GROWTH, YIELD AND QUALITY OF CHINESE CABBAGE AS INFLUENCED BY VERMICOMPOST

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CERTIFICATE

This is to certify that the thesis entitled, ***"GROWTH, YIELD AND QUALITY OF CHINESE CABBAGE AS INFLUENCED BY VERMICOMPOST"*** *submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of* **MASTER OF SCIENCE** in **HORTICULTURE**, *embodies the result of a piece of bona fide research work carried out by* ***NISHAT ISLAM****, Registration No.* ***18- 09249*** *under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

Dated: December, 2020
Place: Dhaka, Bangladesh

Prof. Dr. JasimUddain
Supervisor

DEDICATED

TO

MY BELOVED PARENTS

LIST OF ABBREVIATIONS

BARI	Bangladesh Agricultural Research Institute
RCBD	Randomized Complete Block Design
SRDI	Soil Resources Development Institute
ANOVA	Analysis of Variance
DAT	Day After Transplanting
BRARP	Chinese cabbage *Brassica rapa* L. sp. *pekinensis* cv. Bulam Plus
CUPRAC	Cupric reducing antioxidant capacity
D-T	Drought related
ABTS	2,2-Azino-bis (3-ethyl-benzothiazoline-6-sulfonic acid) diammonium salt
HAS	Human serum albumin
FRAP	Ferric-reducing/antioxidant power
MS	Mass spectra
et al.	And others
MAS	Measurement of Absorbance
LSD	Least Significant Differences
SPSS	Statistical Package for the Social Sciences
NS	Non-significant

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The author

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GROWTH, YIELD AND QUALITY OF CHINESE CABBAGE AS INFLUENCED BY VERMICOMPOST

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ABSTRACT

An experiment was conducted in the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from November 2019 to February 2020 to study the influence of vermicompost on growth, yield, and quality of Chinese cabbage. The experiment consisted of two factors: Factor A: Three cultivars viz; C_1: BARI Chinakopi 1, C_2: Blues and C_3: Retasi; Factor B: Vermicompost (4 levels); VC_0: Control (no vermicompost), VC_1: 6 t/ha, VC_2: 8 t/ha and VC_3: 10 t/ha. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. There were 12 treatment combinations. In the case of cultivars, Blues gave the highest marketable yield (66.38 t/ha) and BARI Chinakopi 1 gave the lowest (43.55 t/ha). For vermicompost levels, VC_3 gave the highest (71.25 t/ha) marketable yield and the lowest (36.14 t/ha) from VC_0. For interaction effect, cultivar Blues treated with vermicompost (10t/ha) (C_2VC_3) gave the highest (83.55 t/ha) marketable yield and the lowest (30 t/ ha) from C_1VC_0. The highest values were recorded for Vit-C (27.50 mg/100g), Beta carotene (156.83 ug/100g), Ca (72.16 mg/100g), Mg (11.23 mg/100g), P (27 mg/100g), K (237.16 mg/100g), Fe (0.87 mg/100g) and Zn (0.21 mg/100g) were recorded from cultivar Blues (C_2). For vermicompost levels, VC_3 gave the maximum amount of Vit-C (28.88 mg/100g), Beta carotene (189.33 ug/100g), Ca (72.66 mg/100g), Mg (11.79 mg/100g), P (26 mg/100g), K (230 mg/100g), Fe (0.63 mg/100g) and Zn (0.21 mg/100g). For interaction effect, cultivar Blues treated with 10t/ha vermicompost (C_2VC_3) gave the highest amount of Vit-C (32 mg/100g), Beta carotene (195 ug/100g),), Ca (74.66 mg/100g), Mg (12.24 mg/100g), P (28 mg/100g), K (249.66 mg/100g), Fe (0.95 mg/100g) and Zn (0.23 mg/100g). So it could be concluded that the cultivar Blues with 10 t/ha vermicompost (C_2VC_3) gave the desirable growth, yield and quality of Chinese cabbage.

CHAPTERI

INTRODUCTION

Chinese cabbage (*Brassica campestris*var. *pekinensis)* is an important fresh and processed vegetable in the Brassicaceae family, particularly in Asian countries. With the Asian population moving to other parts of the world, Chinese cabbage is becoming increasingly common in countries all over the world. The market for this vegetable is growing day by day because of its good taste and high nutritional value(Larkcom, 2003; Laczi*et al*., 2016).

Chinese cabbage has bright green leaves; a prominent white midrib; a short, thick stem; and a large, compact, globular head. These varieties are ideal for mild-temperature cultivation areas (Filgueira, 2013). Chinese cabbage is not well-known in Bangladesh and grows to a very small extent as its consumption and suitable production technology are unaware. However, in recent years several farmers have been involved in the extensive cultivation of this crop.

Today, consumers are demanding products that are rich in nutrients for optimal health benefits. In this respect, the popularity of *Brassica* products is increasing due to their nutritional value, anticancer, antioxidant, and anti-inflammatory properties. As a member of the Brassicaceae, Chinese cabbage contains a large number of carotenoids, polyphenols and nitrogen-containing secondary metabolites, such as glucosinolates, which possess significant anti-oxidant properties and exercise anti-carcinogenic, anti-mutagenic, and anti-viral action (Kopsell*et al*., 2007; Harbaum*et al*., 2010 ; Verkerk*et al*., 2009). Chinese cabbage is rich in vitamins A, B, C, calcium, potassium, and fiber, which stimulates intestinal activity. It also supplies vitamin B_3 (niacin), which helps with gastrointestinal problems and nervous system disorders (Gordin*et al*., 2010). Pickling (a fermented food) is one of the most popular ways to preserve Chinese cabbage for cooking dishes such as kimchi which is Korean representative national and traditional food. A total of about 200 types of kimchi are currently known in Korea (Jang *et al*., 2015).

It is established that the use of inorganic fertilizers is not as good for human health as it is for organic fertilizers because of the residual effect (Hasan and Solaiman, 2012). The most crucial issues of the 21st century will include issues related to soil, water, and air quality (Pósa*et al*., 2013). Various agricultural practices affect the quality of the cultivated soil. The use of organic fertilizers contributes to the improvement of soil structure, humus content, and water retention capacity, with a significant impact on the beneficial activity of macro-and micro-organisms (Laczi*et al*., 2016).

Vermicompost is a good source of different macro and micronutrients. The use of vermicompost for large-scale vegetable production can solve the problem of waste disposal and also solve the problem of lack of organic manure. Earthworms consume large amounts of organic matter and excrete soil as a caste, and this caste contains several enzymes and is rich in plant nutrients, beneficial bacteria, and mycorrhizae (Bhavana*et al*., 2017).It is evident that vermicompost promote growth from 50-100% over conventional compost and 30-40% over chemical fertilizers (SujitAdhikary, 2012).

Several studies suggest that vermicompost is an excellent soil conditioner and can improve the growth and yield of vegetables such as tomatoes (Gutierrez-Miceli*et al*., 2007), chili peppers (Arancon*et al*., 2005), Chinese cabbage (Wang *et al*., 2010), garlic (Argüello*et al*., 2006) and strawberries (Arancon*et al*., 2004).

In the light of the above facts, the present research was conducted with the following goals:

- ❖ To identify the suitable cultivar on growth, yield, and quality of Chinese cabbage.
- ❖ To optimize the vermicompost level on growth, yield, and quality of Chinese cabbage.
- ❖ To find out the combination of cultivar and vermicompost attaining maximum yield of Chinese cabbage.

CHAPTER II

REVIEW OF LITERATURE

Chinese cabbage is a lesser known, cultivated and consumed vegetable species in Bangladesh, although previous studies have shown that it can be successfully grown in this area. The main objective of the current research is to emphasize the effectiveness of various treatments in the growth, yield and quality of Chinese cabbage influenced by vermicompost. Organic energy sources have now gained a great deal of worldwide interest in promoting soil health and improved plant nutrition. Vermicompost is excreta of earthworm capable of improving soil health and nutrient status. Vermi worms are used here as biological agents to consume the waste and to deposit the excreta in a process called vermicompost. Vermicompost can be successfully used for the cultivation of Chinese cabbage in order to improve physiological characteristics, soil fertility and also increase crop growth and yield. Since there is much less literature on the effect of vermicompost on growth, yield and quality of Chinese cabbage; literature on other crops is also included in this chapter for a better understanding of the subject.

Yang *et al.* (2019) studied antioxidant capacities and polyphenols in autumn□growing cultivar of Chinese cabbage (*Brassica rapa* L. sp. *pekinensis* cv. Bulam Plus). The effects of drought stress in autumn-growing Chinese cabbage cultivar on bioactive compounds, total antioxidant and binding properties to human serum albumin (HSA) were studied. Seedlings of 42 days growing Chinese cabbage *Brassica rapa* L. sp. *pekinensis* cv. Bulam Plus (BRARP) were transplanted and maintained into pots during 3 weeks with soil water of the drought-treated (D-T) and control (C) plants at 10% and 30%, respectively. Polyphenols and the values of antioxidant capacities by three radical scavenging assays (CUPRAC, FRAP, ABTS) were determined in methanol extracts of the samples. In samples treated at different times, MS spectra of phenolic extracts were compared. The overall polyphenols and their behaviors in drought-treated Chinese cabage were marginally lower than those in their respective controls. In Chinese cold BRARP it was reduced the effect of polyphenols, complete antioxidants and binding activity in the accumulation of D-T plants during drought stress. Our research offers useful information about the consumption in South Korea and other countries of BRARP Chinese cabbage throughout the year.

Lacz*iet al*. (2016) studied that headed Chinese cabbage growth and yield influenced by different manure types in organic farming system. Chinese cabbage is a less known vegetable species, cultivated and consumed in Transylvania, but studies have shown that it can succeed in growing in this area. The main aim of the present research was to emphasize the efficacy of different treatments in organic farming on the growth, output and quality of Chinese cabbage. Treatments included: different types of fertilization, place of cultivation and various hybrids. Results showed that the characteristics of the cabbage heads, for example length, diameter, weight, leaves number and yield, all of the factors examined had a significant influence When the manure was used for horses (entre 76.50 and 99.30 t/ha) followed by the manure of cattle (entre76.80 and 93.75 t/ha) the best yield was recorded. In comparison to open cultivation (77.50 t/ha) a greater output of better-quality cabbage was achieved in a polyethylene tunnel (89.27 t/ha). The highest yield was achieved by Hybrid Super (92.70 t/ha), followed by Vitimo hybrid (86.09 t/ha).

A pot experiment was conducted by Usman*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. This experiment consisted of two variables and used the randomized design of the factory block. The first factor is the type of vermicompost material that comprises three levels (mixture of mushroom media, cow fume and vegetable waste (V_1); mushroom controlled waste (V_2); cow fumes and leaf litter (V_3). The second factor consisted of a population of five (0, 25, 50, 75 and 100 person m-2) and treatment with one control (inorganic treatment). The results showed that the application of various vermicompost had significantly ($p<0.05$) higher yields than the inorganic treatment. Interaction between the kind of vermicompost and *P.coretrurus* population affected significantly ($p< 0.05$) yield and quality of cabbage. With population 0- 25 and 50 Indiv.m-2, Vermicompost V_1 and V_2 gave a high performance respectively. Vermicompost V_3 provided a high yield of earthworm *P. corethrurus* without inoculation. Based on the quality parameters, the best quality of chicken was provided by the Vermicompost V_1 and V_2 with a population of 0-50 indiv m-2 and V_3 with a population of 25 m-2. The content of sugar and vitamin C increased by 12 percent on average and 57 percent on the chip treated with these three vermicompost sorts. Storage loss (% of initial mass) showed decrease average value by 23% under the treatment of 7 days storage at room temperature (25^{o}C) and 8% under the treatment of 14 days storage at cold temperature (5^{o}C) compared with the inorganic treatment by 85% and 18%, respectively. The results suggest that the application of vermicompost can increase the yield and quality of cabbage.

A field experiment was conducted with Tripathi*et al*. (2015) to evaluate the effect of vermicompost and chemical fertilizers on the performance of Pak choi (*Brassica rapa* CV. Hong Tae) in Chitwan Nepal between November 2012 and January 2013. Four levels of vermicompost (0, 5, 10 and 15 t/ha) and four levels of NPK equivalent in the form of inorganic fertilizer (100, 50, 25 and 0 per cent of recommended doses of 100:60:60 Kg/ha) in 16 combinations were assessed for yield, yield contributing parameters for Pak Choi and soil microbial activity. All levels of chemical fertilizers increased the plant height, the number of leaves and the chlorophyll content of the leaves, but did not increase the root length. Chemical fertilizers at 100:60:60 kg NPK/ha increased biological and economic yield of Pak choi. However, all levels of chemical fertilizers have been found to be strongly suppressing in soil microbial activities. Vermicompost, on the other hand, increased root length, leaf number, biological and economic yield and significantly increased soil microbial activity resulting in increased soil respiration.

Laczi*et al*. (2015) conducted an experiment to Study of Some Headed Chinese Cabbage Varieties and Hybrids Growth and Development in Autumn Open Field Culture in Transylvanian Tableland Specific Conditions. The main purpose of this experiment was to study the behavior of some Chinese cabbage varieties in the Transylvanian Tableland specific conditions in an autumn open field culture. A collection of 5 varieties and hybrids was organized to achieve the objectives of this experiment. During the growing season observations were made on the growth and development of the plants, on the quality of the yield and the quantity of the harvest, and high importance was given to the number of bolted plants. The head weight of the plants ranged from 0.77 kg to 0.99 kg, while the head of the cabbage was between 0.57 kg and 0.86 kg. At harvest, only one hybrid had a minimum bolting percentage, while another one had a 40% bolting percentage. The yields obtained in this experiment ranged between 45.3 and 67.2 t/ha. The success of the Chinese cabbage crop is directly related to the selection of a good hybrid.

An experiment was conducted by Jahan*et al*. (2014) to study the effect of vermicompost and conventional compost on the growth and yield of cauliflower. The experiment consisted of twelve treatments viz. T_1: 100% Recommended Dose of Chemical Fertilizer (RDCF; RDCF= N250P35K65S40 Zn5B1 kgha-1); T_2: 80% RDCF; T_3: 60% RDCF; T_4: 100% RDCF + Vermicompost @ 1.5 t/ha; T_5: 80% RDCF + Vermicompost @ 3 t/ha; T_6: 60% RDCF +Vermicompost @ 6 t/ha; T_7: Vermicompost @ 6 t/ha; T_8:100% RDCF +Conventional compost @ 1.5 t/ha; T_9: 80% RDCF +Conventional compost @ 3 t/ha; T10: 60% RDCF + Conventional compost @ 6 t/ha; T_{11}: Conventional compost @ 6 t/ha and T_{12}: Control (No fertilization) following Randomized Complete Block Design with three replications. Maximum plant height (49.4 cm), number of leaves plant^{-1} (16.3), circumference of curd (46.5 cm), curd height (20.7 cm), total weight (1.60 kg plant-1), marketable weight (13.0 kg plant-1), curd yield (37.6 t ha-1) and stover yield (29.7 t ha-1) were found from T_4 which was statistically identical with or followed by T8 and T5. From the experiment it was found that vermicompost was better that conventional compost in combination with chemical fertilizers.

Ramírez*et al*. (2014) performed a field experiment to test different vermicompost doses in tomato crops (*Solanumlycopersicum* L.) in northern Sinaloa, Mexico. Vermicompost doses of 0, 500, 1000, 1600, 2000 and 4000 kg/ha were tested including a placebo, in a fully randomized design with three replicates per treatment. The variables calculated were fruit size, count and weight. The addition of vermicompost over 4000 kg/ha greatly increased the number of fruits and the size of tomato plants, and it is considered a viable choice for commercial tomato cultivation.

Chatterjee*et al*. (2013) conducted field experiments at UBKV, Pundibari, West Bengal, India in order to gain access to the influence of various organic changes on the growth, head yield and the efficiency of the use of nitrogen in cabbage. The experiment consisted of 15 different sources of nutrients combining inorganic fertilizers, organic manures (farmyard manure and vermicompost) and *Azophos*biofertilizers in RBD with 3 replications. Growth and head attributes of cabbage have been significantly influenced by different nutrient combinations, and vermicompost has emerged as a better source of organic nutrients has emerged as a better source of organic nutrients over farm manure. Inoculation with biofertilizers had a more positive effect on uninoculated treatments. The nutrient schedule, consisting of a higher amount of vermicompost (5 t/ha) along with 75% of the recommended inorganic fertilizers in the presence of biofertilizer inoculation, emerged as a potential source of nutrients and resulted in multiple improvements in the form of vigorous growth, advanced head maturity, maximum curing percent and higher head output compared to other nutrient combinations.

Getnet and Raja (2013) conducted an experiment to study impact of vermicompost on growth and development of Cabbage, Brassica oleracea Linn. and their sucking pest. Vermicompost was applied at the rate of 25, 50, 100 and 200 gm/plant individually. Each application 10 plants were selected and vermicompost application was continued on bimonthly basis. In the control group, 40 plants have been used, in which 10 plants have been randomly selected. Total number of leaves per plant; leaf length and width; plant height and root length; cabbage head round distance and weight and aphid population were the parameters studied in experimental and control cabbage plants. Significant differences ($p<0.05$; LSD) were observed in the growth and development and pest infestation level between vermicompost applied and control plants. The number of plant stand heights, the cabbage head and the cabbage leaves were also significantly different ($p<0.05$; LSD) in experimental cabbage compared to control. Aphid was infested by the maximum number of cabbage plants monitored as experimental classes. Vermicompost eventually has an important effect on fostering cabbage growth and reducing aphid infestation.

John and Prabha (2013) studied the effect of vermicompost on the growth and yield of *Capsicum annum*. Their study found that total macronutrients and micronutrients showed elevated levels of vermicompost compared to control. The vermicompost plant used Capsicum annum has shown an increase in the length of the shoot and the number of leaves compared to the inorganic fertilizer plant used.

Zhao *et al.* (2012) conducted an experiment to identify the effects of drip system uniformity on yield and quality of Chinese cabbage heads. Three Christiansen uniformity coefficients (CU=62, 81 and 96%) and two nitrogen application rates (150 and 300 kg/ha) were evaluated in2009. In 2010, three CU values (57, 74, and 95%) and one nitro-gen application rate (225 kg/ha) were tested. System uniformity was established by randomly assembling segments of drip tubes with five different nominal discharge rates (1.05, 1.4, 1.65, 2.3 and 2.6 L/h) along the drip line. For all the system uniformities tested, the plant height, the head height to the diameter ratio, the dry matter above ground level and the nitrogen uptake showed high uniformity coefficients throughout the entire growing season. The effects of the system uniformity and application rate of nitrogen on mean yield and quality indices and their uniformity were insignificant. With the increase in the field scale controlled by a single drip line, the uniformity of crop growth, yield and quality indices has shown a declining trend. The results of this study showed that uniformity values that are lower than those recommended by the current standards can be used in drip irrigation systems and that their use should take into account the field scale controlled by the drip line.

Theunissen*et al*. (2010) reported vermicompost contains plant nutrients including N, P, K, Ca, Mg, S, Fe, Mn, Zn, Cu and B, the uptake of which has a positive effect on plant nutrition, photosynthesis, chlorophyll content of the leaves and improves the nutrient content of the various plant components (roots, shoots and the fruits). Vermicompost is rich in humic acids since it facilitates the synthesis of 12 phenolic compounds such as anthocyana and flavonic acids that can enhance the quality of plants and prevent pests and diseases.

Prasad *et al.* (2009) worked with Chinese cabbage (*Brassica campestris L. var. pekinensis*) in the response of nitrogen and phosphorus levels on the growth and yield of Chinese cabbage (*Brassica campestris*L. var. *pekinensis*) in the gangetic plains of West Bengal. Adequate quantities of plant nutrients are required to promote proper crop growth with view to achieve success in vegetable production. A field experiment was conducted on response of Chinese cabbage to different doses of nitrogen and phosphorus levels. The aim of this research was to assess the performance of two fertilizers in different doses for growth, yield and quality of Chinese cabbage. Analysis of variance showed significant differences among the treatments for all the traits. The maximum number of outer leaves, head length, head width, total head weight, net head weight and head yield were obtained with the application of 120kg N/ha and 100kg P/ha .Whereas the maximum plant height, plant spread, leaf area and head diameter were recorded with the application of 140kg N/ha and 120kg P/ha. From the experiment, suggested that the application of 120kg nitrogen/ha and 100kg P/ha are best for obtaining higher production in Chinese cabbage in the Gangetic plains of West Bengal.

In their analysis of Azarmi*et al*. (2008), the effects of vermicompost (*Lycopersiconesculentum*) were evaluated on field conditions for growth, yield and fruit quality of tomatoes. The experiment was a random complete block design with four replications. The different rates of vermicompost (0, 5, 10 and 15 t/ha) was incorporated into the top 15 cm of soil. The results revealed that addition of vermicompost at rate of 15 t/ha significantly (at $p < 0.05$) increased growth and yield compared to control. Vermicompost with rate of 15 t/ha increased EC of fruit juice and percentage of fruit dry matter up to 30 and 24%, respectively. The content of K, P, Fe and Zn in the plant tissue increased 55, 73, 32 and 36% compared to untreated plots respectively.

Pankaj (2006) conducted a field experiment during the 2003/04 and 2004/05 kharif seasons in Varanasi, Uttar Pradesh, India, to study the integrated effect of bioinoculants (Azotobacter and phosphorus solubilizing microorganisms (PSM)), organic fertilizer (farmyard manure and digested sludge) and inorganic fertilizers (NPK), alone and in combination, on the growth and yield of cabbage seedlings. Data were recorded for plant height, stem length, number of primary roots, number of wrapper leaves, number of non-wrapper leaves, weight of non-wrapper leaves, head length, head diameter, fresh weight of head, weight per plant and head yield. The results are presented. Data represented that Azotobacter + farmyard manure + NPK and phosphorus solubilizing microorganisms + digested sludge + NPK were was more effective than Azotobacter + farmyard manure, phosphorus solubilizing microorganisms + digested sludge, Azotobacter + digested sludge, phosphorus solubilizing microorganisms + farmyard manure incase of growth (plant height, stem length, number of primary roots, number of wrapper leaves, number of non-wrapper leaves, weight of non-wrapper leaves) and yield (head length, head diameter, fresh weight of head, total weight/plant and head yield) contributing characters of cabbage.

Arancon*et al*. (2005) studied the effects of vermicomposts produced from cattle manure, food waste and paper waste on the growth and yield of peppers in the field. Commercially processed vermicomposts, produced from food wastes, paper wastes and cattle manure, were applied to 8.25 m2field plots, at rates of 10 or 20 t/ha in1999 and 5 or 10 t/ha in 2000, to evaluate their effects on the growth and yields of peppers (*Capsicum annuum* var. King Arthur). Vermicomposts were incorporated into the upper 10 cm of soil and supplemented, on the basis of chemical analyzes, with amounts of inorganic NPK fertilizers calculated to equalize initially at the rates of 95-95 NK kg/ha applied to inorganic fertilizer control plots. Phosphorus was determined to be adequate in soils at the experimental site so that it was not added. All treatments have been replicated four times in a randomized, complete block design. The vermicompost applications increased the growth and yields of peppers significantly; including increased leaf areas, plant shoot biomass, marketable fruit weights and decreased yields of non-marketable fruit. Application of vermicomposts to soils increased their microbial biomass and dehydrogenase activity. Humic materials and other plant growth-influencing substances, such as plant growth hormones, produced by microorganisms during vermicomposting and produced after increased micro biomass and soil activity, may have been responsible for increased pepper growth and yields, regardless of the availability of nutrients.

Thy and Buntha (2005) carried out a study evaluate the response of Chinese cabbage (*Brassica pekinensis*) to different forms of organic fertilizer. The four treatments (each replicated four times) were: raw cattle manure solids, composted cattle manure solids (in piles of 0.5 or 1.0 m3 volume) and the effluent from a mixing indigested (20 day retention time) charged with the liquid and small particles from raw cattle manure. The fertilizers were applied at the same level of nitrogen (150 kg N/ha) at 7 day intervals with increasing quantities equivalent to 10, 20, 30, and 40% of the total amount over the first 28 days. A basal fertilization of 2 kg per m^2 of fresh cattle manure was applied to all plots one week before starting the trials. In Trial 2, when seeding was done directly in the field and the plots were protected with plastic sheet against the rain, biomass yield of the cabbage showed a 100% increase for use of indigested effluent (34 t/ha) as compared of composted manure (14 to 17 t/ha), with lowest results for fresh manure solids (9 t/ha). The residual effects of N (0, 50, 100 and 150 kg/ha) and organic manure (control, rice straw litter or farmyard manure, supplied to rice seedlings transplanted on 15 and 30 June were assessed for the yield, yield components and nutrient uptake. Transplanting dates had no significant residual effects on the yield, yield components and nutrient uptake. Phosphorus uptake increased with increasing N whereas N and K uptake increased only up to 100 kg N/ha. The effects of organic manure and N rates on the yields were significant. All parameters measured were the highest with litter application, the highest with the FYM application. A positive net gain of N was observed at 100 and 150 kg N/ha in combination with organic manure. Lower doses of N, either alone or in combination with FYM, resulted in negative results.

Arancon*et al*. (2004) studied the Influences of vermicomposts on field strawberries: 1. Effects on growth and yields. Vermicomposts processed commercially from food wastes and paper wastes were applied, to 4.5 m (2) field plots, under high plastic hoop tunnels, at rates of 5 or 10 t ha-1 to evaluate their effects on the growth and yields of strawberries (*Fragariaananasavar. 'Chandler'*). Vermicomposts were incorporated into the top 10 cm of soil and supplemented, on the basis of chemical analyzes, with amounts of inorganic NPK fertilizers calculated to equalize the initial fertilization rates of 85-155-125 kg/ha NPK applied to inorganic fertilizer plots. All treatments were replicated four times, in a completely randomized design, at two sites on Doles silt loam or Hoytvillesilty clay loam in Piketon and Fremont, Ohio, respectively. Vermicompost applications increased strawberry growth and yields significantly; including increases of up to 37% in leaf areas, 37% in plant shoot biomass, 40% in numbers of flowers, 36% in numbers of plant runners and 35% in marketable fruit weights. These reactions did not appear to be dose-dependent, as strawberries at one site grew faster and yielded the most in response to the 10 t/ha vermicompost application rate, whereas they responded positively and similarly to both the 5 and 10 t/ha applications at the other site. These reactions could not have been mediated by the availability of macronutrients, since all plots were complemented by inorganic fertilizers, equalizing macronutrient inputs for all treatments, but based on further research in our laboratory could have been due to the production of plant growth regulators by microorganisms during vermicomposting.

Arancon*et al*. (2004) studied that significantly increased growth and yield of tomatoes (*Lycopersiconesculentum*) and peppers (*Capsicum anuumgrossum*) when vermicompost, produced commercially from cattle manure, food waste or recycled paper, were applied to field plots at rates of 20t/ha and 10t/ha in 1999 and at rates of 10 t/ha and 5 t/ha in 2000 compared with those receiving equivalent amounts of inorganic fertilizer.

Ye *et al*. (2004) consisted of a field experiment in China to study the effects of the combined application of organic manure and chemical fertilizer on the yield and quality of Chinese cabbage. The combined use of organic manure and fertilizer improved Chinese cabbage yield and quality. Greater yield and quality were achieved by the application of organic manure at 3750 kg/667 m and by the application of chemical fertilizer at 30 kg/667 m.

CHAPTER III

MATERIALS AND METHODS

An experiment was conducted in the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from November 2019 to February 2020 to study the influence of vermicompost on growth, yield, and quality of Chinese Cabbage influenced by vermicompost. This chapter includes materials and methods that were used conducting in the experiment. It consists of a short description of locations of the experimental site, characteristics of soil, climate, materials used for the seedlings, treatment of the investigation, layout, and design of the experiment, land preparation, manuring and fertilizing, transplanting of seedlings, intercultural operations, harvesting, data collection procedure, economic and statistical analysis, etc. The details regarding materials and methods of this experiment are presented below under the following headings –

3.1 Experimental Site

The location of the site in 23°74/ N latitude and 90°35/ E longitude with an elevation of 8.2 meter from sea level (Anon, 1989).

3.2 Characteristics of Soil

The soil of the experimental area was silty clay and belongs to the Modhupur Tract (UNDP, 1988) under AEZ 28. The selected plot was medium high land and the soil series was Tejgaon (FAO, 1988). The experimental site was a medium high land and p^H of the soil was 5.47-5.63 having organic matter 0.83%. The drainage condition was well drained. The characteristics of the soil under the experimental plot were analyzed in the SRDI, Soil testing Laboratory, Khamarbari, Dhaka and details of the soil characteristics are presented in Appendix I.

3.3 Weather Condition of the Experimental Site

The experimental site climate was subtropical, characterized by three distinct seasons, the winter season from November to February and the pre-monsoon or hot season from March to April and the monsoon season from May to October (Edris*et al.*, 1979).

3.4 Planting Materials

Three cultivars were used as planting materials viz. (i) BARI Chinakopi1 (ii) Blues (iii) Retasi. Seeds of Chinese Cabbage cultivars were used in the experiment and the seeds were collected from Bangladesh Agricultural Research Institute (BARI) and Dhaka Seed Store, Siddique Bazar, Dhaka.

3.5 Raising of seedlings

The seedlings were raised at Horticulture Farm of the Sher-e-Bangla Agricultural University, Dhaka under special care in a 1 m × 1 m size 3 seed beds for 3 cultivars. The soil of the seed bed was well plowed with a spade and prepared for loose, friable, dried mass and to obtain good tilth to provide a favorable condition for the vigorous growth of young seedlings. Weeds, stubbles and dead roots of the previous crop have been removed. The seed bed was dried in the sun to destroy the soil insect and to protect the young seedlings from the attack of disease damping. To control damping off disease autistin fungicide were applied @ 0.2g/1L water. Decomposed cowdung was applied to the prepared seedbed at the rate of 10 t/ha. Five (5) grams of seeds were sown in each seedbed on November 12, 2019. After sowing, the seeds were covered with finished light soil. At the end of germination shading was done by polythene over the seedbed to protect the young seedlings. Light watering, weeding and mulching were done as and when necessary to provide seedlings with the ideal conditions for better growth.

3.6 Treatment of the experiment

The experiment was conducted to find out the influence of vermicompost on growth, yield and quality of Chinese cabbage cultivars. The experiment consisted of two factors-

Factor A: Cultivars (3 cultivars)

(i) C_1: BARI Chinakopi 1

(ii) C_2: Blues

(iii) C_3: Retasi

Factor B: Vermicompost (4 levels)

(i)VC_0: Control (Novermicompost)

(ii)VC_1: Vermicompost : 6 t/ha, 1.08 kg/plot

(iii) VC_2: Vermicompost : 8 t/ha, 1.44 kg/plot

(iv) VC_3: Vermicompost : 10 t/ha, 1.8 kg/plot

3.7 Layout of the Experiment

The experimental plot was laid out in Randomized Complete Block Design (RCBD) with three replications. The layout of the experiment was prepared for distributing the treatment combinations in each plot of each block. Each block was divided into 12 plots where 12 treatment combinations were allotted at random. There were 36 unit plots altogether in the experiment. The size of the plot was 1.5 m x 1.2 m. The distance between two blocks and two plots were kept 0.6m and 0.5 m, respectively. The layout of the experiment is shown in Figure 1.

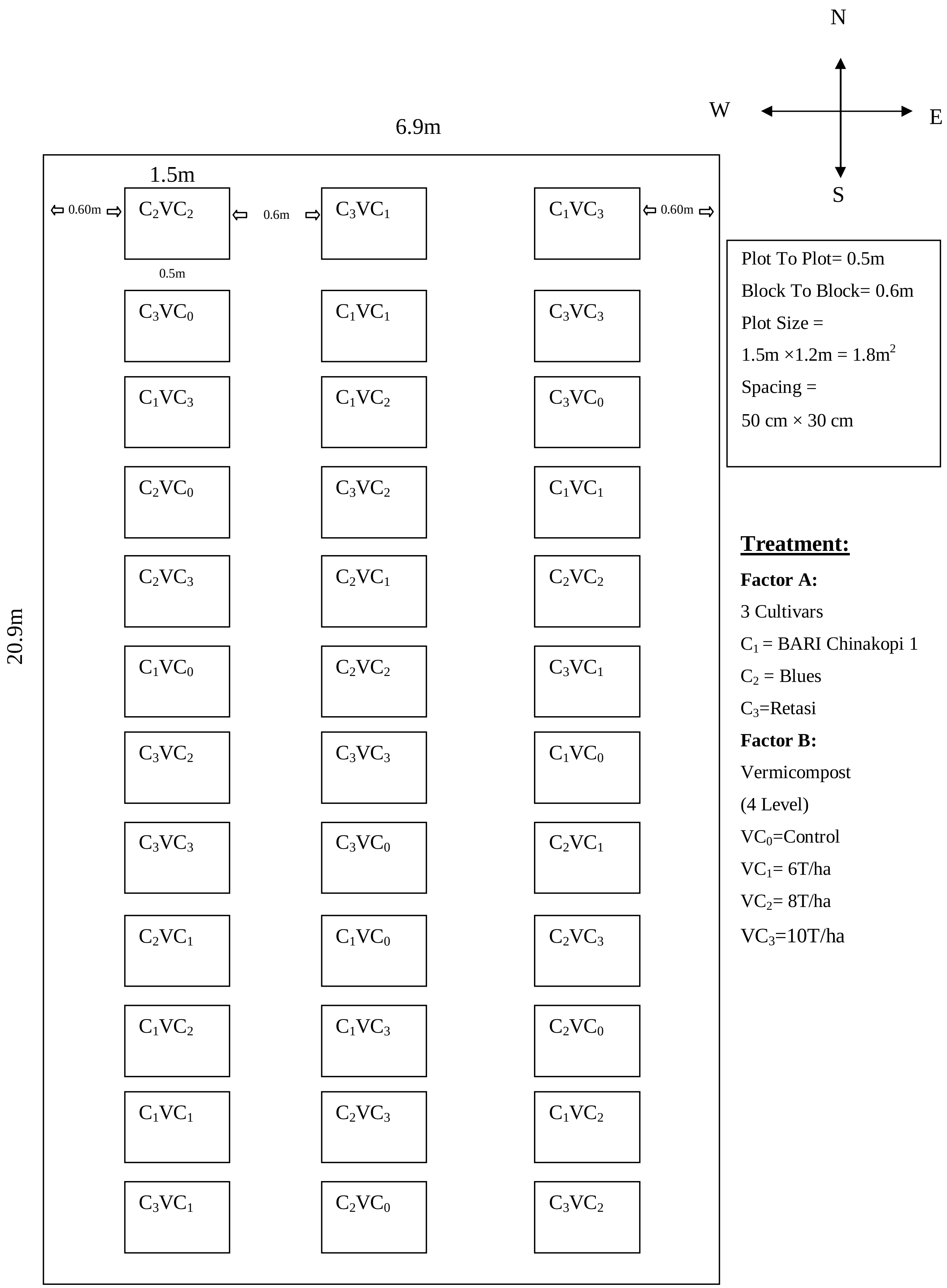

Figure 1. Layout of the experimental field

3.8 Preparation of the main field

The selected experimental plot was opened in November 2019 with a power tiller and was exposed to the sun for a week. After 2 days the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilth. Weeds and stubbles were removed and finally obtained a desirable tilth of soil for planting of Chinese cabbage seedlings. The experimental plot was partitioned into the unit plots in accordance with the experimental design and vermicompost was applied as per treatments of each unit plot. The soil was treated with fungicide autistin against the fungal attack.

3.9 Application of vermicompost

Doses of vermicomost applied in the field according to the treatments were as follows:

(i) VC_0: Control : No vermicompost

(ii) VC_1: Vermicompost : 6 t/ha, 1.08 kg/plot

(iii) VC_2: Vermicompost : 8 t/ha, 1.44 kg/plot

(iv) VC_3: Vermicompost : 10 t/ha, 1.8 kg/plot

3.10 Transplanting of seedlings in the main field

Healthy and uniform sized twenty three days old seedlings were transplanted in the main field on 5th December, 2019. The seedlings were uprooted carefully from the seedbed to avoid any damage to the root system. To minimize the root damage of the seedlings the seedbed was watered one hour before uprooting the seedlings. Transplanting was done in the afternoon. During transplanting a spacing of 50cm x 30cm between row to row and plant to plants were maintained. Thus each unit plot accommodated 12 plants. The seedlings were watered immediately after transplanting. A number of seedlings were also planted in the border of the experiment plots for gap filling if necessary later on.

3.11 Intercultural operation

When the seedlings were laid in the beds, they were always kept under careful observation. Various intercultural operations: Irrigation and drainage, gap filling,weeding, top dressing were carried out to improve the growth and development of Chinese cabbage seedlings.

3.11.1 Irrigation and drainage

Light overhead irrigation was provided with a watering can to the plots twice immediately after transplantation in the morning and evening for the first week. Irrigation is done once on an alternate day before harvesting. Further irrigation has been done, and if necessary. At the time of excess irrigation, stagnant water was effectively drained out.

3.11.2 Gap filling

Dead, wounded and weak seedlings were replaced with healthy seedlings, kept on the edge of the experimental plot. These seedlings have been re-planted with a large mass of root soil to minimize transplant shock. Replacement was done in 12th December, 2019 with healthy seedlings having soil balls, which were also planted on the same date on the border line. For the proper establishment of the seedlings, the transplanted seedlings were watered for 07 days.

3.11.3 Weeding

Weeding was done to keep the experimental plots free from weeds, easy aeration of soil, which ultimately ensured better growth and development. 1st weeding was done after 7 days of transplanting and then it was done after every 1 week interval and also when weeding was necessary.

3.12 Plant Protection

The crop was protected from the attack of insect-pest by spraying Ripcord @3ml/3L water. The insecticide application were made fortnightly as a matter of routine work from transplanting up to the end of head formation.

3.13 Harvesting

The crop was harvested on the basis of the maturity of the Chinese cabbage. Harvesting was completed by manually. During the harvest period, proper care was taken to avoid leaf and plant damage.

3.14 Data collection

Data were collected from the inner rows of plants of each treatment to avoid border effects. In each unit plot, 6 plants were randomly selected for data collection. Data were collected on plant growth characteristics and yield of Chinese cabbage. Data on plant height, plant spread number of folded and unfolded leaves were counted at 15, 30, 45 days and at harvest.However, all 12 plants of each unit plot were considered for gross and marketable yield per plot. All other parameters were recorded at harvest time. The following parameters have been set for recording data and interpreting results. The data were recorded in the following parameters:

3.14.1 Plant height

The height of plant was recorded in centimeter (cm) at 15, 30, 45 days after transplanting (DAT) and at harvest by using a meter scale. The height was measured from the ground level to the tip of the growing point of each plant. The mean value of the 6 selected plants was calculated for each unit plot.

3.14.2 Plant spread

The spread of plant was measured with a meter scale as the horizontal distance covered by the plant. The data were recorded from randomly selected 6 plants at 15, 30, 45 days after transplanting and at harvest and mean value was calculated and was expressed in centimeter (cm).

3.14.3 Number of folded leaves per plant

The number of folded leaves per plant was counted at 15, 30, 45 DAT, and harvest from 6 plants, and mean value was recorded accurately.

3.14.4 Number of unfolded leaves per plant

The number of unfolded leaves per plant was counted at 15, 30, 45 DAT, and harvest from 6 plants, and mean value was recorded.

3.14.5 Days from sowing to initiation of head

The days from the sowing to the initiation of the head formation were counted from the sowing date to the initiation of the head formation and recorded as treatment wise.

3.14.6 Days from sowing to head maturity

Days from sowing to head maturity was counted from the date of seed sowing to the optimum condition for the harvest.

3.14.7 Length of roots

After harvesting, the root length was recorded from the root-shoot junction to the tip of the main root and expressed in centimeter with the help of a meter scale.

3.14.8 Fresh weight of roots

After harvesting weight of roots was calculated by the help of a digital balance and was expressed in gram.

3.14.9 Fresh weight of unfolded leaves per plant

The fresh weight of the unfolded leaves, which was collected at harvest time was taken and expressed in gram and the mean value for the unit plant was recorded.

3.14.10 Fresh weight of head per plant

The heads from sample plants were cleaned by removing unfolded leaves and roots. The weight of every head was measured by a digital balance and was expressed in kg.

3.14.11 Fresh weight of total plant

The fresh weight of plant at harvest was recorded as the average of 6 plants selected at random from each unit plot. The weight of the total plant was recorded immediately after harvest and was expressed in kg.

3.14.12 Diameter of head

The heads of the sample plants were cut vertically in 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 the other of the widest part of the sectioned head and the mean value were recorded.

3.14.13 Thickness of head

The thickness of the head was measured in centimeter (cm) with a meter scale, as the vertical distance from the lower to the uppermost leaves of the head was calculated when the head was cut vertically in the middle position and the mean value was calculated.

3.14.14 Dry matter content of head

A sample of one hundred grams of the chopped head of 6 selected plants was dried fresh in direct sunlight for two days and then dried in an oven at 65°C for 72 hours until a constant weight was achieved. The dry weight of the sample was recorded in grams and the mean value was calculated. In the following formula the percentage of dry matter content in the heads was determined.

$$\%\ \text{Dry matter of head} = \frac{\text{Dry weight of leaf (g)}}{\text{Fresh weight of head (g)}} \times 100$$

3.14.15 Gross yield per plot

Gross yield of Chinese cabbage per plot was recorded as the whole plant weight of all the plants within a plot and was expressed in kilogram. Gross yield included weight of head, unfolded leaves, stem and roots.

3.14.16 Gross yield per hectare

Gross yield per hectare of Chinese cabbage was calculated by converting the weight of plot yield to hectare and was expressed in ton.

3.14.17 Marketable yield per plot

Marketable yield per plot was recorded as the whole plant weight of all the plants within a plot and was expressed in kilogram. Marketable yield included only the fresh weight of head.

3.14.18 Marketable yield per hectare

The weight of all compact head excluding leaves, stem and root produced in a plot was taken and converted into yield per hectare and was expressed in ton.

3.14.19 Ascorbic acid (Vitamin C) determination

For ascorbic acid determination, 10 g of Chinese cabbage was ground and homogenized in 100 ml of cold metaphosphoric acid (HPO_3) using a blender for two minutes and filtered through What'sman filter paper No.2. The clear supernatant was collected for assaying ascorbic acid content by 2, 6-dichlorophenolindophenol titration method (AOAC, 1994).

3.14.20 *β*- carotene Extraction and determination

Preparation of the chemicals reaction solution (RS):

80% Acetone: 80ml Acetone+20 ml distilled water

5% KOH solution: 5g KOH + 95ml ethanol

Only mix as much solvent as you plan to use in and keep in a dark well stoppered bottle.

Formula for ***β*- carotene** (mg/g):

(3.984 X OD 451 X V)/(1000 X Wt. of sample taken)

Where,

OD 451 is the absorbance at 451 nm

V is the volume taken

3.14.21. Calcium Determination

Dried plant materials were digested with concentrated HNO_3, and $HClO_4$, mixture as described by Piper (1966) for determination of total calcium content.

Digestion procedure:

1) Oven-dried plant sample of 0.5 g was taken in a 50 ml boiling flask.

2) Then 5 ml of nitric-perchloric acid solution was added to the boiling flask.

3) The flask was placed on cool hot plate and the temperature was turned to 3750 F and the digestion was allowed for 2 hours

4) The task was then removed and 15 ml distilled water was added to the flask. The flask was agitated and heated to dissolve the ash.

5) The contents were filtered through a filter paper (Whatman No. 42) in a 100 ml volumetric flask and then distilled water was added to make the volume up to the mark (stock solution).

Dilution of simple solution:

An amount of 10 ml plant extract (stock solution) was taken in a 100 ml volumetric flask and I ml of lanthanum chloride was added and then distilled water was added to make the volume up to the mark.

Measurement of absorbance by MAS:

The instrument (Atomic Absorption Spectrophotometer. Model No. 170-30, HITACHI. Japan) was calibrated with standard solutions of Ca and a calibration curve was prepared by the series of standard solutions. Atomic absorption spectrophotometer readings of each standard solutions and plant extracts were recorded at wavelength of 422.8 nm.

Calculation

Total Ca (%) = (S-B) ×(100ml/10ml) × (100ml /0.5g) × 1/10

3.14.22. Magnesium determination

Dried plant materials were digested with concentrated HNO_3 and $HCIO_4$ mixture, described by Piper (1966) for determination of total magnesium content.

Calculation

Mg (%) = (S-B) × (100ml / 10ml) ×(100ml/0.5g)×1/ 104

3.14.23 Phosphorus calculation

Dried plant materials were digested with concentrated HNO_3 and $HClO_4$ mixture as described by Piper (1966) for determination of total phosphorus content.

Total P (%) = (S-B) ×(100ml 10ml) ×(50ml / 0.5g) × 1/10

3.14.24 Potassium Determination

Oven dried plant materials were digested with concentrated HNO3 and HClO4 mixture as described by Piper (1966) for determination of total potassium content.

Total K (%) = (S-B)×(100ml/10ml) ×(100ml/0.5g) × 1/102

3.14.25 Fe & Zn Determination

Ground plant samples were digested with di-acid mixture (HNO_3-$HClO_4$) (5: 1) as described by Piper (1966) for determination of Zn & Fe. Oven-dried plant sample of 0.5 g was taken in a 50 mL digestion flask, 5 mL of diacid mixture (HNO_3 and $HClO_4$) was added to the flask. The flask was placed on cool hot plate and the temperature was raised up to 375° F and the digestion was continued for 2 hours. The flask was then removed and allowed to cool to room temperature. The contents were diluted with distilled water and filtered through a filter paper (Whatman No. 42) in a 100 mL volumetric flask and volume was made up to the mark. Total Zn contents in the digest were directly determined by Atomic Absorption Spectrophotometer (Model No.VARIANSpectrAA 55B, Australia).

Preparation of standards

For convenience, the Fe, and Zn were prepared together in water. The high concentration for these elements was as follows: 10µg Fe/ml and 2 µg Zn/ml.

Digestion solution

Nitric-perchloric solution.

Conc. Perchloric acid (100 ml) was added to 500 ml concentrated HNO_3 to prepare nitric-perchloric solution as described by Piper (1966)

Digestion of plant samples for determination of Fe and Zn

Digestion procedure

Weighted 500 gm dry sample and put into a 50 ml boiling flask. 5 ml of nitric-perchloric solution was allowed on cool hot plate and turned temperature to 375o C. It was allowed to digest for 1 hour and 30 minutes. The flask was removed from digestion chamber and was cooled and 15 ml water was added. The flask was agitated and heated to dissolve the ash and filter (Lindsay and Norvell, 1978).

Analytical procedure

By using a combination diluter-dispenser, 1 ml aliquot was taken from filtrate and 19 ml water (dilution 1) was added. The other dilutions were made in the following order. For Fe and Zn determination, the original filtrate was used to analyze these elements by AA procedure with wavelength of 510 nm for Fe and 213.9 nm for Zn.

3.15 Statistical analysis

The data obtained for different characters were statistically analyzed to find out the significance of the cultivars and vermicompost on yield and yield contributing characters of Chinese cabbage. The analysis of variance was performed by using SPSS Program.

CHAPTERIV

RESULTS AND DISCUSSION

This experiment was conducted in order to find out how vermicompost affects the growth, yield and quality of Chinese cabbage cultivars. Cultivars and vermicompost effects and their interactions on growth and yield of Chinese cabbage have been presented in different tables and figures and discussed in this chapter. The analysis of variance (ANOVA) data of the different yield contributing characteristics and the different yield levels of Chinese cabbage was presented in the Appendices. The results of the experiment and possible interpretations were provided under the following headings.

4.1 Plant height

4.1.1 Performance of cultivars on plant height

The Cultivar is an essential factor considering plant height. In the present study, the height of the plant was significantly influenced by different cultivars of Chinese cabbage at 15, 30, 45 (DAT) and at harvest (Figure 2 and appendix IV). At harvest, the highest plant height (33.64 cm) was observed from C_2 (Blues)treatment and lowest plant height (28.29 cm) was observed from C_1 (BARI Chinakopi 1) treatment.

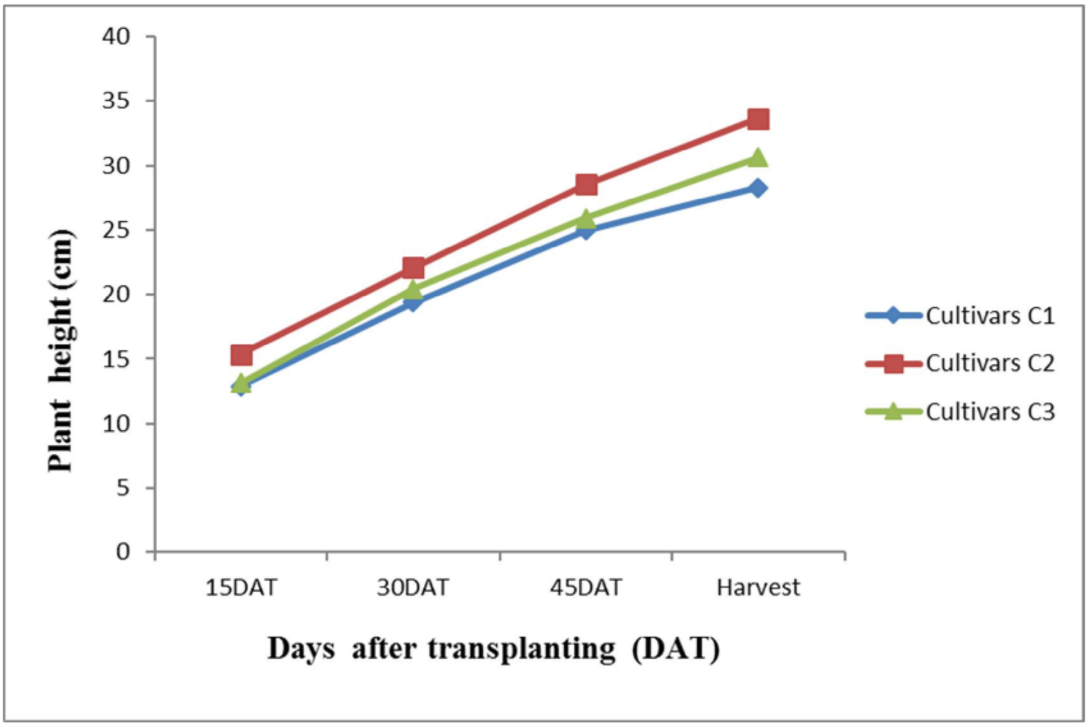

Figure 2. Performance of cultivars on plant height at different days after transplanting of Chinese cabbage; Here, C_1= BARI Chinakopi 1, C_2= Blues, C_3= Retasi

4.1.2 Effect of vermicompost on plant height

The most essential factor for achieving the best crop yield is fertilizer. In the present study, plant height was significantly affected by different levels of vermicompost. It is evident that plant height was increased with increasing level of vermicompost (Table 1 and appendix IV). At harvest he highest plant height (34.89) was obtained from maximum doses of vermicompost VC_3 (10t/ha) treatment and lowest plant height (26.89 cm) was obtained from the control treatment VC_0 (Control) .Thy and Bhuntha (2005) reported that there was a tendency for the growth in height of the Chinese cabbage to be highest when fertilized with bio digester effluent and lowest when the fertilizer was raw manure.

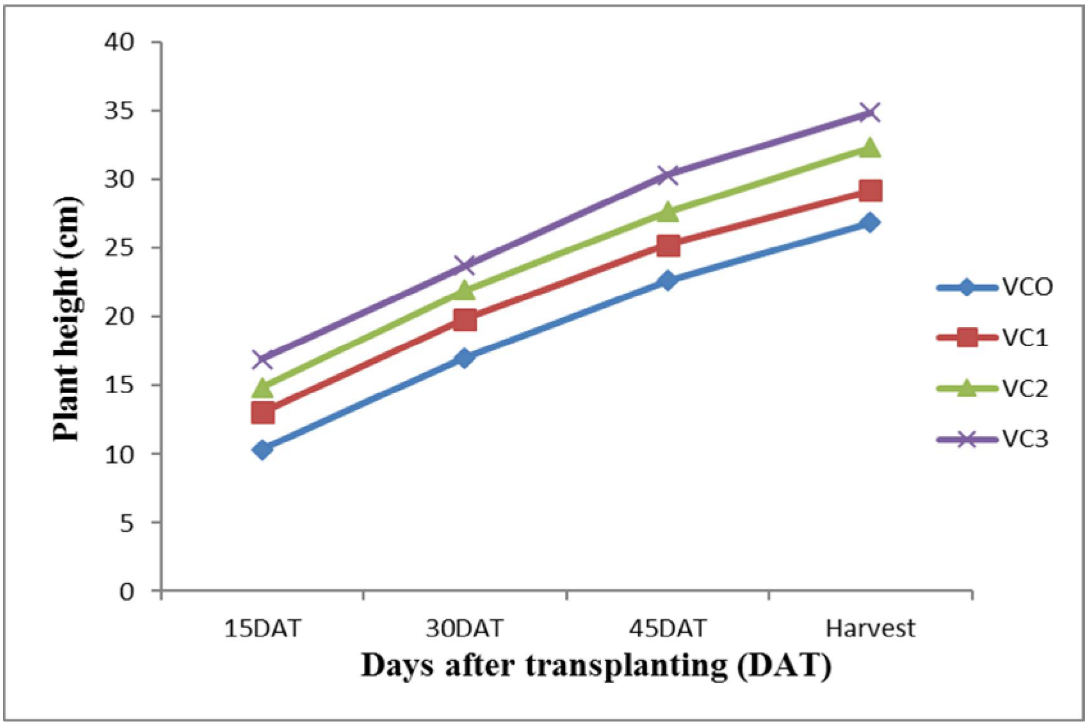

Figure 3. Effect of vermicompost on plant height at different days after transplanting of Chinese cabbage; Here, VC_0= Control, VC_1= 6 t/ha, VC_2= 8 t/ha, VC_3=10 t/ha

4.1.3 Interaction effect of cultivars and vermicompost on plant height of Chinese Cabbage

The interaction effect of cultivars and different levels of vermicompost on plant height varied statistically at 15, 30, 45, and, at harvest under the present study (Table 1 and appendix IV). At harvest, the highest plant height (39.88 cm) was recorded from C_2VC_3 (Blues cultivar with vermicompost @ 10 t/ha) treatment combination the lowest plant height (25.67 cm) was recorded from the treatment combination C_1VC_0 (control). Results under the present study on plant height of Chinese cabbage were supported by Getnet and Raja (2013).

Table 1. Interaction effect of variety and vermicompost on plant height at different growth stages of Chinese cabbage

Treatments	**Plant Height (cm) at**			
	15DAT	30DAT	45DAT	Harvest
C_1VC_0	9.62±0.35[g]	16.17±0.56[j]	21.61±0.73[i]	25.67±0.47[i]
C_1VC_1	11.76±0.73[ef]	18.79±0.67[gh]	24±0.63[gh]	27.64±0.28[h]
C_1VC_2	14.10±0.97[cd]	21.13±0.66[ef]	25.83±0.22[ef]	29.11±0.39[fg]
C_1VC_3	16.09±0.94[b]	22.22±0.57[bcd]	28.50±0.71[cd]	30.73±0.39[e]
C_2VC_0	11.47± 0.63[efg]	17.73±0.45[hi]	23.78±0.50[gh]	27.90±0.26[gh]
C_2VC_1	14.55± 0.67[bcd]	21.03±0.40[def]	26.62±0.31[ef]	30.41±0.53[def]
C_2VC_2	16.45±0.63[b]	23.62±0.35[b]	30.23±0.50[b]	36.39±0.39[b]
C_2VC_3	19.05±0.088[a]	25.96±0.33[a]	33.51±0.69[a]	39.88±0.84[a]
C_3VC_0	10.02±0.32[fg]	17.16±0.64[ij]	22.51±0.53[hi]	27.10±0.34[h]
C_3VC_1	12.87±0.33[de]	19.75±0.33[fg]	25.13±0.64[fg]	29.69±0.29[ef]
C_3VC_2	13.99±0.60[cd]	21.80±0.144[ce]	26.97±0.024[de]	31.60±0.60[d]
C_3VC_3	15.65±0.54[bc]	22.99±0.07[b]	29.11±0.37[bc]	34.05±0.26[c]
Level of Significance	***	***	***	***

In a column means having similar letter (s) are statistically similar and those having dissimilar differ significantly at 5% level and C_1= BARI Chinakopi 1, C_2= Blues, C_3= Retasi; VC_0= Control, VC_1= 6 t/ha, VC_2= 8 t/ha, VC_3= 10 t/ha and *** Indicates significant at <1% level of probability

4.2 Plant spread

4.2.1 Performance of cultivars on plant spread

A statistically significant variation was recorded in terms of plant spread due to the different cultivars at 15, 30, 45 DAT and at harvest (Figure 4 and Appendix V). At harvest, the highest plant spread (44.81 cm) was observed from C_2 (Blues) treatment and the lowest plant spread (40.31) cm was recorded from C_1 (BARI Chinakopi 1) treatment.

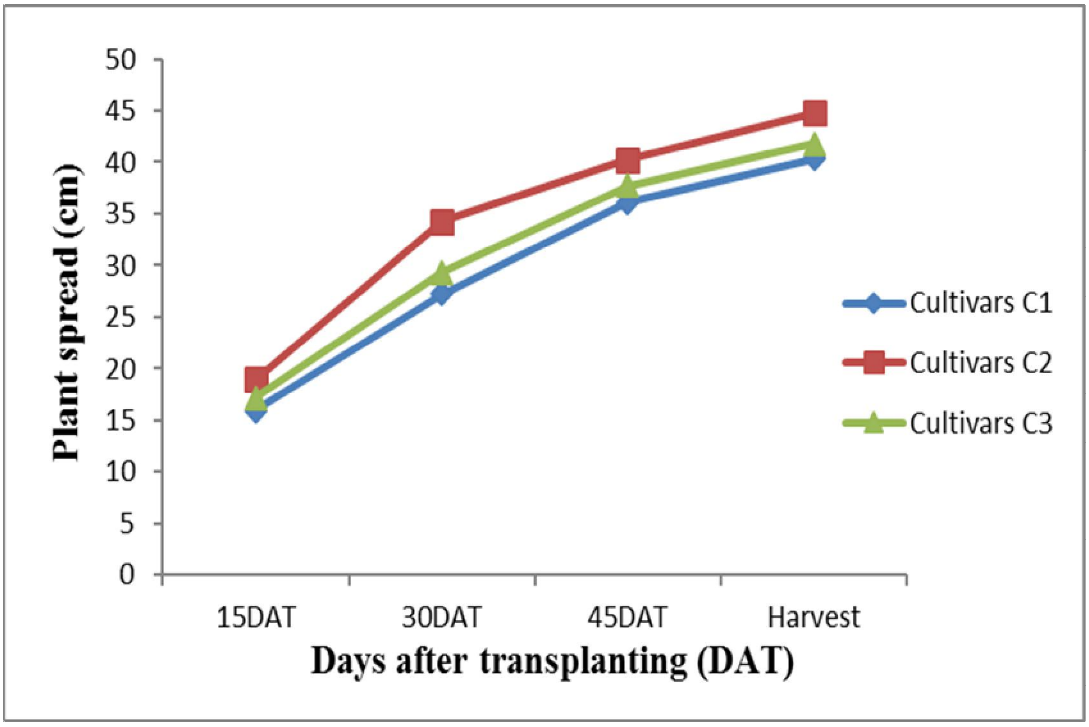

Figure 4. Performance of cultivars on plant spread at different days after transplanting of Chinese cabbage; Here, C_1= BARI Chinakopi 1, C_2= Blues, C_3= Retasi

4.2.2 Effect of vermicompost on plant spread

Plant spread significantly varied due to the application of different levels of vermicompost (Figure 5 and appendix V). At harvest the highest spreading of the plant (45.87 cm) was found in VC_3 (10 t/ha) treatment and the lowest spreading (38.66 cm) was observed from VC_0 (Control) treatment. It was found that spreading of the plant increased with the higher levels of vermicompost application. Usman*et al.* (2016) reported that the application of vermicompost increased crop diameter of cabbage.

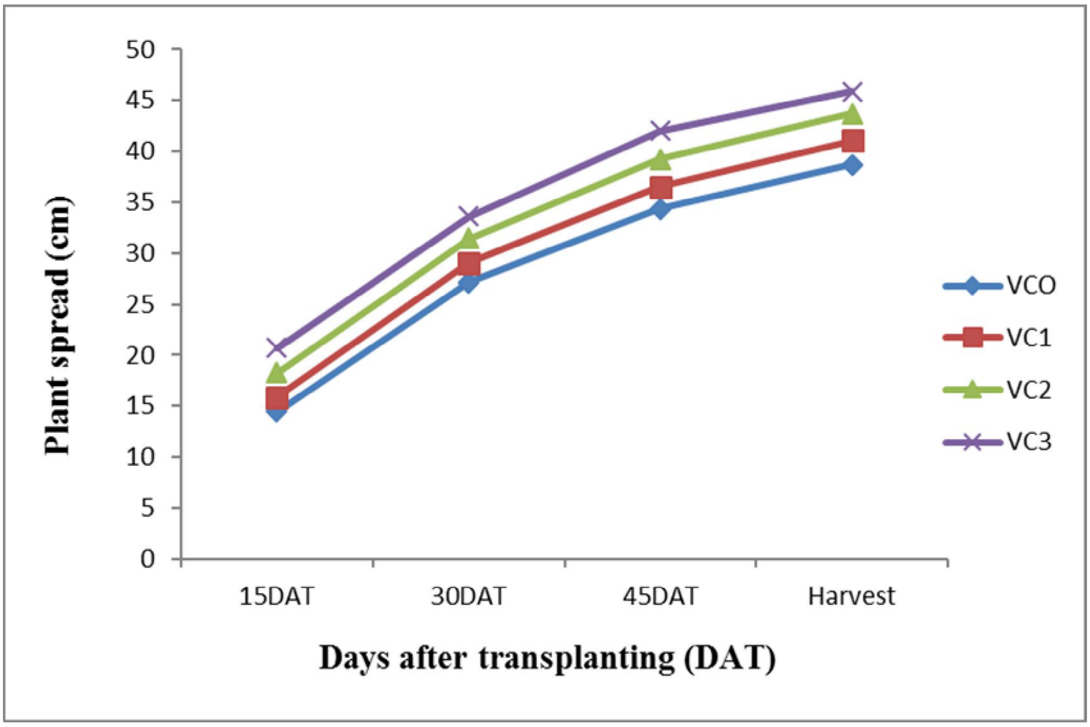

Figure 5. Effect of vermicompost on plant spread at different days after transplanting of Chinese cabbage; Here, VC_0= Control, VC_1= 6 t/ha, VC_2= 8 t/ha, VC_3= 10 t/ha

4.2.3 Interaction effect of cultivars and vermicompost on plant spread of Chinese cabbage

A significant variation was observed in the case of spreading of the plant with the interaction effect of cultivars and different levels of vermicompost (Table 2 and appendix V). At harvest, it was observed that the highest plant spread (49.13 cm) was recorded from the C_2VC_3 (Blues cultivar with vermicompost @10t/ha) treatment combination. On the other hand, the lowest plant spread at harvest was 36.67 cm from the C_1VC_0 (Control) treatment combination.

Table 2. Interaction effect of cultivars and vermicompost on plant spread at different growth stages of Chinese cabbage

Treatments	Plant spread (cm) at			
	15DAT	30DAT	45DAT	Harvest
C_1VC_0	12.80±0.31^{f}	23.73±0.84^{i}	32.96±0.32^{i}	36.67±0.65^{h}
C_1VC_1	14.73±0.73^{e}	25.92±0.88^{h}	34.90±0.24^{gh}	38.46±0.42^{g}
C_1VC_2	16.86±0.07^{d}	28.72±0.88^{f}	37.17±0.34^{de}	41.86±0.23^{de}
C_1VC_3	19.26±0.28^{b}	30.77±0.17^{d}	39.33±0.60^{c}	44.25±0.64^{c}
C_2VC_0	15.65± 0.62^{d}	31.01±0.42^{d}	35.70±0.23^{g}	40.37±0.43^{f}
C_2VC_1	17.01± 0.64^{cd}	33.15±0.34^{c}	38.27±0.08^{cd}	43.11±0.31^{cd}
C_2VC_2	19.65±0.57^{b}	35.13±0.43^{b}	41.79±0.44^{b}	46.65±0.52^{b}
C_2VC_3	23.27±0.48^{a}	37.77±0.30^{a}	45.31±0.49^{a}	49.13±0.18^{a}
C_3VC_0	14.91±0.72^{de}	26.65±0.86^{gh}	34.28±0.17^{h}	38.93±0.47^{g}
C_3VC_1	16.00±0.26^{de}	28.13±0.77^{fg}	36.44±0.58^{ef}	41.44±0.15^{ef}
C_3VC_2	18.30±0.42^{bbc}	30.47±0.19^{de}	38.68±0.42^{c}	42.61±0.27^{de}
C_3VC_3	19.58±0.32^{b}	32.25±0.53^{cd}	41.42±0.53^{b}	44.23±0.50^{c}
Level Of Significance	***	***	***	***

In a column means having similar letter (s) are statistically similar and those having dissimilar differ significantly at 5% level and C_1= BARI Chinakopi 1, C_2= Blues, C_3= Retasi; VC_0= Control, VC_1= 6 t/ha, VC_2= 8 t/ha, VC_3= 10 t/ha and *** Indicates significant at <1% level of probability

4.3 Number of folded leaves per plant

4.3.1 Performance of cultivars on number of folded leaves per plant

A statistically significant variation was recorded in terms of number of folded leaves per plant due to the different cultivars at 15, 30, 45 DAT and at harvest (Figure 6 and appendix VI). At harvest, the highest number of folded leaves (28.04) was recorded from C_2 (Blues) treatment and the lowest number of folded leaves was recorded from C_1 treatment. Studies upon a collection of hybrids and varieties of Chinese cabbage showed that in spring culture the leaves number from cabbage heads varied between

19.83 and 43.33 (Laczi, *et al*., 2012), while in case of autumn crops between 28.17 and 58.33 (Laczi *et al*., 2014)

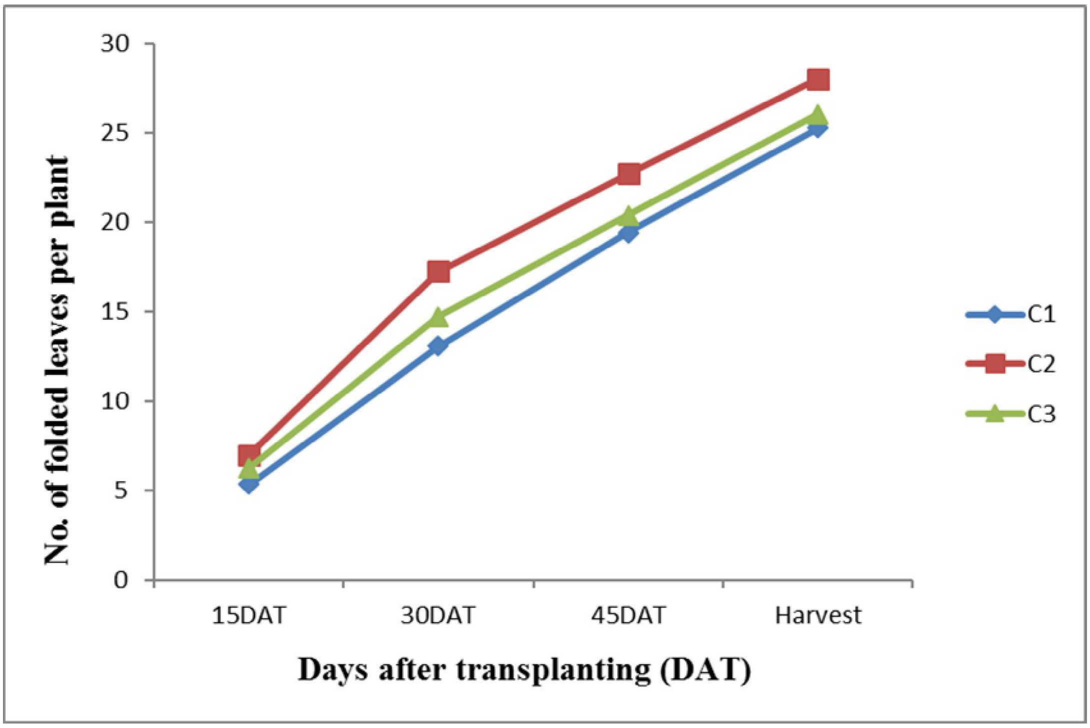

Figure 6. Performance of cultivars on number of folded leaves plant at different days after transplanting of Chinese cabbage; Here, C_1= BARI Chinakopi 1, C_2= Blues, C_3= Retasi

4.3.2 Effect of vermicompost on number of folded leaves per plant

Number of folded leaves per plant significantly varied due to the application of different levels of vermicompost (Figure 7 and Appendix VI). At harvest, the highest number of folded leaves (30.11) was found in VC_3 (10 t ha^{-1}) treatment and the lowest (22.57) was observed from VC_0 (Control)treatment. Easmin*et al*. (2009) showed that leaves number from cabbage heads was directly influenced by the quantity of fertilizers.

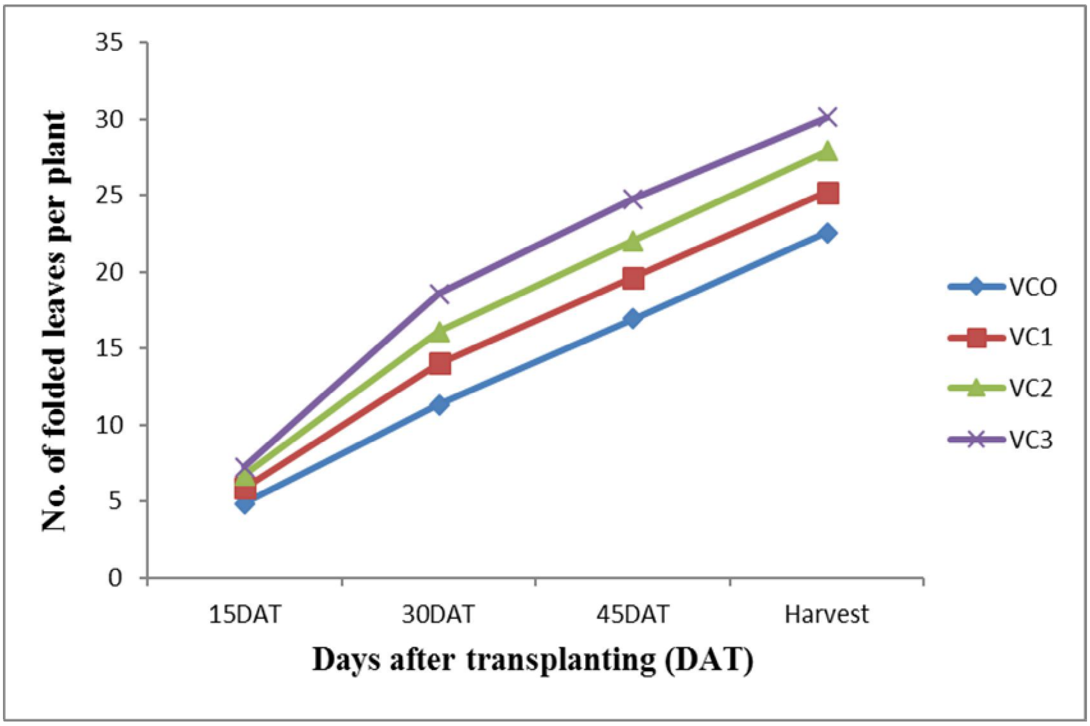

Figure 7. Effect of vermicompost on number of folded leaves per plant at different growth stages of Chinese cabbage; Here, VC_0= Control, VC_1= 6 t/ha, VC_2= 8 t/ha, VC_3= 10 t/ha

4.3.3 Interaction effect of cultivars and vermicompost on number of folded leaves per plant

A significant variation was observed in the case of number of folded leaves per plant with the interaction effect of cultivars and different levels of vermicompost under the present study (Table 3). At harvest, it was observed that the highest number of folded leaves (32.33) was obtained from the C_2VC_3 (Blues cultivar with vermicompost @10t/ha) treatment combination and the lowest number of folded leaves per at harvest was 21.55 from the C_1VC_0 (Control) treatment combination.

Table 3. Interaction effect of variety and vermicompost on number of folded leaves per plant at different days after transplanting of Chinese cabbage

Treatments	Number of folded leaves per plant			
	15DAT	30DAT	45DAT	Harvest
C_1VC_0	4.11±0.40^{c}	9.55±0.61^{h}	15.92±0.84^{g}	21.55±0.46^{f}
C_1VC_1	5.23±0.91^{bc}	12.00±0.40^{g}	18.52±0.33^{f}	24.30±0.62^{e}
C_1VC_2	5.66±0.84^{abc}	14.64±0.41d^{ef}	20.47±0.57^{de}	26.63±0.46^{d}
C_1VC_3	6.30±1.14^{abc}	16.03±0.20^{c}	22.70±0.72^{bc}	28.64±0.40^{bc}
C_2VC_0	5.28± 0.61^{bc}	12.94±0.20d^{fg}	18.31±0.34^{f}	23.81±0.17^{e}
C_2VC_1	6.38± 0.79^{abc}	16.01±0.65^{cd}	21.05±0.36^{cd}	26.49±0.39^{d}
C_2VC_2	7.80±0.75^{ab}	18.01±0.43^{b}	24.10±0.45^{b}	29.53±0.31^{b}
C_2VC_3	8.40±0.60^{a}	21.95±0.94^{a}	27.36±0.44^{a}	32.33±0.55^{a}
C_3VC_0	5.13±0.64^{bc}	11.49±0.71^{g}	16.54±0.71^{g}	22.35±0.61^{f}
C_3VC_1	6.06±0.89^{abc}	14.02±0.83^{ef}	19.29±0.61^{ef}	24.84±0.58^{e}
C_3VC_2	6.67±0.94^{abc}	15.64±0.35^{de}	21.50±0.30^{cd}	27.59±0.49^{cd}
C_3VC_3	7.10±1.09^{ab}	17.72±0.52^{bc}	24.25±0.64^{b}	29.38±0.54^{b}
Level Of Significance	NS	***	***	***

In a column means having similar letter (s) are statistically similar and those having dissimilar differ significantly at 5% level and C_1= BARI Chinakopi 1, C_2= Blues, C_3= Retasi; VC_0= Control, VC_1= 6 t/ha, VC_2= 8 t/ha, VC_3= 10 t/ha and *** Indicates significant at <1% level of probability

4.4 Number of unfolded leaves per plant

4.4.1 Performance of cultivars on number of unfolded leaves per plant

A Statistically significant variation was recorded in the number of unfolded leaves per plant due to the different cultivars at 15, 30, 45 DAT, and at harvest (Figure 8 and appendix VII). The cultivar Blues (C_2) gave the minimum (5.67) number of unfolded leaves per plant at 15 DAT while the maximum (6.82) number of unfolded leaves at 15 DAT was recorded from C_1 treatment which was statistically similar with C_3 (6.28) treatment. In the case of 30, 45 DAT and at harvest the minimum number of unfolded leaves 6.93, 10.45, and 12.94 were observed in C_2 treatment while the maximum number of unfolded leaves at 30, 45, and at harvest was 9.66, 13.28, and 15.32 was recorded from C_1 treatment.

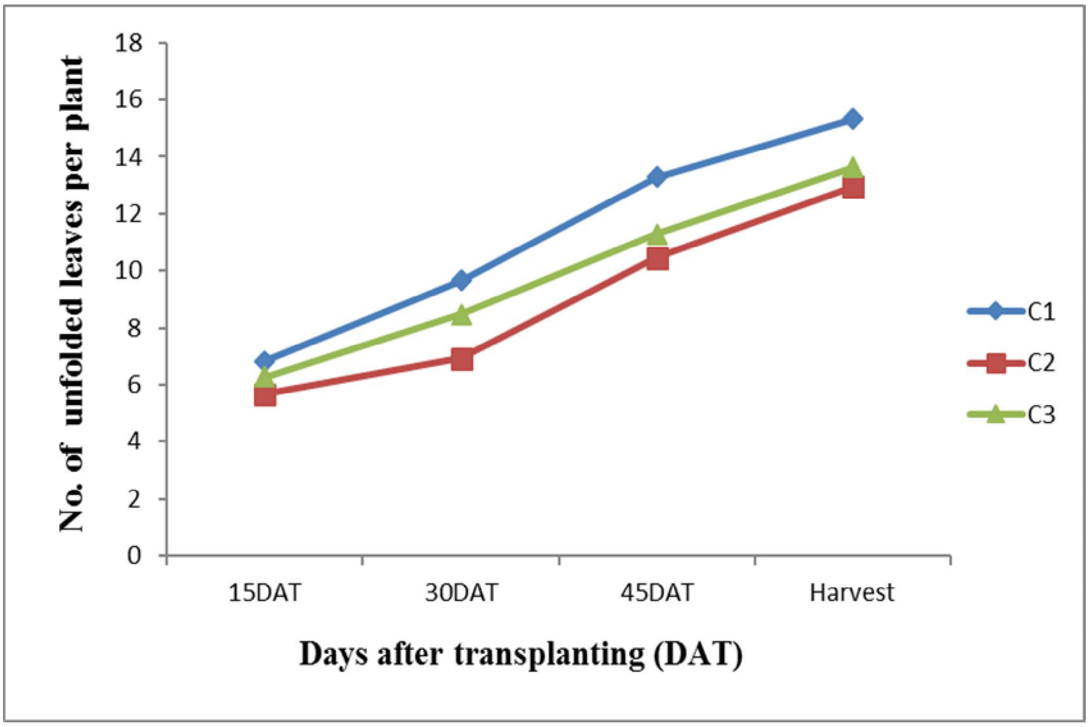

Figure 8. Performance of cultivars on number of unfolded leaves per plant at different days after transplanting of Chinese cabbage; Here, C_1= BARI Chinakopi 1, C_2= Blues, C_3= Retasi

4.4.2 Effect of vermicompost on number of unfolded leaves per plant

A significant variation was observed in the case of number of unfolded leaves per plant with different levels of vermicompost under the present study (Figure 9 and appendix VII). At harvest, it was observed that the minimum number of unfolded leaves was obtained (11.81) from the VC_3 (10 t/ha) treatment. On the other hand, the maximum number of unfolded leaves per plant at harvest was 16.28 from the VC_0 (control) treatment.

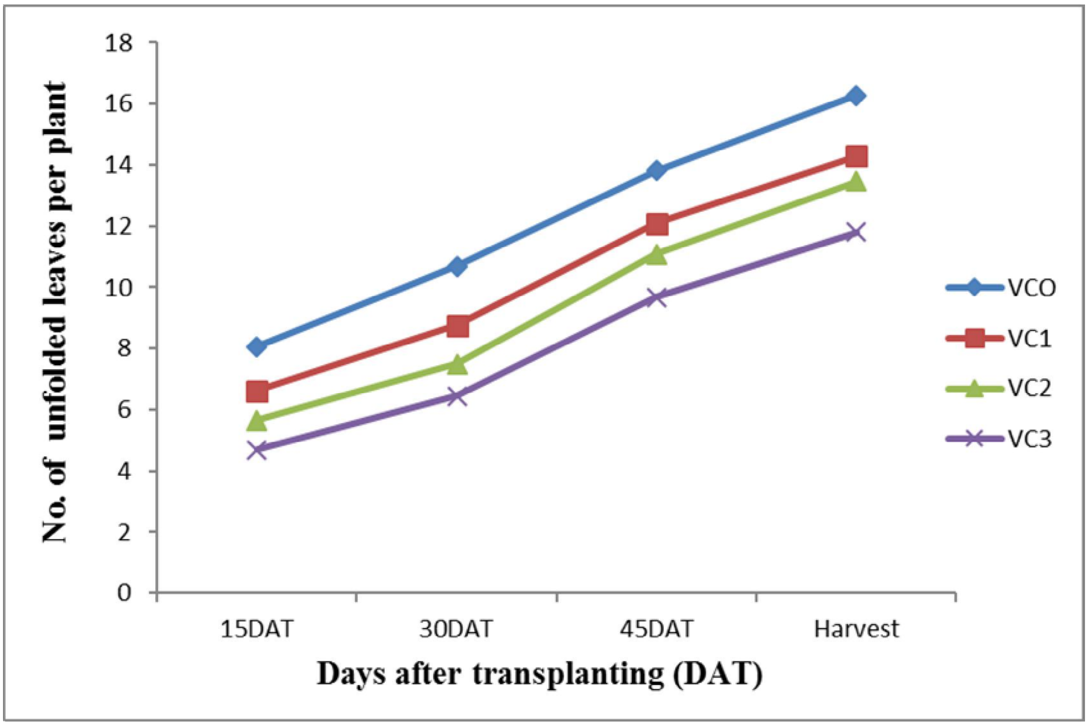

Figure 9. Effect of vermicompost on number of unfolded leaves plant^{-1} at different days after transplanting of Chinese cabbage; Here, VC_0= Control, VC_1= 6 t/ha, VC_2= 8 t/ha, VC_3= 10 t/ha

4.4.3 Interaction effect of cultivars and vermicompost on number of unfolded leaves per plant

The interaction effect of cultivars and different levels of vermicompost on the number of unfolded leaves per plant significantly varied at 15, 30, 45 DAT and at harvest under the present study (Table 4 and Appendix VII). It was calculated that the maximum number of unfolded leaves per plant was 17.35 at harvest from treatment combination C_1VC_0 (Control) which was statistically similar with C_3VC_0 treatment combination. The minimum number of unfolded leaves per plant at harvest 10.17 obtained from C_2VC_3 treatment combination.

Table 4. Interaction effect of variety and vermicompost on number of unfolded leaves per plant at different growth stages of Chinese cabbage

Treatments	Number of unfolded leaves per plant			
	15DAT	30DAT	45DAT	Harvest
C_1VC_0	8.43±0.66[c]	11.67±0.33[a]	15.05±0.62[a]	17.35±0.23[a]
C_1VC_1	7.20±0.20[bc]	10.14±0.46[b]	13.52±0.67[ab]	15.70±0.24[b]
C_1VC_2	6.12±0.44[cd]	8.95±0.38d[cd]	12.76±0.69[bcd]	14.65±0.22[bc]
C_1VC_3	5.54±0.19[def]	7.90±0.26[de]	11.79±0.75[bcde]	13.59±0.64[cd]
C_2VC_0	7.64± 0.32[ab]	9.74±0.41d[bc]	13.42±0.57[ab]	15.47±0.26[b]
C_2VC_1	5.96± 0.29[cde]	7.27±0.26[ef]	11.03±0.71[cde]	13.61±0.48[cd]
C_2VC_2	5.18±0.26[ef]	5.93±0.21[g]	9.71±0.38[e]	12.51±0.51[de]
C_2VC_3	3.93±0.41[g]	4.78±0.30[h]	7.62±0.35[f]	10.17±0.42[f]
C_3VC_0	8.16±0.64[a]	10.68±0.17[ab]	12.96±0.46[abc]	16.01±0.34[b]
C_3VC_1	6.66±0.21[cd]	8.92±0.34[cd]	11.72±0.79[bcde]	13.57±0.36[cd]
C_3VC_2	5.69±0.36[def]	7.62±0.18[ef]	10.75±0.98[de]	13.23±0.51[cd]
C_3VC_3	4.60±0.40[g]	6.66±0.24[fg]	9.64±0.68[e]	11.69±0.70[e]
Level Of Significance	***	***	***	***

In a column means having similar letter (s) are statistically similar and those having dissimilar differ significantly at 5% level and C_1= BARI Chinakopi 1, C_2= Blues, C_3= Retasi; VC_0= Control, VC_1= 6 t/ha, VC_2= 8 t/ha, VC_3= 10 t/ha and *** Indicates significant at <1% level of probability

4.5 Days required to head initiation

4.5.1 Performance of cultivars on days required to head initiation

A significant variation was observed among Chinese cabbage cultivars from transplanting to initiation of the head. The minimum days (16.41 days) required for initiation of the head is C_2 cultivar whereas the maximum days (20.5 days) were required in case of C_1 treatment (table 5).

4.5.2. Effect of vermicompost on days required to head initiation

From transplanting to head initiation different levels of vermicompost had several impacts on Chinese cabbage. The minimum (15.44 days) was observed for transplanting to head formation in VC_3 treatment and the maximum (21.88 days) was required for VC_0 (control) treatment.

4.5.3 Interaction effect of cultivars and vermicompost on days required to head initiation

Interaction effects of Chinese cabbage cultivars and vermicompost levels was significantly influenced the days required from transplanting to head initiation (table 6). The highest days to start head formation (24.33.00 days) were recorded from the treatment combination C_1VC_0 and the lowest (13.67 days) were recorded from the treatment combination C_2VC_3. According to Thy and Buntha (2005), it was reported that organic manure ensures favorable condition for the growth and development of Chinese cabbage and the results was the increased level of optimum vermicompost causes the shortest duration for attaining head formation.

4.6 Days to head maturity

4.6.1 Performance of cultivars on days from transplanting to head maturity

In the case of Chinese cabbage, cultivars showed significant effect in respect of days to head maturity (Table 5 and appendix VIII). C_1 cultivars required the maximum time after transplanting to head maturity (55.75 days), which was statistically dissimilar with C_3 cultivar. The minimum time (52.66 days) was taken by the cultivar C_2. The similar result was reported by Kato (1981) when find out the physiological mechanism of heading in Chinese cabbage.

4.6.2 Effect of vermicompost on days from transplanting to head maturity

Days required from transplanting to head maturity of Chinese cabbage varied significantly due to different levels of vermicompost (Table 5 and appendix VIII). In case of vermicompost level, the treatment VC_3 required minimum days (51.44 days) from transplanting to head maturity whereas the treatment VC_0 required maximum days (56.66 days).

4.6.3 Interaction effect of cultivars and vermicompost on days to head maturity

A statistically significant variation was observed between the Chinese cabbage cultivars and the level of vermicompost on days required to head maturity (Table 6 and appendix VIII). The minimum time (49.33 days) was recorded from the treatment combination C_2VC_3 from transplanting to head maturity. On the other hand, the longest time (58.33 days) was taken by the treatment combination of C_1VC_0.

Table 5. Performance of cultivars and effect of vermicompost on days required to head initiation and days to head maturity of Chinese cabbage

Treatments	**Days required from transplanting to head initiation**	**Days required from transplanting to head maturity**
Performance of cultivars		
C_1	20.5 ± 0.90^{a}	55.75 ± 0.52^{a}
C_2	16.41 ± 0.71^{b}	52.66 ± 0.79^{b}
C_3	18.58 ± 0.75^{ab}	53.41 ± 0.58^{b}
Level of Significance	0.004	0.005
Effect of vermicompost		
VC_0	21.88 ± 0.73^{a}	56.66 ± 0.47^{a}
VC_1	19.66 ± 0.78^{b}	54.55 ± 0.33^{b}
VC_2	17 ± 0.62^{c}	53.11 ± 0.63^{b}
VC_3	15.44 ± 0.50^{c}	51.44 ± 0.74^{c}
Level of Significance	***	***

In a column means having similar letter (s) are statistically similar and those having dissimilar differ significantly at 5% level and C_1= BARI Chinakopi 1, C_2= Blues, C_3= Retasi; VC_0= Control, VC_1= 6 t/ha, VC_2= 8 t/ha, VC_3= 10 t/ha and *** Indicates significant at <1% level of probability

Table 6. Interaction effect of cultivars and vermicompost on days required to head initiation and days required from transplanting to head maturity of Chinese cabbage

Treatments	Days required from transplanting to head initiation	Days required from transplanting to head maturity
C_1VC_0	24.33±0.33[a]	58.33±0.33[a]
C_1VC_1	22.00±0.57[b]	55.66±0.33b[c]
C_1VC_2	19.00±0.57[c]	55±0.57[bcd]
C_1VC_3	16.66±0.33[d]	54±0.51[cde]
C_2VC_0	19.66±0.88[c]	56±0.57[b]
C_2VC_1	17.00±0.57[d]	53.66±0.33[e]
C_2VC_2	15.33±0.33[d]	51.66±0.88[f]
C_2VC_3	13.67±0.33[e]	49.33±0.66[g]
C_3VC_0	21.66±0.33[b]	55.67±0.33[bc]
C_3VC_1	20.00±0.57[c]	54.33±0.33[bcde]
C_3VC_2	16.66±0.88[d]	52.66±0.88[ef]
C_3VC_3	16±0.57[d]	51.00±0.57[f]
Level of significance	***	***

In a column means having similar letter (s) are statistically similar and those having dissimilar differ significantly at 5% level and C_1= BARI Chinakopi 1, C_2= Blues, C_3= Retasi; VC_0= Control, VC_1= 6 t/ha, VC_2= 8 t/ha, VC_3= 10 t/ha and *** Indicates significant at <1% level of probability

4.7 Roots length

4.7.1 Performance of cultivars on root length

In the case of Chinese cabbage, cultivars showed significant performance in respect of length of root (Table 7 and appendix VIII). Cultivar C_1 had the minimum root length (15.01 cm) which was statistically identical with C_3 cultivar (16.06 cm). The root length (19.21 cm) was identified from the cultivar C_2.

4.7.2. Effect of vermicompost on root length

The level of vermicompost had significant effect on root length. It is evident that different levels of vermicompost showed different length of root (Table 7 and appendix VIII). The highest root length (19.04 cm) was indicated with the treatment VC_3 while the lowest root length (14.90 cm) was measured from control (VC_0) treatment.

4.7.3 Interaction effect of cultivars and vermicompost on root length

A statistically significant variation was observed in case of length of root with interaction effect of Chinese cabbage cultivars and different levels of vermicompost under the present study (Table 8 and appendix VIII). Different treatment combination showed different root length. The highest root length (21.82 cm) was recorded with C_2VC_3 treatment combination. On the other hand, the lowest root length (13.74 cm) was recorded with C_1VC_0 which was statistically similar with C_1VC_1 and C_3VC_0 treatment combination.

4.8 Roots weight

4.8.1 Performance of cultivars on root weight

Different Chinese cabbage cultivar showed different root weight (Table 7 and appendix VIII). The maximum fresh weight of root (25.39 g) was recorded from Cultivar C_2 and the minimum (19.86 g) was observed from cultivar C_1.

4.8.2 Effect of vermicompost on root weight

Fresh weight of root varied significantly due to the application of different levels of vermicompost in Chinese cabbage (Table 7 and appendix VIII). The highest fresh weight of root (26.74 g) was recorded from VC_3 treatment. On the other hand, the minimum fresh weight of root (17.95 g) was recorded from VC_0 treatment. It was experimented that fresh weight of root increased with increased level of vermicompost.

Table 7. Effect of cultivars and vermicompost on root length (cm), fresh weight of root & unfolded leaves of Chinese cabbage

Treatments	Root length (cm)	Fresh weight of root (g)	Fresh weight of unfolded leaves (g)
Performance of cultivars			
C_1	15.01±0.43[b]	19.86±1.02[b]	134.87±4.21[b]
C_2	19.21±0.58[a]	25.39±0.95[a]	153.99±5.60[a]
C_3	16.06±0.49[b]	22.83±1.11[ab]	140.31±4.17[b]
Level of significance	***	***	**
Effect of vermicompost			
VC_0	14.90±0.50[c]	17.95±0.88[c]	120.15±1.88[d]
VC_1	15.89±0.72[bc]	21.51±0.90[b]	140.33±2.11[c]
VC_2	17.23±0.69[ab]	24.59±0.77[a]	149.91±4.29b
VC_3	19.04±0.74[a]	26.74±0.86[a]	161.83±3.40[a]
Level of significance	***	***	***

In a column means having similar letter (s) are statistically similar and those having dissimilar differ significantly at 5% level and C_1= BARI Chinakopi 1, C_2= Blues, C_3= Retasi; VC_0= Control, VC_1= 6 t/ha, VC_2= 8 t/ha, VC_3= 10 t/ha and *** Indicates significant at <1% level of probability ; ** Indicates significant at <5% level of probability

4.8.3 Interaction effect of cultivars and vermicompost on root weight

A statistically significate variation was observed in case of fresh weight of root with interaction effect of cultivars and different levels of vermicompost under the present study (Table 8 and appendix VIII). Different treatment combination showed different fresh weight of root. It was recorded that the maximum (29.04 g) fresh weight of root was recorded from C_2VC_3 treatment combination, while C_1VC_0 gave the minimum (15.27 g) fresh weight of root**.**

Table 8. Interaction effect of cultivars and vermicompost on root length (cm), fresh weight of root and unfolded leaves of Chinese cabbage

Treatment	Root length (cm)	Fresh weight of root (g)	Fresh weight of unfolded leaves (g)
C_1VC_0	13.74±0.62^{f}	15.27±0.71^{g}	114.67±0.28^{l}
C_1VC_1	14.07±0.58^{ef}	18.30±0.41^{f}	132.57±0.49^{i}
C_1VC_2	15.21±0.32^{e}	22.11±0.57^{de}	138.66±0.84^{h}
C_1VC_3	17.04±0.13^{d}	23.78±0.56^{cd}	153.57±1.19^{d}
C_2VC_0	16.63±0.29^{d}	21.05±0.58^{e}	127.18±0.97^{j}
C_2VC_1	18.58±0.39^{c}	24.27±0.65^{c}	147.01±0.34^{e}
C_2VC_2	19.82±0.25^{b}	27.21±0.47^{b}	166.72±0.26^{b}
C_2VC_3	21.82±0.36^{a}	29.04±0.80^{a}	175.06±1.91^{a}
C_3VC_0	14.32±0.48^{ef}	17.54±0.20^{f}	118.61±0.92^{k}
C_3VC_1	15.01±0.33^{ef}	21.95±0.51^{e}	141.40±0.37^{g}
C_3VC_2	16.67±0.35^{d}	24.44±0.36^{c}	144.34±0.50^{f}
C_3VC_3	18.26±0.50^{c}	27.40±0.87^{a}	156.87±0.59^{c}
Level of significance	***	***	***

In a column means having similar letter (s) are statistically similar and those having dissimilar differ significantly at 5% level and C_1= BARI Chinakopi 1, C_2= Blues, C_3= Retasi; VC_0= Control, VC_1= 6 t/ha, VC_2= 8 t/ha, VC_3= 10 t/ha and *** Indicates significant at <1% level of probability

4.9 Fresh weight of unfolded leaves at harvest

4.9.1 Performance of cultivars on fresh weight of unfolded leaves

A significant performance of cultivars was observed on fresh weight of unfolded leaved per plant at harvest (Table 7 and appendix IX). The maximum fresh weight of unfolded leaves (153.99 g) was observed in C_2 cultivar and the minimum weight of unfolded leaves (134.87 g) was observed from cultivar C_1 at harvest.

4.9.2 Effect of vermicompost on fresh weight of unfolded leaves

Different level of vermicompost had several effect on weight of unfolded leaves at harvest (Table 7 and appendix IX). The maximum weight of unfolded leaves (161.83 g) was recorded from VC_3 treatment and the minimum weight of unfolded leaves (120.15 g) was recorded from VC_0 treatment at harvest. Singh *et al* (1989) reported similar results from their experiment.

4.9.3 Interaction effect of cultivars and vermicompost on fresh weight of unfolded leaves

A statistically significant variation was observed in case of fresh weight of unfolded leaves with interaction effect of Chinese cabbage cultivars and different levels of vermicompost under the present study (Table 8 and appendix IX). Different treatment combination viewed different fresh weight of unfolded leaves. It was observed that the maximum (175.06 g) fresh weight of unfolded leaves was recorded from C_2VC_3 treatment combination, while C_1VC_0 treatment combination gave the minimum (114.67 g) fresh weight of unfolded leaves.

4.10 Diameter of head

4.10.1 Performance of cultivars on diameter of head

In case of Chinese cabbage head diameter is a measurement of the size of actual shape that indicates amount of yield and/or market value. A statistically significant variation was observed in terms of diameter of head due to the different cultivars (Table 9 & appendix IX). Blues (C_2) cultivar gave the maximum (15.10 cm) diameter of head, while BARI Chinakopi 1 (C_1) cultivar gave the minimum (12.88cm) diameter of head which was statistically similar with Retasi (C_3) (13.69cm).

4.10.2 Effect of vermicompost on diameter of head

In case of head diameter, a statistically significant variation was recorded due to different level of vermicompost under the study (Table 9 and Appendix IX). It was recorded that the highestdiameter of head (16.24 cm) was obtained with the treatment VC_3 (10 t/ha).On the other hand, the lowest diameterof head (11.60 cm) was measured with control (VC_0) treatment.

4.10.3 Interaction effect of cultivars and vermicompost on diameter of head

The interaction effect of Chinese cabbage cultivars with different levels of vermicompost showed significant variation on diameter of head under (Table 10). It was observed that the highest diameter of head (18.13 cm) was recorded from C_2VC_3 treatment combination. On the other hand, the lowest diameter of head (10.88 cm) was obtained from C_1VC_0 treatment combination which was statistically identical with C_3VC_0 treatment combination. Easmin*et al*. (2009) reported that Chinese cabbage head diameter varied due to different doses of fertilizers.

4.11 Thickness of head

4.11.1 Performance of cultivars on thickness of head

A statistically significant variation was recorded in terms of thickness of head due to the different cultivars (Table 9 and appendix IX). The maximum (23.81 cm) thickness of head was recorded from cultivar Blues (C_2), while the minimum (18.75 cm) was recorded from C_1 cultivar.

4.11.2 Effect of vermicompost on thickness of head

A statistically significant variation was recorded in terms of thickness of head due to the different levels of vermicompost (Table 9 and appendix IX). The highest thickness (24.36 cm) was found in VC_3 treatment, while the minimum thickness (18.13 cm) was observed in Control (VC_0) treatment. Zhang *et al.* (2004) reported from their experiment that organic fertilizers created compactness in the Chinese cabbage head as well as thickness of head.

4.11.3 Interaction effect of cultivars and vermicompost on thickness of head

A Significant variation was observed in case of thickness of head of Chinese cabbage with interaction effect of cultivars and different levels of vermicompost under the present study (Table 10 and appendix IX). Different treatment combination viewed different thickness of head in Chinese cabbage. It was observed that the highest thickness of head (27.22 cm) was achieved with C_2VC_3 treatment combination, while the lowest thickness of head (15.12 cm) was obtained from C_1VC_0 treatment combination.

Table 9. Effect of cultivars and vermicompost on diameter and thickness of head

Treatments	**Diameter of head (cm)**	**Thickness of head (cm)**
Performance of cultivars		
C_1	12.88 ± 0.47^{b}	18.75 ± 0.79^{c}
C_2	15.10 ± 0.68^{a}	23.81 ± 0.73^{a}
C_3	13.69 ± 0.52^{ab}	21.24 ± 0.71^{b}
Level of Significance	0.030	0.000
Effect of vermicompost		
VC_0	11.60 ± 0.26^{d}	18.13 ± 0.87^{c}
VC_1	12.99 ± 0.32^{c}	20.19 ± 0.77^{bc}
VC_2	14.73 ± 0.39^{b}	22.35 ± 0.66^{a}
VC_3	16.24 ± 0.57^{a}	24.36 ± 0.85^{a}
Level of Significance	***	***

In a column means having similar letter (s) are statistically similar and those having dissimilar differ significantly at 5% level and C_1= BARI Chinakopi 1, C_2= Blues, C_3= Retasi; VC_0= Control, VC_1= 6 t/ha, VC_2= 8 t/ha, VC_3= 10 t/ha and *** Indicates significant at <1% level of probability

Table 10. Interaction effect of cultivars and vermicompost on diameter and thickness of head of Chinese cabbage

Treatments	Diameter of head (cm)	Thickness of head (cm)
C_1VC_0	10.88±0.19[g]	15.12±0.53[i]
C_1VC_1	12.34±0.69[ef]	17.83±0.19b[h]
C_1VC_2	13.85±0.47[cd]	20.22±0.47[fg]
C_1VC_3	14.48±0.63[c]	21.72±0.88[ef]
C_2VC_0	12.39±0.27[ef]	20.78±0.51[ef]
C_2VC_1	13.72±0.50[cd]	22.72±0.55[cd]
C_2VC_2	16.17±0.16[b]	24.54±0.32[b]
C_2VC_3	18.13±0.27[a]	27.22±0.14[a]
C_3VC_0	11.55±0.39[fg]	18.49±0.76[gh]
C_3VC_1	12.92±0.27[de]	20.03±0.90[fg]
C_3VC_2	14.17±0.27[cd]	22.28±0.53[de]
C_3VC_3	16.12±0.36[b]	24.14±0.59[bc]
Level of significance	**	***

In a column means having similar letter (s) are statistically similar and those having dissimilar differ significantly at 5% level and C_1= BARI Chinakopi 1, C_2= Blues, C_3= Retasi; VC_0= Control, VC_1= 6 t/ha, VC_2= 8 t/ha, VC_3= 10 t/ha and *** Indicates significant at <1% level of probability ; ** Indicates significant at <5% level of probability

4.12 Dry matter content of head (%)

4.12.1 Performance of cultivars on dry matter content of head (%)

Performance of cultivars on dry matter content of Chinese cabbage varied significantly (Table 11 and appendix X). The maximum content of dry matter (13.36%) was observed in cultivar Blues while the minimum content of dry matter (10.96%) was found in BARI Chinakopi-1.

4.12.2 Effect of vermicompost on dry matter content of head (%)

The different level of vermicompost management practices showed significant effect on the dry matter content of Chinese cabbage head (Table 11 and appendix X). The highest dry matter content (14.86%) was found in VC_3 treatment while the minimum dry matter content of head (8.88%) was observed in VC_0 treatment.

4.12.3 Interaction effect of cultivars and vermicompost on dry matter content of head (%)

A significant variation was observed in case of dry matter content of head due to interaction effect of cultivars and different levels of vermicompost (Table 12 and appendix X). It was observed that the highest amount of dry matter content of head (16.63%) was achieved with C_2VC_3 treatment combination. On the other hand, the lowest dry matter content of head (8.36%) was obtained from C_1VC_0 treatment combination which was statistically identical with C_3VC_0 treatment combination.

4.13 Fresh weight of head per plant (kg)

4.13.1 Performance of cultivars on fresh weight of head/plant (kg)

Performance of Chinese cabbage cultivars showed a significant variation in case of fresh weight of head plant^{-1} (Table 11 and appendix X). The maximum weight of head plant^{-1} (0.99 kg) was observed in C_2 cultivar and the minimum weight of head plant^{-1} (0.65kg) was recorded from C_1 cultivar.

4.13.2 Effect of vermicompost on fresh weight of head/plant (kg)

Fresh weight of Chinese cabbage head per plant varied significantly among different levels of vermicompost management (Table 11 and appendix X). The maximum fresh weight of Chinese cabbage head per plant (1.06 kg) was recorded in VC_3 treatment. On the other hand, minimum fresh weight (0.54 kg) of individual head was recorded in VC_0 treatment.

4.13.3 Interaction effect of cultivars and vermicompost on fresh weight of head/plant (kg)

In case of fresh weight of head/plant showed a significant variation due to interaction effect of Chinese cabbage cultivars and different levels of vermicompost (Table 12 and Appendix X). It was observed that the maximum (1.25 kg) fresh weight of head/plant was achieved with C_2VC_3 treatment combination. On the other hand, the lowest (0.45 kg) fresh weight of head plant^{-1} was obtained from C_1VC_0 treatment combination, which was statistically identical to C_3VC_0 treatment combination.

4.14 Fresh weight of whole plant (kg)

4.14.1 Performance of cultivars on fresh weight of whole plant (kg)

Different cultivars showed different fresh weight of whole plant (Table 11 and appendix x). Among the cultivars maximum fresh weight of whole plant (1.17 kg) was obtained from C_2 cultivar and the minimum weight of whole plant (0.80 kg) was recorded from C_1 cultivar.

4.14.2 Effect of vermicompost on fresh weight of whole plant (kg)

A statistically significant variation was observed on fresh weight of whole plant (kg) due to different level of vermicompost (Table 11 and appendix x). The maximum fresh weight of whole plant (1.24 kg) was recorded in VC_3 treatment. On the other hand, minimum fresh weight (0.67 kg) of fresh weight of whole plant was recorded in VC_0 treatment.

4.14.3 Interaction effect of cultivars and vermicompost on fresh weight of plant

Weight of whole plant (kg) of Chinese cabbage showed a significant variation due to interaction effect of cultivars and different levels of vermicompost (Table 12 and Appendix x). It was observed that the maximum (1.44 kg) fresh weight of whole plant was achieved with C_2VC_3 treatment combination. On the other hand, the lowest (0.58 kg) fresh weight of whole plant was obtained from C_1VC_0 treatment combination. Laczi*et al.*, (2016) reported the similar weight of Chinese cabbage in their study.

Table 11. Effect of cultivars and vermicompost on dry matter content of head (%), fresh weight of head per plant (kg) and fresh weight of whole plant (kg) of Chinese cabbage

Treatments	Dry matter content of head (%)	Fresh weight of head per plant (kg)	Fresh weight of whole plant (kg)
Performance of cultivars			
C_1	10.96±0.56^{b}	0.65±0.04^{b}	0.80±0.04^{b}
C_2	13.36±0.80^{a}	0.99±0.06^{a}	1.17±0.07^{a}
C_3	12.02±0.69^{ab}	0.81±0.07^{ab}	0.97±0.08^{ab}
Level of significance	NS	***	***
Effect of vermicompost			
VC_0	8.88±0.22^{d}	0.54±0.03^{c}	0.67±0.04^{c}
VC_1	11.29±0.25^{c}	0.72±0.03^{b}	0.88±0.03^{b}
VC_2	13.42±0.49^{b}	0.95±0.06^{a}	1.13±0.07a
VC_3	14.86±0.49^{a}	1.06±0.06^{a}	1.24±0.07^{a}
Level of significance	***	***	***

In a column means having similar letter (s) are statistically similar and those having dissimilar differ significantly at 5% level and C_1= BARI Chinakopi 1, C_2= Blues, C_3= Retasi; VC_0= Control, VC_1= 6 t/ha, VC_2= 8 t/ha, VC_3= 10 t/ha and *** Indicates significant at <1% level of probability

Table 12: Interaction effect of cultivars and vermicompost on dry matter content of head (%), fresh weight of head per plant (kg) and fresh weight of whole plant (kg) of Chinese cabbage

Treatment	Dry matter content of head (%)	Fresh weight of head per plant (kg)	Fresh weight of whole plant (kg)
C_1VC_0	8.36±0.06^{g}	0.45±0.01^{g}	0.58±0.01^{g}
C_1VC_1	10.35±0.08^{e}	0.63±0.02^{f}	0.78±0.02^{f}
C_1VC_2	11.69±0.26^{d}	0.73±0.37^{e}	0.89±0.03^{e}
C_1VC_3	13.44±0.03^{c}	0.80±0.25^{d}	0.97±0.02^{d}
C_2VC_0	9.77±0.08^{f}	0.69±0.00^{ef}	0.84±0.0.01^{ef}
C_2VC_1	12.01±0.12^{d}	0.85±0.01^{d}	1.02±0.01^{d}
C_2VC_2	15.05±0.08^{b}	1.18±0.01^{b}	1.37±0.01^{b}
C_2VC_3	16.63±0.41^{a}	1.25±0.02^{a}	1.44±0.02^{a}
C_3VC_0	8.51±0.10^{g}	0.48±0.01^{g}	0.61±0.06^{g}
C_3VC_1	11.50±0.19^{d}	0.67±0.01^{ef}	0.84±0.01^{ef}
C_3VC_2	13.53±0.23^{c}	0.96±0.02^{c}	1.13±0.04^{c}
C_3VC_3	14.52±0.28^{b}	1.15±0.02^{b}	1.31±0.04^{b}
Level of significance	***	***	***

In a column means having similar letter (s) are statistically similar and those having dissimilar differ significantly at 5% level and C_1= BARI Chinakopi 1, C_2= Blues, C_3= Retasi; VC_0= Control, VC_1= 6 t/ha, VC_2= 8 t/ha, VC_3= 10 t/ha and *** Indicates significant at <1% level of probability

4.15 Marketable Yield of Chinese cabbage/plot

4.15.1 Performance of cultivars on marketable yield of Chinese cabbage per plot:

In case of marketable yield (kg/plot) a statistically significant variation was observed among cultivars (Table 13). In this experiment Blues cultivar (C_2) gave the highest marketable yield (11.95 kg/plot) and BARI Chinakopi-1 (C_1) gave the lowest marketable yield (7.84 Kg/plot) whereas Retasi (C_3) cultivar recorded medium marketable yield (9.82 kg/plot).

4.15.2 Effect of vermicompost on marketable yield of Chinese cabbage per plot:

A statistically significant variation was recorded in terms of marketable yield of Chinese cabbage per plot due to the different level of vermicompost (Table 13). The highest yield was recorded from treatment VC_3 (12.82 kg/plot) and the lowest yield was found from treatment VC_0 (6.50 kg/plot). Tripathi*et al*. (2015) reported that different levels of vermicompost application produced significantly higher yield compared to control.

4.15.3 Interaction effect of variety and vermicompost on marketable yield of Chinese cabbage per plot:

The interaction effect of cultivars and vermicompost had significant effect on marketable yield of Chinese cabbage/plot (Table 15).Among the treatment combinations the highest marketable yield was obtained from C_2VC_3 treatment combination (15.04 kg/plot) and the minimum (5.40 kg/plot) was obtained from the treatment combination of C_1VC_0, which was statistically identical to C_3VC_0 treatment combination.

4.16 Marketable Yield of Chinese cabbage/ha

4.16.1 Performance of cultivars on marketable yield of Chinese cabbage/ha:

In case of marketable yield (t/ha), a statically significant variation was observed among cultivars (Table 13). Blues cultivar (C_2) gave the highest marketable yield (66.38 t/ha) and BARI Chinakopi 1 (C_1) gave the lowest marketable yield (43.55 t/ha) whereas Retasi (C_3) cultivar recorded medium marketable yield 54.55 t/ha (Table 13).

4.16.2 Effect of vermicompost on marketable yield of Chinese cabbage/ha

A statistically significant variation was recorded among the cultivars of Chinese cabbagein terms of marketable yield (t/ha) due to the different level of vermicompost. The highest yield was recorded from treatment VC_3 (71.25 t/ha) and the lowest yield was observed from treatment VC_0 (36.14 t/ha). Previous research proved that the application of organic fertilizers led to an increase of the yield of several vegetables (Gana 2009).

4.16.3 Interaction effect of variety and vermicompost on marketable yield of Chinese cabbage (t/ha)

The interaction effect of cultivars and vermicompost had significant effect (Table 15) on marketable yield of Chinese cabbage (t/ha). Among the treatment combinations the highest marketable yield was obtained from C_2VC_3 treatment combination (83.55 t/ha) and the minimum (30 t/ha) was obtained from the treatment combination of C_1VC_0, which was statistically identical to C_3VC_0 (32 t/ha) treatment combination.

Table 13. Effect of cultivars and vermicompost on marketable yield of Chinese Cabbage

Treatments	Marketable yield (kg/plot)	Marketable yield (t/ha)
Performance of cultivars		
C_1	7.84±0.49[b]	43.55±2.74[b]
C_2	11.95±0.83[a]	66.38±4.63[a]
C_3	9.82±0.94[ab]	54.55±5.23[ab]
Level of significance	***	***
Effect of vermicompost		
VC_0	6.50±0.46[c]	36.14±2.60[c]
VC_1	8.65±0.41[b]	48.07±4.32[b]
VC_2	11.49±0.79[a]	63.85±4.42[a]
VC_3	12.82±0.83[a]	71.25±4.66[a]
Level of significance	***	***

In a column means having similar letter (s) are statistically similar and those having dissimilar differ significantly at 5% level and C_1= BARI Chinakopi 1, C_2= Blues, C_3= Retasi; VC_0= Control, VC_1= 6 t/ha, VC_2= 8 t/ha, VC_3= 10 t/ha and *** Indicates significant at <1% level of probability

4.17 Gross yield of Chinese cabbage (kg/plot)

4.17.1 Performance of cultivars on gross yield of Chinese cabbage/plot:

Among three cultivars the highest amount of gross yield was recorded from C_2 treatment (14.04 kg/plot) whereas the lowest amount of yield was recorded from C_1 treatment (9.68 kg/plot) (Table 14). The gross yield recorded from C_3 treatment was 11.71 kg/plot.

4.17.2 Effect of vermicompost on gross yield of Chinese cabbage/plot

Gross yield of Chinese cabbage/plot significantly influenced by vermicompost management (Table 14). The lowest amount of yield (8.14 kg/ plot) was obtained from the control treatment VC_0 and the highest yield (14.96 kg/plot) was obtained from the treatment VC_3 (10 t/ha)

4.17.3 Interaction effect of cultivars and vermicompost on gross yield of Chinese cabbage/plot

The interaction effect of cultivars and vermicompost had significant effect on yield of Chinese cabbage/plot (Table 15). Among the combinations of treatment, the maximum yield was observed in C_2VC_3 treatment combinations (17.36 kg/plot) and the minimum (6.96 kg/plot) was obtained from the treatment combination of C_1VC_0, which was statistically identical to C_3VC_0 treatment combination.

4.18 Gross yield of Chinese cabbage (t/ha)

4.18.1 Performance of cultivars on gross yield of Chinese cabbage (t/ha)

Among three cultivars the highest amount of gross yield was recorded from C_2 treatment (78 t/ha) whereas the lowest amount of yield was recorded from C_1 treatment (53.77 t/ha) The gross yield recorded from C_3 treatment was 65.05 t/ha (Table 14).

4.18.2 Effect of vermicompost on gross yield of Chinese cabbage (t/ha)

Gross yield of Chinese cabbage (t/ha) was significantly influenced by vermicompost management (Table 14). The lowest amount of yield (45.26 t/ha) was obtained from the control treatment VC_0 and the highest yield (83.11 t/ha) was obtained from the treatment VC_3 (10 t/ha).

4.18.3 Interaction effect of cultivars and vermicompost on gross yield of Chinese cabbage (t/ha)

The interaction effect of cultivars and vermicompost had significant effect on gross yield of Chinese cabbage (t/ha). Among the combinations of treatment, the maximum yield was observed in C_2VC_3 treatment combinations (91.33 t/ha) and the minimum (38.66 t/ha) was obtained from the treatment combination of C_1VC_0, which was statistically identical to C_3VC_0 treatment combination (Table 15).

Table 14: Effect of cultivars and vermicompost on gross yield of Chinese cabbage/ha

Treatments	Gross yield (kg/plot)	Gross yield (t/ha)
Effect of cultivars		
C_1	9.68±0.55b	53.77±3.06b
C_2	14.04±0.90a	78±5.01a
C_3	11.71±0.98ab	65.05±5.44ab
Level of significance	***	***
Effect of vermicompost		
VC_0	8.14±0.49c	45.26±2.72a
VC_1	10.57±0.45b	58.74±2.51b
VC_2	13.56±0.84a	75.33±4.71a
VC_3	14.96±0.86a	83.11±4.97a
Level of significance	***	***

In a column means having similar letter (s) are statistically similar and those having dissimilar differ significantly at 5% level and C_1= BARI Chinakopi 1, C_2= Blues, C_3= Retasi; VC_0= Control, VC_1= 6 t/ha, VC_2= 8 t/ha, VC_3= 10 t/ha and *** Indicates significant at <1% level of probability

Table 15. Interaction effect of variety and vermicompost on marketable yield (kg/plot), marketable yield (t/ha), gross yield (kg/plot), gross yield (t/ha)

Treatment combination	Marketable yield (kg/plot)	Marketable yield (t/ha)	Gross yield (kg/plot)	Gross yield (t/ha)
C_1VC_0	5.40±0.13^{g}	30±0.76^{g}	6.96±0.13^{g}	38.66±0.77^{g}
C_1VC_1	7.60±0.28^{f}	42.22±1.55^{f}	9.36±0.27^{f}	52.00±1.54^{f}
C_1VC_2	8.76±0.45^{e}	48.66±2.52^{e}	10.68±0.45^{e}	59.33±2.52^{e}
C_1VC_3	9.60±0.30^{d}	53.33±1.67^{d}	11.72±0.28^{d}	65.11±1.55^{d}
C_2VC_0	8.36±0.10^{ef}	46.44±0.58^{ef}	10.08±0.12^{ef}	56.00±0.66^{ef}
C_2VC_1	10.24±0.17^{d}	56.89±0.97^{d}	12.28±0.17^{d}	68.22±0.97^{d}
C_2VC_2	14.16±0.18^{b}	78.66±1.01^{b}	16.44±0.18^{b}	91.33±1.02^{b}
C_2VC_3	15.04±0.28^{a}	83.55±1.60a	17.36±0.31^{a}	96.44±1.70^{a}
C_3VC_0	5.76±0.06^{g}	32.00±0.38^{g}	7.4±0.08^{g}	41.11±0.44^{g}
C_3VC_1	8.12±0.17^{f}	45.11±0.97^{ef}	10.08±0.20^{ef}	56.00±1.15^{ef}
C_3VC_2	11.56±0.28^{c}	64.22±1.55^{c}	13.56±0.31^{c}	75.33±1.76^{c}
C_3VC_3	13.84±0.34^{b}	76.88±1.93^{b}	15.80±0.53^{b}	87.77±2.98^{b}
Level of significance	***	***	***	***

In a column means having similar letter (s) are statistically similar and those having dissimilar differ significantly at 5% level and C_1= BARI Chinakopi 1, C_2= Blues, C_3= Retasi; VC_0= Control, VC_1= 6 t/ha, VC_2= 8 t/ha, VC_3= 10 t/ha and *** Indicates significant at <1% level of probability

4.19 Amount of Vitamin C

4.19.1 Performance of cultivars on amount of Vitamin C

Amount of Vitamin C was found to have significant variation among different cultivars (Table 16 and appendix XII). Blues cultivar (C_2) gave the maximum amount of Vitamin C (27.50 mg/100g) and cultivar Retasi (C_1) gave the minimum (18.75 mg/100g) amount of Vitamin C.

4.19.2 Effect of vermicompost on amount of Vitamin C

A significant variation in Vit-C was observed due to different level of vermicompost (Table 16 and appendix XII). It was observed that the treatment VC_3 gave the highest amount of Vitamin C (28.88 mg/100g) whereas VC_0 gave the lowest amount of Vitamin C (19.44 mg/100g). Usman*et al*. (2016) reported that the vitamin C and sugar content were higher in response to the treatment combination of the kind of vermicompost and earthworm *P. corethrurus*population than in response to the inorganic fertilization.

4.19.3 Interaction effect of cultivars and vermicompost on amount of Vitamin C

In case of interaction effect the treatment combination C_2VC_3 (32 mg/100g) showed highest amount of Vitamin C and the treatment combination C_3VC_0 (15.66 mg/100g) was recorded the lowest amount of Vitamin C (Table 17).

4.20 Amount of Beta carotene

4.20.1 Performance of cultivars on amount of Beta carotene

There was actually no significant variation was observed among different cultivars in case of beta carotene ((Table 16 and appendix XII).

4.20.2 Effect of vermicompost on amount of Beta carotene

A statistically significant variation was observed due to different level of vermicompost (Table 16 and appendix XII). It was observed that the treatment VC_3 gave the highest amount of Beta carotene (189.33 ug/100g) whereas VC_0 gave the lowest amount of Beta carotene (95.44 ug/100g).

4.20.3 Interaction effect of cultivars and vermicompost on amount of Beta carotene

In case of interaction effect the treatment combination C_2VC_3 (195 ug/100g) showed highest amount of Beta carotene and the treatment combination C_1VC_0 (91.00 mg/100g) was recorded the lowest amount of Beta carotene.

4.21 Amount of Calcium

4.21.1 Performance of cultivars on amount of Ca

There was a significant variation was observed on the performance of cultivars on amount of Ca (Table 16 and appendix XII). The maximum amount of Ca (72.16

mg/100g) was found in C_2 cultivar and the minimum amount of Ca (68.08mg/100g) frecorded in C_1 cultivar which was statistically similar with C_3 treatment.

4.21.2 Effect of vermicompost on amount of Ca

There were no significant variation was observed in case of amount of Ca on Chinese cabbage due to different level of vermicompost.

4.21.3 Interaction effect of cultivars and vermicompost on amount of Ca

In case of interaction effect the treatment combination C_2VC_3 (74.66 mg/100g) showed highest amount of Ca and the treatment combination C_1VC_0 (64.66 mg/100g) was recorded the lowest amount of Ca.

4.22 Amount of Magnesium

4.22.1 Performance of cultivars on amount of Mg

There was no significant variation was observed in case of amount of Mg on Chinese cabbage due to different cultivars.

4.22.2 Effect of vermicompost on amount of Mg

Actually, there were no significant variation was observed in case of amount of Mg on Chinese cabbage due to different level of vermicompost.

4.22.3 Interaction effect of cultivars and vermicompost on amount of Mg

In case of interaction effect the treatment combination C_2VC_3 (12.24 mg/100g) showed highest amount of Mg and the treatment combination C_3VC_0 (7.74 mg/100g) was recorded the lowest amount of Mg (Table 17 and appendix XII).

Table 16. Effect of cultivars and vermicompost on amount of Vit-C, Beta carotene, Ca and Mg

Treatments	Vit-C (mg/100g)	Beta carotene (ug/100g)	Ca (mg/100g)	Mg (mg/100g)
Performance of cultivars				
C_1	24.33±1.59[a]	147.25±10.94[a]	68.08±0.86[b]	10.22±0.35[ab]
C_2	27.50±0.84[a]	156.83±11.47[a]	72.16±0.60[a]	11.23±0.27[a]
C_3	18.75±0.95[b]	151.91±10.92[a]	69.50±0.49[b]	9.83±0.47[b]
Level of significance	***	NS	***	**
Effect of vermicompost				
VC_0	19.44±1.45[b]	95.44±1.24[d]	66.88±0.84[c]	9.02±0.44[b]
VC_1	22.00±1.58[b]	143.66±0.78[c]	69.00±0.84[b]	9.88±0.34[b]
VC_2	23.77±0.87[b]	179.55±2.35[b]	71.11±0.45[a]	11.01±0.19[a]
VC_3	28.88±1.67[a]	189.33±1.50[a]	72.66±0.57[a]	11.79±0.22[a]
Level of significance	***	***	***	***

In a column means having similar letter (s) are statistically similar and those having dissimilar differ significantly at 5% level and C_1= BARI Chinakopi 1, C_2= Blues, C_3= Retasi; VC_0= Control, VC_1= 6 t/ha, VC_2= 8 t/ha, VC_3= 10 t/ha and *** Indicates significant at <1% level of probability ; ** Indicates significant at <5% level of probability

Table 17. Interaction effect of cultivars and vermicompost on amount of Vit-C, Beta carotene, Ca and Mg

Treatment combination	Amount of Vit-C (mg/100g)	Amount of Beta carotene (mg/100g)	Amount of Ca (mg/100g)	Amount of Mg (mg/100g)
C_1VC_0	17.66±0.33^{f}	91±0.57^{i}	64.66±0.88^{f}	9±0.57^{d}
C_1VC_1	23.66±0.33^{cd}	141±0.57^{f}	66.33±0.66^{f}	9.73±0.41^{cd}
C_1VC_2	23.66±0.33^{cd}	171±0.57^{d}	70±0.57^{cde}	10.55±0.29^{bc}
C_1VC_3	32.33±0.88^{a}	186±0.56^{b}	71.33±0.66^{bcd}	11.60±0.55^{ab}
C_2VC_0	25.00±0.57^{bc}	99.33±0.66^{g}	69.66±0.66^{de}	10.34±0.43^{bc}
C_2VC_1	26.33±0.33^{b}	146±0.57^{e}	71.66±0.88^{bcd}	10.93±0.52^{bc}
C_2VC_2	26.66±0.88^{b}	187±0.57^{b}	72.66±0.33^{b}	11.40±0.34^{ab}
C_2VC_3	32.00±0.57^{a}	195±1.15^{a}	74.66±0.33^{a}	12.24±0.26^{a}
C_3VC_0	15.66±0.88^{f}	96±0.57^{h}	66.33±0.88^{g}	7.74±0.37^{e}
C_3VC_1	16.00±0.15^{f}	144±0.57^{e}	69±0.57^{e}	8.99±0.11^{d}
C_3VC_2	21±0.57^{e}	180.66±0.88^{c}	70.66±0.33^{c}	11.08±0.22^{ab}
C_3VC_3	22.33±0.33^{de}	187±1.15^{b}	72±0.57^{bc}	11.52±0.28^{ab}
Level of significance	***	***	***	***

In a column means having similar letter (s) are statistically similar and those having dissimilar differ significantly at 5% level and C_1= BARI Chinakopi 1, C_2= Blues, C_3= Retasi; VC_0= Control, VC_1= 6 t/ha, VC_2= 8 t/ha, VC_3= 10 t/ha and *** Indicates significant at <1% level of probability

4.23 Amount of Phosphorus

2.23.1 Performance of cultivars on amount of Phosphorus

A statistically significant variation was observed among the cultivar on the amount of P (Table 18 and appendix XII). The maximum amount of P was recorded from treatment C_2 (27 mg/100g) and the minimum amount of P was recorded from treatment C_3 (22.08 mg/100g).

4.23.2 Effect of vermicompost on amount of Phosphorus

In case of amount of P there were a significant obtained due to different levels of vermicompost (Table 18 and appendix XII). The treatment VC_3 gave the highest amount of P (26 mg/100g) and the treatment VC0 gave the lowest amount of P (22.66 mg/100g).

4.23.3 Interaction effect of cultivars and vermicompost on amount of Phosphorus

In case of interaction effect the treatment combination C_2VC_3 (28 mg/100g) showed highest amount of P and the treatment combination C_3VC_0 (20.33 mg/100g) was recorded the lowest amount of P which was statistically similar with the treatment combination C_1VC_0 (Table 19 and appendix XII).

4.24 Amount of Potassium

4.24.1 Performance of cultivars on amount of Potassium

A statistically significant variation was observed among cultivars on the amount of K (Table 18 and appendix XII). The maximum amount of K was recorded from treatment C_2 (237.16 mg/100g) and the minimum amount of K was recorded from treatment C_1 (212.91 mg/100g).

4.24.2 Effect of vermicompost on amount of Potassium

In case of amount of K there were a statistically significant variation due to different levels of vermicompost (Table 18 and appendix XII). The treatment VC_3 gave the highest amount of K (230 mg/100g) and the treatment VC_0 gave the lowest amount of K (212.66 mg/100g).

4.24.3 Interaction effect of cultivars and vermicompost on amount of Potassium

In case of interaction effect the treatment combination C_2VC_3 (249.66 mg/100g) showed highest amount of K and the treatment combination C_1VC_0 (201 mg/100g) was recorded the lowest amount of K (Table 19 and appendix XII).

4.25 Amount of Fe

4.25.1 Performance of cultivars on amount of Fe

A statistically significant variation was observed among cultivars on the amount of Fe (Table 18 and appendix XII). The maximum amount of Fe was recorded from treatment C_2 (0.87 mg/100g) and the minimum amount of Fe was recorded from treatment C_3 (0.28 mg/100g).

4.25.2 Effect of vermicompost on amount of Fe

In case of amount of Fe there were a statistically significant variation obtained due to different levels of vermicompost (Table 18 and appendix XII). The treatment VC_3 gave the highest amount of Fe (0.63 mg/100g) and the treatment VC_0 gave the lowest amount of Fe (0.51 mg/100g).

4.25.3 Interaction effect of cultivars and vermicompost on amount of Fe

In case of interaction effect the treatment combination C_2VC_3 (0.95 mg/100g) showed highest amount of Fe and the treatment combination C_3VC_0 (0.26 mg/100g) was recorded the lowest amount of Fe (Table 19 and appendix XII).

4.26 Amount of Zn

4.26.1 Performance of cultivars on amount of Zn

There was a little significant variation was observed among cultivars on the amount of Zn (Table 18 and appendix XII). The maximum amount of Zn was recorded from treatment C_2 (0.21 mg/100g) and the minimum amount of Zn was recorded from treatment C_3 (0.17 mg/100g).

4.26.2 Effect of vermicompost on amount of Zn

In case of amount of Zn there were no statistically significant variation obtained due to different levels of vermicompost (Table 18 and appendix XII). The treatment VC_3 gave the highest amount of Zn (0.21 mg/100g) and the treatment VC_0 gave the lowest amount of Zn (0.18 mg/100g).

4.26.3 Interaction effect of cultivars and vermicompost on amount of Zn

In case of interaction effect the treatment combination C_2VC_3 (0.23 mg/100g) showed highest amount of Zn and the treatment combination C_3VC_0 (0.15 mg/100g) was recorded the lowest amount of Zn (Table 19 and appendix XII).

Table 18. Effect of cultivars and vermicompost on amount of P, K, Fe and Zn

Treatments	P (mg/100g)	K (mg/100g)	Fe (mg/100g)	Zn (mg/100g)
Performance of cultivars				
C_1	23.83 ± 0.57^{b}	212.91 ± 2.22^{b}	0.52 ± 0.02^{b}	0.20 ± 0.00^{a}
C_2	27 ± 0.21^{a}	237.16 ± 2.96^{a}	0.87 ± 0.01^{a}	0.21 ± 0.00^{a}
C_3	22.08 ± 0.39^{c}	217.16 ± 1.37^{b}	0.28 ± 0.00^{c}	0.17 ± 0.00^{b}
Level of significance	***	NS	***	**
Effect of vermicompost				
VC_0	22.66 ± 0.94^{b}	212.66 ± 3.64^{c}	0.51 ± 0.08^{a}	0.18 ± 0.00^{c}
VC_1	23.88 ± 0.75^{ab}	219.11 ± 2.58^{bc}	0.54 ± 0.08^{a}	0.19 ± 0.00^{bc}
VC_2	24.66 ± 0.66^{ab}	227 ± 4.19^{ab}	0.55 ± 0.08^{a}	0.20 ± 0.00^{ab}
VC_3	26 ± 0.64^{a}	230 ± 4.71^{a}	0.63 ± 0.09^{a}	0.21 ± 0.00^{a}
Level of significance	**	***	NS	***

In a column means having similar letter (s) are statistically similar and those having dissimilar differ significantly at 5% level and C_1= BARI Chinakopi 1, C_2= Blues, C_3= Retasi; VC_0= Control, VC_1= 6 t/ha, VC_2= 8 t/ha, VC_3= 10 t/ha and *** Indicates significant at <1% level of probability

Table 19. Interaction effect of cultivars and vermicompost on amount of P, K, Fe and Zn

Treatment combination	Amount of P (mg/100g)	Amount of K (mg/100g)	Amount of Fe (mg/100g)	Amount of Zn (mg/100g)
C_1VC_0	21.33±0.33^{fg}	201±0.57^{k}	0.43±0.00^{f}	0.19±0.006^{fg}
C_1VC_1	23.33±0.33^{cd}	213±0.57^{i}	0.50±0.00^{e}	0.20±0.003^{cdef}
C_1VC_2	24.33±0.66^{c}	217.33±0.33^{g}	0.51±0.00^{e}	0.21±0.000^{ab}
C_1VC_3	26.33±0.33^{b}	220.33±0.33^{f}	0.64±0.00^{d}	0.21±0.003^{abc}
C_2VC_0	26.66±0.33^{b}	226±0.57^{d}	0.84±0.00^{c}	0.19±0.003^{fg}
C_2VC_1	26.33±0.33^{b}	229.33±0.33^{c}	0.85±0.00^{bc}	0.20±0.003^{cde}
C_2VC_2	27±0.00^{ab}	243.66±0.66^{b}	0.86±0.00^{b}	0.22±0.006^{ab}
C_2VC_3	28±0.00^{a}	249.66±0.88a	0.95±0.00^{a}	0.23±0.005^{a}
C_3VC_0	20.33±0.33^{g}	211±0.57^{j}	0.26±0.00^{i}	0.15±0.005^{h}
C_3VC_1	21.66±0.33^{ef}	215±0.57^{h}	0.27±0.00^{hi}	0.16±0.005^{h}
C_3VC_2	22.66±0.33^{de}	220±0.57^{f}	0.28±0.00^{h}	0.18±0.005^{g}
C_3VC_3	23.66±0.33^{cd}	222.66±0.33^{e}	0.30±0.00^{g}	0.19±0.005^{def}
Level of significance	***	***	***	***

In a column means having similar letter (s) are statistically similar and those having dissimilar differ significantly at 5% level and C_1= BARI Chinakopi 1, C_2= Blues, C_3= Retasi; VC_0= Control, VC_1= 6 t/ha, VC_2= 8 t/ha, VC_3= 10 t/ha and *** Indicates significant at <1% level of probability

CHAPTERV

SUMMERY AND CONCLUSION

An experiment was conducted in the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from November 2019 to February 2020 to study the influence of vermicompost on growth, yield and quality of Chinese cabbage cultivars influenced by vermicompost. The experiment consisted of two factors. Factor A: three cultivars viz. C_1: BARI Chinakopi 1, C_2: Blues and C_3: Retasi; Factor B: Vermicompost (4 levels) viz. VC_0: Control, VC_1: 6 t/ha, VC_2: 8 t/ha and VC_3: 10 t/ha. The experiment was laid out in two factors Randomized Complete Block Design with three replications. There were 12 treatment combination. Data on different growth, quality and yield parameters of Chinese cabbage were recorded and statistically analyzed.

Data were collected on Plant height, Plant spread, Number of folded leaves per plant' Number ofunfolded leaves per plant, Days from sowing to initiation of head, Days from sowing to head maturity, Root length at harvest (cm), Fresh weight of root (g), Fresh weight of unfolded leaves (g), Thickness of head (cm) at harvest, Diameter of head (cm) at harvest, Dry matter content of plant (%), Fresh weight of head/plant (kg), weight of whole plant (kg), amount of Vitamin C, amount of Beta carotene, amount of Ca, Amount of K, Amount of Fe, Amount of Zn , Marketable yield/plot and marketable yield/ha, Gross yield/plot and gross yield/hawere evaluated to identify the higher performance of cultivars and vermicompost. Three effects have been considered to evaluate the experiment such as (i) Effect of cultivars, (ii) Effect of vermicompost and (iii) Interaction effect of cultivars and vermicompost. The experimental results of maximum parameters were significantly influenced by different cultivars of Chinese cabbage, different levels of vermicompost and the interaction effect of cultivars and vermicompost.

Cultivars of Chinese cabbage had significant effect on growth and yield. The highest plant height at harvest (33.64 cm), plant spread at harvest (34.26 cm), number of folded leaves per plant at harvest (28.04), root length (19.21 cm), root weight (25.39 g), weight of unfolded leaves (153.99 g), thickness of head (23.81 cm), diameter of head (15.10 cm), fresh weight of head (0.99 kg per plant), fresh weight of whole plant

(1.17 kg per plant), head dry matter content per plant (13.36%), amount of Vitamin C (27.50 mg/100g), amount of Beta carotene (156.83ug/100g), amount of Ca (72.16 mg/100g), amount of Mg (11.23 mg/100g), amount of Fe (0.87 mg/100g), amount of Zn (0.21 mg/100g), marketable yield per plot (11.95 kg/plot), marketable yield/ha (66.38 t/ha), gross yield per plot (14.04 kg/plot) and gross yield/ha(78.00 t/ha) were found in cultivar Blue (C_2). The highest number of unfolded leaves per plant at harvest (15.32), days from transplanting to head initiation (20.50 days) and the maximum days required from transplanting to head maturity (55.75 days) was recorded from cultivar C_1(BARI Chinakopi 1).

The lowest plant height at harvest (28.29 cm), plant spread at harvest (40.31 cm), number of folded leaves per plant at harvest (25.28), root length (15.01 cm), root weight (19.86 g), weight of unfolded leaves (134.87 g), thickness of head (18.72 cm), diameter of head (12.88 cm), fresh weight of head (0.65 kg plant-1), fresh weight of whole plant (0.80 kg plant-1), head dry matter content per plant (10.96 %), amount of Beta carotene (147.25ug/100g), amount of Ca (68.08 mg/100g), marketable yield per plot (7.84 kg/plot), marketable yield ha^{-1} (43.55 t/ha), Gross yield per plot (9.68 kg/plot) and Gross yield ha-1(53.77 t/ha) were obtained from the cultivar BARI Chinakopi 1 (C_1). The lowest amount of Vitamin C (18.75 mg/100g), amount of Mg (9.83 mg/100g), amount of Fe (0.28 mg/100g) and amount of Zn (0.17 mg/100g) was recorded from cultivar C_3 (Retasi). On the other hand, the lower number of unfolded leaves per plant at harvest (12.94), days from transplanting to head initiation (16.41 days) and the days required from transplanting to head maturity (52.66 days) was recorded from cultivar C_2 (Blues).

A significant variation was also observed on growth, yield and quality of Chinese cabbage due to the effect of vermicompost. In case of different level of vermicompost application the best results of all parameters of Chinese cabbage were found with VC_3 (10 t ha^{-1}) treatment and the lowest results were obtained with VC_0 (control) treatment.

The interaction effect of the cultivar and vermicompost had a significant influence on growth and yield contributing parameters of Chinese cabbage.The maximum plant height at harvest (39.88 cm), plant spread at harvest (49.13 cm), number of folded leaves per plant at harvest (32.33), root length (21.82 cm), root weight (g), weight of unfolded leaves (175.06 g), thickness of head (27.22 cm), diameter of head (18.13 cm), fresh weight of head (0.99 kg $plant^{-1}$), fresh weight of whole plant (1.44 kg plant-1), head dry matter content per plant (16.63%/100g), amount of Beta carotene (195 ug/100g), amount of Ca (74.66 mg/100g), amount of Mg (12.24 mg/100g), amount of Fe (0.95 mg/100g), amount of Zn (0.23 mg/100g), marketable yield per plot (15.04 kg/plot), marketable yield ha^{-1} (83.55 t/ha), gross yield per plot (17.36 kg/plot) and gross yield ha-1(96.44 t/ha) were obtained with the treatment combination C_2VC_3. The highest number of unfolded leaves per plant at harvest (17.35), days from transplanting to head initiation (24.33 days), the maximum days required from transplanting to head maturity (58.33 days) were observed from the C_1VC_0 treatment combination. On the other hand, the highest amount of vitamin C (32.33 mg/100g) was calculated from C_1VC_3 treatment combination.

Conclusion

Considering above results it may be concluded that cultivar Blue (C_2) performed in best and gave the highest gross yield(78.00 t/ha). In respective of cultivarChinese cabbage treated with vermicompost @19t/ha (VC_3) recorded the best results and produced maximum gross yield (83.11 t/ha). The cultivar Blue (V_2) in combination with vermicompost (10 t/ha) showed best performance in all parameters studied and recorded in highest gross yield (96.44 t/ha).

Recommendation

The present work was done at the Sher-e-Bangla Agricultural University Horticulture Farm and only one season. In the light of the present study, the following recommendation may be suggested:

I. Following a follow-up trial, the best Chinese cabbage variety could be proposed for commercial cultivation throughout different AEZ.

II. In order to obtain more yield and maximum economic returns, vermicompost levels could be increased.

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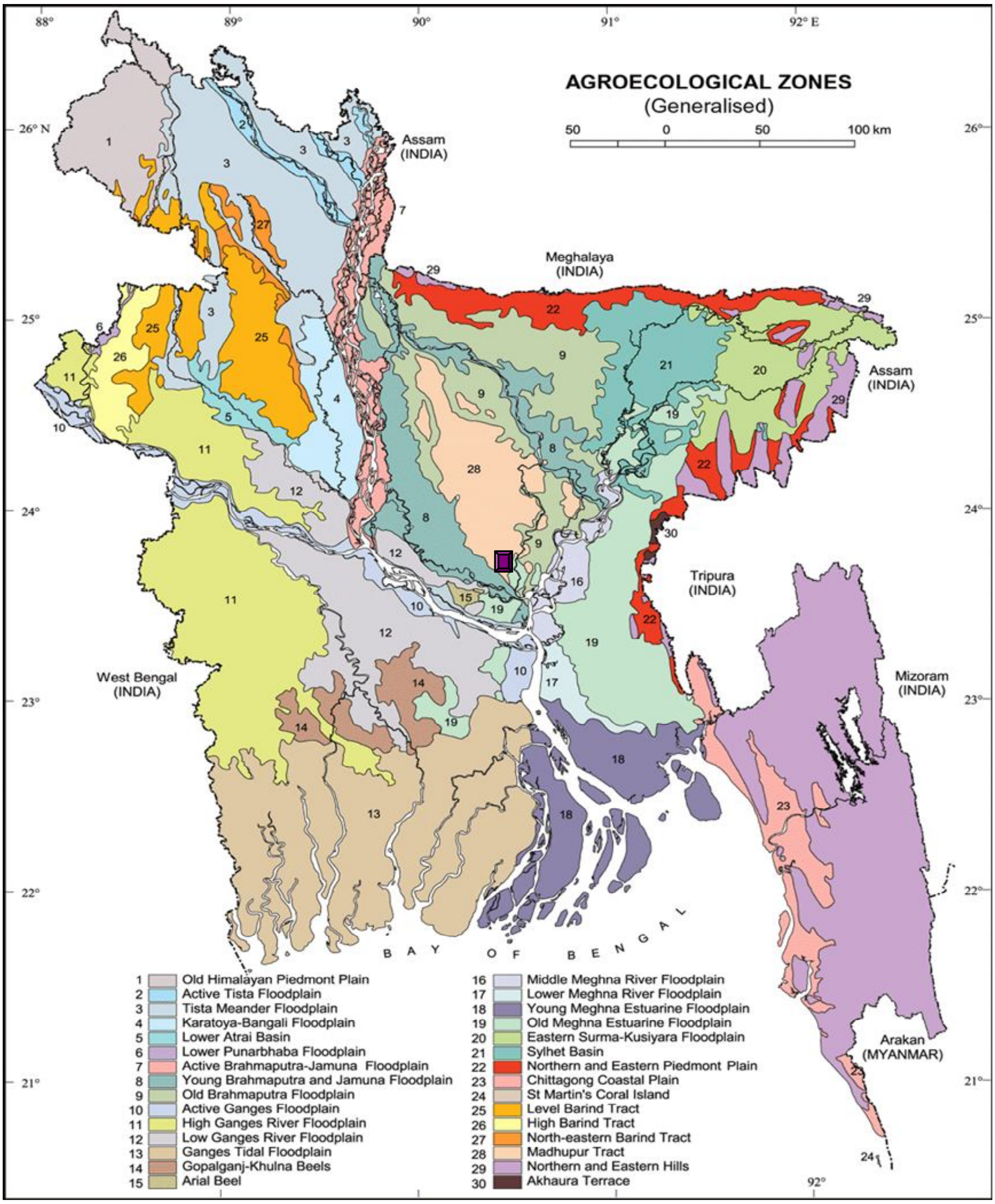
APPENDICES

Appendix I. Experimental location on the map of agro-ecological zones of Bangladesh



The experimental site under study

Appendix II. Monthly record of air temperature, rainfall, relative humidity and sunshine hours during the period from November 2019 to March 2020

Year	Month	Average air temperature (^{0} C)		Total rainfall (mm)	Average humidity (%)	Total sunshine hours
		Max.	Min.			
2019	November	29.6	19.2	34.4	53	8
-	December	26.4	14.1	12.8	50	9
2020	January	25.4	12.7	7.7	46	9
-	February	28.1	15.5	28.9	37	8.1
-	March	32.5	20.4	65.8	38	7

Source: Bangladesh Metrological Department (Climate and Weather Division), Agargaon, Dhaka

Appendix III. Characteristics of Horticulture Farm soil is analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Horticulture Farm,SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained

Source: Soil Resources Development Institute (SRDI), 2020

Appendix III.Contd.

B. Physical and chemical properties of the initial soil

Characteristics	**Value**
% Sand	28
% Silt	42
% clay	30
Textural class	Silty clay
pH	5.47 –5.63
Organic matter (%)	0.83%
Total N (%)	0.03
Available P (ppm)	20
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	23

Source: Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka.

Appendix IV. Analysis of variance of the data on plant height of Chinese cabbage as influenced by cultivars &vermicompost and their interaction

Source of variation	**Degrees of Freedom**	**Mean square**			
		Plant height (cm)			
		15 DAT	**30 DAT**	**45 DAT**	**At Harvest**
Cultivars A	2	22.57*	21.99^{NS}	40.61**	86.59***
Vermicompost B	3	69.56***	75.63***	98.69***	110.62***
Interaction (A×B)	6	23.48***	25.07***	35.43***	51.15***

^{NS}: Indicates non-significant
*: Indicates significant at <5% level of probability
**: Indicates significant at 1% level of probability
***: Indicates significant at <1% level of probability

Appendix V. Analysis of variance of the data on plant spread of Chinese cabbage as influenced by cultivars &vermicompost and their interaction

Source of variation	Degrees of Freedom	Mean square			
		Plant spread (cm)			
		15 DAT	30 DAT	45 DAT	At Harvest
Cultivars A	2	26.90^{NS}	154.07***	53.23***	63.06***
Vermicompost B	3	67.63***	71.21***	100.09***	89.02***
Interaction (A×B)	6	24.13***	47.65***	37.91***	37.14***

^{NS}: Indicates non-significant
*: Indicates significant at <5% level of probability
**: Indicates significant at 1% level of probability
***: Indicates significant at <1% level of probability

Appendix VI. Analysis of variance of the data on number of folded leaves/plants of Chinese cabbage cultivars as influenced by vermicompost

Source of variation	Degrees of Freedom	Mean square			
		No. of folded leaves plant^{-1}			
		15 DAT	30 DAT	45 DAT	At Harvest
Cultivars A	2	8.07*	52.90***	34.43**	24.45^{NS}
Vermicompost B	3	10.01***	85.14***	101.06***	96.54***
Interaction (A×B)	6	4.37 ^{NS}	33.69***	34.29***	31.04***

^{NS}: Indicates non-significant
*: Indicates significant at <5% level of probability
**: Indicates significant at 1% level of probability
***: Indicates significant at <1% level of probability

Appendix VII. Analysis of variance of the data on number of unfolded leaves/plants of Chinese cabbage cultivars as influenced by vermicompost

Source of variation	Degrees of Freedom	Mean square			
		No. of unfolded leaves plant^{-1}			
		15 DAT	30 DAT	45 DAT	At Harvest
Cultivars A	2	3.93 ^{NS}	22.50***	25.54***	18.04***
Vermicompost B	3	18.73***	30.04***	27.18***	31.02***
Interaction (A×B)	6	5.88***	12.41***	12.65***	12.02***

^{NS}: Indicates non-significant
*: Indicates significant at <5% level of probability
**: Indicates significant at 1% level of probability
***: Indicates significant at <1% level of probability

Appendix VIII. Analysis of variance of the data on yield contributing characters of Chinese cabbage as influenced by cultivars and vermicompost and their interaction

Source of variation	Degrees of freedom	Mean Square			
		Days from transplanting to initiation of head	Days from transplanting to head maturity	Length of root (cm)	Weight of root (g)
Cultivars (A)	2	50.08***	31.02***	57.27***	91.79***
Vermicompost (B)	3	73.29***	44.18***	28.91***	131.52***
Interaction (A×B)	6	29.66***	18.41***	18.64***	52.94***

^{NS}: Indicates non-significant
*: Indicates significant at <5% level of probability
**: Indicates significant at 1% level of probability
***: Indicates significant at <1% level of probability

Appendix IX. Analysis of variance of the data on yield contributing characters of Chinese cabbage as influenced by cultivars and vermicompost and their interaction

Source of variation	Degrees of freedom	Mean Square		
		Diameter of head (cm)	Thickness of head (cm)	Weight of unfolded leaves $plant^{-1}$ (g)
Cultivars (A)	2	15.11**	77.83***	1165.49**
Vermicompost (B)	3	36.80***	65.06***	2794.82***
Interaction (A×B)	6	13.30***	32.13***	1006.56***

^{NS}: Indicates non-significant
*: Indicates significant at <5% level of probability
**: Indicates significant at 1% level of probability
***: Indicates significant at <1% level of probability

Appendix X. Analysis of variance of the data on yield contributing characters of Chinese cabbage cultivars as influenced by cultivars and vermicompost and their interaction

Source of variation	Degrees of freedom	Mean Square		
		Dry matter (%)	Fresh weight of head (kg/plant)	Fresh weight of whole plant (kg/plant)
Cultivars (A)	2	17.39^{NS}	0.352***	0.397***
Vermicompost (B)	3	61.22***	0.504***	0.582***
Interaction (A×B)	6	20.39***	0.213***	0.242***

^{NS}: Indicates non-significant
*: Indicates significant at <5% level of probability
**: Indicates significant at 1% level of probability
***: Indicates significant at <1% level of probability

Appendix XI. Analysis of variance of the data on yield of Chinese cabbage as influenced by cultivars and vermicompost and their interaction

Source of variation	Degrees of freedom	Mean Square			
		Marketable yield kg/plot)	Marketable yield (t/ha)	Gross yield (kg/plot)	Gross yield (t/ha)
Cultivars (A)	2	50.69***	1564.78***	57.11***	1762.96***
Vermicompost (B)	3	72.50***	2237.91***	83.80***	2586.27***
Interaction (A×B)	6	30.69***	947.47***	34.82***	1074.72***

^{NS}: Indicates non-significant
*: Indicates significant at <5% level of probability
**: Indicates significant at 1% level of probability
***: Indicates significant at <1% level of probability

Appendix XII. Analysis of variance of the data on amount Vitamin C, Beta carotene, Ca, K, Fe and Zn of Chinese cabbage as influenced by cultivars and vermicompost& their interaction

Source of variation	Degrees of freedom	Mean Square			
		Vitamin C (mg/100g)	Beta carotene (ug /100g)	Ca (mg/100g)	Mg (mg/100g)
Cultivars (A)	2	235.52***	275.58^{NS}	51.58***	6.219**
Vermicompost (B)	3	143.435***	16263.185***	56.991***	13.339***
Interaction (A×B)	6	89.967***	4497.152***	25.705***	5.266***

^{NS}: Indicates non-significant
*: Indicates significant at <5% level of probability
**: Indicates significant at 1% level of probability
***: Indicates significant at <1% level of probability

Appendix XII.contd.

Source of variation	Degrees of freedom	Mean Square			
		P (mg/100g)	K (mg/100g)	Fe (mg/100g)	Zn (mg/100g)
Cultivars (A)	2	74.52***	2012.250***	1.07***	0.007***
Vermicompost (B)	3	17.583**	596.324***	0.024^{NS}	0.002***
Interaction (A×B)	6	19.179***	551.886***	0.204***	0.002***

^{NS}: Indicates non-significant
*: Indicates significant at <5% level of probability
**: Indicates significant at 1% level of probability
***: Indicates significant at <1% level of probability