from Vi_0. At 20, 30, 40, 50 DAT and harvest, the highest number of leaves/plant (8.60, 15.51, 21.00, 22.62 and 23.89, respectively) was found from Vi_3, whereas the lowest number (7.00, 12.09, 14.80, 15.93 and 17.04, respectively) from Vi_0 treatment. At 20, 30, 40, 50 DAT and harvest, the longest leaf (14.11, 20.12, 26.58, 28.70 and 31.18 cm, respectively) was recorded from Vi_3, while the shortest (11.01, 14.71, 21.43, 23.53 and 25.10 cm, respectively) from Vi_0 treatment. At 20, 30, 40, 50 DAT and harvest, the highest leaf breadth (12.64, 14.74, 15.85, 16.69 and 17.23 cm, respectively) was recorded from Vi_3, whereas the lowest (10.43, 11.97, 12.67, 13.61 and 14.20 cm, respectively) from Vi_0 treatment.

The minimum days to 1st head initiation (35.04) was observed from Vi_3, while the maximum days (38.82) from Vi_0 treatment. The highest length of stem (7.62 cm) was recorded from Vi_3, whereas the lowest (5.86 cm) from Vi_0 treatment. The highest diameter of stem (2.35 cm) was found from Vi_3 treatment, whereas the lowest (1.70 cm) from Vi_0 treatment. The highest fresh weight of stem (58.95 g) was found from Vi_3, while the lowest (50.08 g from Vi_0 treatment. The highest dry matter content of stem (13.79%) was recorded from Vi_3, while the lowest (11.19%) from Vi_0 treatment. The highest length of roots (17.29 cm) was recorded from Vi_3, whereas the lowest (13.11 cm) from Vi_0 treatment. The highest thickness of head (14.55 cm) was recorded from Vi_3, while the lowest (11.64 cm) from Vi_0 treatment. The highest diameter of head (8.57 cm) was observed from Vi_3, whereas the lowest (6.66 cm) from Vi_0 treatment. The highest gross weight of head (1.44 kg) was recorded from Vi_3, while the lowest (1.16 kg) from Vi_0 treatment. The highest dry matter content of head (8.39%) was recorded from Vi_3, whereas the lowest (6.23%) from Vi_0 treatment. The highest marketable yield/plant (1.03 kg) was observed from Vi_3, while the lowest (0.79 kg) from Vi_0 treatment. The highest marketable yield/hectare (51.62 t/ha) was found from Vi_3, whereas the lowest (39.62 t/ha) from Vi_0 treatment.

Due to the combined effect of different levels of vermicompost and plant vitalizer, at 20, 30, 40, 50 DAT and harvest, the tallest plant (20.35, 29.64, 37.71, 41.74 and 42.38 cm, respectively) was observed from Vr_2Vi_3 and the shortest plant (13.19, 17.22, 23.05, 26.55 and 27.51 cm, respectively) from Vr_0Vi_0. At 20, 30, 40, 50 DAT and harvest, the highest number of leaves/plant (9.60, 17.27, 23.33, 24.93 and 26.67, respectively) was found from Vr_2Vi_3, while the lowest number (6.53, 10.60, 12.13, 13.80 and 14.60, respectively) from Vr_0Vi_0 treatment combination. At 20, 30, 40, 50 DAT and harvest, the longest leaf (15.37, 21.53, 27.44, 30.41 and 33.03 cm, respectively) was recorded from Vr_2Vi_3 and the shortest leaf (10.52, 12.96, 17.77, 19.86 and 21.24 cm, respectively) from Vr_0Vi_0 treatment combination. At 20, 30, 40, 50 DAT and harvest, the highest leaf breadth (14.09, 16.05, 17.55, 18.39 and 18.79 cm, respectively) was observed from Vr_2Vi_3, while the lowest (10.13, 11.26, 11.84, 12.88 and 13.43 cm, respectively) from Vr_0Vi_0 treatment combination.

The minimum days to 1st head initiation (34.00) was recorded from Vr_2Vi_3, whereas the maximum days (39.73) from Vr_0Vi_0 treatment combination. The highest length of stem (9.34 cm) was observed from Vr_2Vi_3 and the lowest length of stem (6.27 cm) from Vr_0Vi_0 treatment combination. The highest diameter of stem (2.65 cm) was observed from Vr_2Vi_3, while the lowest (1.65 cm) from Vr_0Vi_0 treatment combination. The highest fresh weight of stem (62.67 g) was found from Vr_2Vi_3 and the lowest (44.42 g) from Vr_0Vi_0 treatment combination. The highest dry matter content of stem (14.95%) was observed from Vr_2Vi_3, whereas the lowest (10.17%) from Vr_0Vi_0 treatment combination. The highest length of roots (19.15 cm) was recorded from Vr_2Vi_3 and the lowest (12.18 cm) from Vr_0Vi_0 treatment combination. The highest thickness of head (15.90 cm) was observed from Vr_2Vi_3, whereas the lowest (11.28 cm) from Vr_0Vi_0 treatment combination. The highest diameter of head (9.47 cm) was observed from Vr_2Vi_3, while the lowest (6.21 cm) from Vr_0Vi_0 treatment combination. The highest gross weight of head (1.54 kg) was observed from Vr_2Vi_3, whereas the lowest weight (1.12 kg) from Vr_0Vi_0 treatment combination. The highest dry matter content of head (9.20%) was found from Vr_2Vi_3 and the lowest (6.02%) from Vr_0Vi_0 treatment combination. The highest marketable yield/plant (1.18 kg) was recorded from Vr_2Vi_3, whereas the lowest (0.68 kg) from Vr_0Vi_0 treatment combination. The highest marketable yield/hectare (33.83 t/ha) was observed from Vr_2Vi_3, while the lowest (58.77 t/ha) from Vr_0Vi_0 treatment combination.

For the application of different levels of vermicompost and plant vitalizer, the highest gross return (881,550Tk./ha) was obtained from the treatment combination Vr_2Vi_3 and the lowest gross return (507,450 Tk./ha) was obtained from Vr_0Vi_0. In case of net return, the highest net return (547,300 Tk./ha) was found from the treatment combination Vr_2Vi_3 and the lowest (203,919 Tk./ha) net return was obtained Vr_0Vi_0. The highest benefit cost ratio (2.64) was noted from the combination of Vr_2Vi_3 and the lowest benefit cost ratio (1.67) was obtained from Vr_0Vi_0. From economic point of view, it is apparent from the above results that the combination of Vr_2Vi_3 was best than rest of the combination in red cabbage cultivation.

Conclusion

Among the combination of different levels of vermicompost and plant vitalizer, 8 ton vermicompost/ha and foliar application of 6 ml vitalizer/*l* water provided superior growth, yield and benefit of red cabbage cultivation.

Considering the situation of the present experiment, further studies in the following areas may be suggested:

- The experiment was conducted only one growing season under AEZ No. 28. Before more confirmation and recommendation further such type study is required in different agro-ecological zones of Bangladesh with other management practices.

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Appendices

APPENDICES

Appendix I. Soil characteristics of experimental field as analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Horticulture farm field , SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled

B. Physical and chemical properties of the initial soil

Characteristics	Value
% Sand	26
% Silt	43
% clay	31
Textural class	Sandy loam
pH	5.9
Catayan exchange capacity	2.64 meq 100 g/soil
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

Appendix II. Monthly record of air temperature, relative humidity, rainfall and sunshine hour of the experimental site during the period from October 2017 to February 2018

Month	Air temperature (ºC)		Relative humidity (%)	Total Rainfall (mm)	Sunshine (hr)
	Maximum	Minimum			
October, 2017	26.5	19.4	81	22	6.9
November, 2017	25.8	16.0	76	00	6.8
December, 2017	22.6	13.4	78	05	6.6
January, 2018	24.9	12.2	64	00	5.8
February, 2018	27.7	16.9	69	30	6.7

Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka-1212

Appendix III. Analysis of variance of the data on plant height at different days after transplanting (DAT) and at harvest of red cabbage as influenced by different levels of vermicompost and plant vitalizer

Treatments	Degrees of freedom	Plant height (cm) at				
		Mean square				
		20 DAT	30 DAT	40 DAT	50 DAT	Harvest
Replication	2	0.113	0.237	1.412	1.010	0.040
Levels of vermicompost (A)	2	32.889**	147.791**	107.114**	153.159**	148.667**
Levels of plant vitalizer (B)	3	30.596**	47.604**	119.066**	116.582**	111.821**
Interaction (A×B)	6	3.629*	6.938*	5.235*	12.456**	10.473**
Error	22	1.306	2.345	1.958	3.541	2.995

**: Significant at 0.01 level of significance; *: Significant at 0.05 level of significance

Appendix IV. Analysis of variance of the data on number of leaves/plant at different days after transplanting (DAT) and at harvest of red cabbage as influenced by different levels of vermicompost and plant vitalizer

Treatments	Degrees of freedom	Number of leaves/plant at				
		Mean square				
		20 DAT	30 DAT	40 DAT	50 DAT	Harvest
Replication	2	0.008	0.001	0.268	0.408	0.114
Levels of vermicompost (A)	2	7.684**	21.528**	53.138**	58.004**	64.341**
Levels of plant vitalizer (B)	3	4.757**	20.987**	67.036**	84.117**	82.413**
Interaction (A×B)	6	0.564*	2.017*	6.440*	2.284*	3.669*
Error	22	0.176	0.743	0.842	0.825	1.384

**: Significant at 0.01 level of significance; *: Significant at 0.05 level of significance

Appendix V. Analysis of variance of the data on leaf length at different days after transplanting (DAT) and at harvest of red cabbage as influenced by different levels of vermicompost and plant vitalizer

Treatments	Degrees of freedom	Leaf length (cm) at				
		Mean square				
		20 DAT	30 DAT	40 DAT	50 DAT	Harvest
Replication	2	0.051	0.494	1.279	0.183	0.291
Levels of vermicompost (A)	2	11.189**	27.754**	69.406**	58.810**	60.479**
Levels of plant vitalizer (B)	3	18.008**	56.683**	48.881**	50.638**	69.404**
Interaction (A×B)	6	0.840*	2.207*	3.577*	2.990*	2.865*
Error	22	0.288	0.883	1.320	1.160	1.075

**: Significant at 0.01 level of significance; *: Significant at 0.05 level of significance

Appendix VI. Analysis of variance of the data on leaf breath at different days after transplanting (DAT) and at harvest of red cabbage as influenced by different levels of vermicompost and plant vitalizer

Treatments	Degrees of freedom	Leaf breadth (cm) at				
		Mean square				
		20 DAT	30 DAT	40 DAT	50 DAT	Harvest
Replication	2	0.149	0.184	0.102	0.366	0.166
Levels of vermicompost (A)	2	12.881**	16.132**	26.002**	22.476**	21.798**
Levels of plant vitalizer (B)	3	8.695**	13.467**	17.374**	16.923**	18.043**
Interaction (A×B)	6	1.637*	1.535*	1.153*	1.339*	1.273*
Error	22	0.490	0.304	0.407	0.512	0.483

**: Significant at 0.01 level of significance; *: Significant at 0.05 level of significance

Appendix VII. Analysis of variance of the data on yield contributing characters of red cabbage as influenced by different levels of vermicompost and plant vitalizer

Treatments	Degrees of freedom	Mean square					
		Days to 1st head initiation	Length of stem (cm)	Diameter of stem (cm)	Fresh weight of stem (g)	Dry matter content of stem (%)	Length of roots (cm)
Replication	2	0.163	1.083	0.001	0.201	0.056	0.115
Levels of vermicompost (A)	2	27.223*	20.139**	0.610**	196.488**	15.669**	31.598**
Levels of plant vitalizer (B)	3	22.194*	5.896**	0.753**	143.860**	11.995**	31.829**
Interaction (A×B)	6	19.398*	7.982**	0.054*	5.986*	0.695**	1.791*
Error	22	6.253	1.219	0.020	2.129	0.193	0.712

**: Significant at 0.01 level of significance; *: Significant at 0.05 level of significance

Appendix VIII. Analysis of variance of the data on yield contributing characters and yield of red cabbage as influenced by different levels of vermicompost and plant vitalizer

Treatments	Degrees of freedom	Mean square					
		Thickness of head (cm)	Diameter of head (cm)	Gross weight of head (kg)	Dry matter content of head (%)	Marketable yield/plant (kg)	Marketable yield/ hectare (ton)
Replication	2	0.022	0.014	0.002	0.089	0.001	2.176
Levels of vermicompost (A)	2	13.946**	6.480**	0.142**	7.128**	0.260**	649.571**
Levels of plant vitalizer (B)	3	14.798**	6.434**	0.150**	8.833**	0.105**	262.915**
Interaction (A×B)	6	1.279*	0.267*	0.009*	0.558**	0.007*	17.903*
Error	22	0.488	0.098	0.003	0.158	0.002	5.809

**: Significant at 0.01 level of significance; *: Significant at 0.05 level of significance

Appendix IX. Per hectare production cost of red cabbage

A. Input cost

Treatments	Labour cost	Ploughing cost	Seedling Cost	Water for plant Establishment	Vermocompost	Plant Vitalizer	Insecticide/ pesticides	Sub total (A)
Vr_0Vi_0	65,000	48,000	24,000	30,000	0	0	20,000	187,000
Vr_0Vi_1	65,000	48,000	24,000	30,000	0	1,200	20,000	188,200
Vr_0Vi_2	65,000	48,000	24,000	30,000	0	2,400	20,000	189,400
Vr_0Vi_3	65,000	48,000	24,000	30,000	0	3,600	20,000	190,600
Vr_1Vi_0	65,000	48,000	24,000	30,000	12,000	0	20,000	199,000
Vr_1Vi_1	65,000	48,000	24,000	30,000	12,000	1,200	20,000	200,200
Vr_1Vi_2	65,000	48,000	24,000	30,000	12,000	2,400	20,000	201,400
Vr_1Vi_3	65,000	48,000	24,000	30,000	12,000	3,600	20,000	202,600
Vr_2Vi_0	65,000	48,000	24,000	30,000	24,000	0	20,000	211,000
Vr_2Vi_1	65,000	48,000	24,000	30,000	24,000	1,200	20,000	212,200
Vr_2Vi_2	65,000	48,000	24,000	30,000	24,000	2,400	20,000	213,400
Vr_2Vi_3	65,000	48,000	24,000	30,000	24,000	3,600	20,000	214,600

Vr_0: No vermicompost (control condition)

Vr_1: 4 ton vermicompost/ha

Vr_2: 8 ton vermicompost/ha

Vi_0: No vitalizer (control condition)

Vi_1: 2 ml vitalizer/*l* water

Vi_2: 4 ml vitalizer/*l* water

Vi_3: 6 ml vitalizer/*l* water

Appendix IX. Per hectare production cost of red cabbage

B. Overhead cost (Tk./ha)

Treatments	Cost of lease of land (12% of value of land Tk. 15,00000/year	Miscellaneous cost (Tk. 5% of the input cost	Interest on running capital for 6 months (Tk. 12% of cost/year)	Sub total (Tk) (B)	Total cost of production (Tk./ha) [Input cost (A)+ overhead cost (B)]
Vr_0Vi_0	90,000	9,350	17,181	116,531	303,531
Vr_0Vi_1	90,000	9,410	17,257	116,667	304,867
Vr_0Vi_2	90,000	9,470	17,332	116,802	306,202
Vr_0Vi_3	90,000	9,530	17,408	116,938	307,538
Vr_1Vi_0	90,000	9,950	17,937	117,887	316,887
Vr_1Vi_1	90,000	10,010	18,013	118,023	318,223
Vr_1Vi_2	90,000	10,070	18,088	118,158	319,558
Vr_1Vi_3	90,000	10,130	18,164	118,294	320,894
Vr_2Vi_0	90,000	10,550	18,693	119,243	330,243
Vr_2Vi_1	90,000	10,610	18,769	119,379	331,579
Vr_2Vi_2	90,000	10,670	18,844	119,514	332,914
Vr_2Vi_3	90,000	10,730	18,920	119,650	334,250

Vr_0: No vermicompost (control condition)

Vr_1: 4 ton vermicompost/ha

Vr_2: 8 ton vermicompost/ha

Vi_0: No vitalizer (control condition)

Vi_1: 2 ml vitalizer/*l* water

Vi_2: 4 ml vitalizer/*l* water

Vi_3: 6 ml vitalizer/*l* water