EFFECTS OF ORGANIC AND INORGANIC FERTILIZERS ON GROWTH, YIELD AND NUTRIENTS CONTENT OF CAPSICUM (*Capsicum annuum* L.)

REGISTRATION NO. 15-06843

DEPARTMENT OF AGRICULTURAL CHEMISTRY

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BY

REGISTRATION NO. :15-06843
Email: radit.angur@gmail.com
Contact: 01776-079558

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Approved by:

Prof. Dr. Md. Abdur Razzaque
Department of Agricultural Chemistry
SAU, Dhaka
Supervisor

Prof. Dr. Sheikh Shawkat Zamil
Department of Agricultural Chemistry
SAU, Dhaka
Co-Supervisor

Prof. Dr. Mohammed Ariful Islam
Chairman
Examination committee
Department of Agricultural Chemistry

DEPARTMENT OF AGRICULTURAL CHEMISTRY
Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka-1207

CERTIFICATE

This is to certify that the thesis entitled **"EFFECTS OF ORGANIC AND INORGANIC FERTILIZERS ON GROWTH, YIELD AND NUTRIENTS CONTENT OF CAPSICUM (*Capsicum annuum* L.)"** submitted to the Department of Agricultural Chemistry, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTERS OF SCIENCE (M.S.)** in **AGRICULTURAL CHEMISTRY**, embodies the result of a piece of bonafide research work carried out by **MD. ANGOR HOSSAIN**, Registration No. 15-06843 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

June, 2022

Dhaka, Bangladesh

(Dr. Md. Abdur Razzaque)
Professor
Department of Agricultural Chemistry
SAU, Dhaka

Dedicated to

My

Beloved Parents

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The Author

EFFECTS OF ORGANIC AND INORGANIC FERTILIZERS ON GROWTH, YIELD AND NUTRIENTS CONTENT OF CAPSICUM (*Capsicum annuum* L.)

ABSTRACT

An experiment was carried out at Sher-e-Bangla Agricultural University (SAU), Sher-e-Bangla Nagar, Dhaka-1207 to study the effects of organic and inorganic fertilizers on growth, yield, and nutrients content of capsicum (*Capsicum annuum L.*) during the period from November 2021 to March 2022. The experiment considered 8 treatments *viz*. T_0 (control), T_1 (Recommended doses; RD of inorganic fertilizer), T_2 (Vermicompost - 3.5 t ha^{-1}), T_3 (Poultry manure - 8 t ha^{-1}), T_4 (50% vermicompost + 50% inorganic fertilizer of RD), T_5 (25% vermicompost + 75% inorganic fertilizer of RD), T_6 (50% poultry manure + 50% inorganic fertilizer of RD) and T_7 (25% poultry manure + 75% inorganic fertilizer of RD). The treatment T_5 (25% vermicompost + 75% inorganic fertilizer of RD) exhibited the highest plant height (51.93 cm) but the treatment T_4 (50% vermicompost + 50% inorganic fertilizer of RD) showed the highest number of leaves $plant^{-1}$ (52.07 cm), branches $plant^{-1}$ (9.47), flowers $plant^{-1}$ (11.53), fruits $plant^{-1}$ (8.71), fruit length (89.93 mm), fruit diameter (67.27 mm), individual fruit weight (94.85 g), number of fruits $plot^{-1}$ (40.67), yield $plot^{-1}$ (3859.00 g) and yield (19.30 t ha^{-1}) whereas control treatment showed least performance. Regarding the nutrient content of capsicum, N content differed significantly and the treatment T_7 (25% poultry manure + 75% inorganic fertilizer of RD) showed the maximum N content (1.73%) whereas T_0 (control) treatment showed the lowest result (0.57%). P and K contents of fruit showed non-significant variation among the treatments. So, it can be concluded that the treatment T_4 (50% vermicompost + 50% inorganic fertilizer of RD) treatment was very much promising for higher capsicum production (ASTHA F1) followed by T_5 (25% vermicompost + 75% inorganic fertilizer of RD). Treatment of 50% vermicompost + 50% inorganic fertilizer of RD (T_4) can be recommended at farmers level to achieve higher capsicum production.

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ABBREVIATIONS AND ACRONYMS

AEZ	=	Agro-Ecological Zone
BBS	=	Bangladesh Bureau of Statistics
BCSIR	=	Bangladesh Council of Scientific Research Institute
cm	=	Centimeter
CV %	=	Percent Coefficient of Variation
DAS	=	Days After Sowing
DAT	=	Days After Transplanting
DMRT	=	Duncan's Multiple Range Test
et al.,	=	And others
e.g.	=	exempli gratia (L), for example
etc.	=	Etcetera
FAO	=	Food and Agriculture Organization
g	=	Gram (s)
i.e.	=	id est (L), that is
Kg	=	Kilogram (s)
LSD	=	Least Significant Difference
m^2	=	Meter squares
ml	=	Mili Litre
M.S.	=	Master of Science
No.	=	Number
SAU	=	Sher-e-Bangla Agricultural University
var.	=	Variety
^oC	=	Degree Celceous
%	=	Percentage
NaOH	=	Sodium hydroxide
GM	=	Geometric mean
mg	=	Miligram
P	=	Phosphorus
K	=	Potassium
Ca	=	Calcium
L	=	Litre
μg	=	Microgram
USA	=	United States of America
WHO	=	World Health Organization

CHAPTER I

INTRODUCTION

Capsicum (*Capsicum annuum* L.), is an important vegetable crop and widely cultivated worldwide due to its high nutritional value and economic significance. It is commonly known as bell pepper or sweet pepper which belongs to the family Solanaceae. It has high nutritional value and economic significance. Capsicum is a rich source of vitamin C, bioflavonoids, and 6-carotene. It is commonly used in salads and also is being consumed as cooked food. Capsicum is notable for its richness in capsaicin, which may have anti-inflammatory properties and powerful antioxidant capabilities. It is available in various colors, ranging from green to yellow, red, orange, purple, and black (Teshm, 1998). Considered an excellent source of bioactive nutrients, capsicum contains primary antioxidant compounds such as ascorbic acid (vitamin C), carotenoids and phenolic compounds (Marin *et al.*, 2004). The levels of vitamin C, carotenoids, and phenolic compounds in vegetables fluctuate due to several factors, including cultivar, agricultural management practices, physiological maturity, and storage duration (Lee and Kader, 2000).

Vermicompost is an organic fertilizer produced through the action of earthworms on organic matter. It is a rich source of nutrients and is widely recognized as a valuable resource for improving soil health and enhancing plant growth and yield (Das and Adhya, 2018). Inorganic fertilizers, on the other hand, are chemical fertilizers that provide plants with essential nutrients but can have negative environmental impacts if overused. The integration of vermicompost with inorganic fertilizers has been suggested as a potential approach to optimize crop production while reducing the negative environmental impacts associated with excessive use of chemical fertilizers (Shakir and Zayed, 2019).Several studies have investigated the effects of vermicompost integrated with inorganic fertilizers on the growth and yield of capsicum. For instance, Adekiya*et al*. (2018) reported that the combined application of vermicompost and inorganic fertilizers significantly improved the growth, yield, and fruit quality of bell pepper plants. Ali *et al*. (2017) also found that the application of vermicompost in combination with inorganic fertilizers increased the growth and yield of capsicum plants. Similarly, Benítez *et al*. (2017) reported that the application of vermicompost and humic acids in combination with inorganic fertilizers resulted in higher yields and improved fruit quality of capsicum plants.

Other studies have investigated the effects of vermicompost and inorganic fertilizers on different types of capsicum, such as sweet pepper. Njoroge and Okalebo (2018) found that the combined application of organic and inorganic fertilizers significantly increased the yield and quality of sweet pepper (capsicum). Shakir and Zayed (2019) also reported that the application of vermicompost and inorganic fertilizers resulted in higher growth rates, yield, and quality of capsicum.

In addition, several studies have compared the effects of vermicompost and inorganic fertilizers to those of inorganic fertilizers alone. Das and Adhya (2018) found that the combined application of vermicompost and inorganic fertilizers resulted in higher yields and better fruit quality of bell pepper (capsicum) plants compared to the use of inorganic fertilizers alone. Similarly, López-Mosquera *et al*. (2019) reported that the integrated use of vermicompost and inorganic fertilizers resulted in higher yields and better plant growth of sweet pepper (capsicum) plants compared to the use of inorganic fertilizers alone.

Overall, these studies suggest that the integration of vermicompost with inorganic fertilizers could be a promising approach for enhancing the growth and yield of capsicum.

The present investigation was initiated to study the effects of organic and inorganic fertilizers on the growth, yield, and nutrients content of capsicum (*Capsicum annuum*, L.) with the following objectives:

1. To find out the effect of different combinations of organic and inorganic fertilizers on growth and yield of capsicum, and
2. To determine N, P and K content in capsicum.

CHAPTER II

REVIEW OF LITERATURE

Capsicum (*Capsicum annuum* L.) is an important vegetable crop with high nutritional value. The use of fertilizers is crucial for obtaining high yield and nutrient content in capsicum. This review summarizes the effects of organic and inorganic fertilizers on the growth, yield, and nutrient content of capsicum.

Singh *et al*. (2021) performed a study on the impact of organic and inorganic fertilizers on growth, yield, and nutrient uptake by chili (*Capsicum annuu*m L.). This study evaluated the effects of different organic and inorganic fertilizers on the growth, yield, and nutrient content of capsicum. Results showed that the application of organic fertilizers increased plant height, fruit weight and nutrient uptake compared to inorganic fertilizers.

Ali *et al*. (2021) carried out a study aimed to evaluate the comparative effect of organic and inorganic fertilizers on the growth, yield, and fruit quality of capsicum. Results exhibited that the application of organic fertilizers significantly increased plant height, fruit weight, and fruit quality compared to inorganic fertilizers.

Hussain *et al*. (2021) evaluated the effects of different organic and inorganic fertilizers on the yield and quality of capsicum. Results showed that the application of organic fertilizers combined with inorganic fertilizers increased growth, yield, and quality attributes such as plant height, leaf number, flower number, fruit number, yield/ha, vitamin C, total phenolics, and antioxidant activity compared to control or inorganic fertilizers.

Arif *et al*. (2021) carried out a study to evaluate the effect of organic and inorganic fertilizers on the growth, yield, and nutrient content of capsicum in temperate climates and the results showed that the application of organic fertilizers significantly increased plant height, fruit weight, and nutrient content compared to inorganic fertilizers.

Ahmed *et al*. (2020) conducted a study to determine the effect of different fertilizers on the growth and yield of capsicum in the agro-climatic condition at Jammu. Results revealed that the application of organic and inorganic fertilizers significantly increased plant height, flower number, fruit weight, and yield compared to control.

Shah *et al*. (2020) performed a study to evaluate the effect of organic and inorganic fertilizers on the growth, yield, and quality of capsicum in a semi-arid climate. Results showed that the application of organic fertilizers significantly increased plant height, fruit weight, and yield compared to inorganic fertilizers.

Saeed *et al*. (2020) carried out a study aimed to determine the effect of organic and inorganic fertilizers on the growth, yield, and nutrient uptake of capsicum in Pakistan. Results showed that the application of organic fertilizers in combination with inorganic fertilizer significantly increased plant height, number of leaves, fruit number, fruit weight, and nutrient uptake compared to inorganic fertilizers and organic fertilizers.

Ghani *et al*. (2020) carried out a study aimed to determine the comparative effect of organic and inorganic fertilizers on the growth, yield, and quality of capsicum under open field conditions. Results showed that the application of organic fertilizers significantly increased yield and quality parameters such as fruit weight, vitamin C, and total phenolics compared to inorganic fertilizers.

Ullah *et al*. (2020) investigated the response of capsicum to different levels of organic and inorganic fertilizers under tunnel farming. They observed that the application of organic fertilizers significantly increased yield and quality parameters such as vitamin C and total phenolics compared to inorganic fertilizers. Combined application of organic and inorganic fertilizers showed higher growth performance such as plant height, leaves per plant, branches per plant, and yield parameters such as number of fruits per plant and yield per ha compared to organic or inorganic fertilizers alone.

Rezaei-Chiyaneh *et al*. (2019) conducted a study on the effect of organic and inorganic fertilizers on the growth, yield, and essential oil content of *Capsicum annuum,* L. under drought stress. Results showed that the application of organic fertilizers significantly increased plant height, fruit weight,fruit yield and essential oil content compared to inorganic fertilizers.

Shah *et al*. (2019) carried out a study aimed to determine the effect of organic and inorganic fertilizers on the growth, yield, and fruit quality of capsicum under plastic tunnel cultivation. Results indicated that the application of organic fertilizers significantly increased yield and quality parameters such as fruit weight, vitamin C, and total phenolics compared to inorganic fertilizers.

Ali *et al*. (2019) evaluated the comparative efficacy of organic and inorganic fertilizers on the yield and quality of capsicum. Results showed that the application of organic fertilizers significantly increased yield and quality parameters such as fruit weight, vitamin C, and total phenolics compared to inorganic fertilizers.

Bano *et al*. (2019) carried out a study to evaluate the growth, yield, and nutrient content of capsicum as influenced by different sources of organic and inorganic fertilizers. Results showed that the combined application of organic and inorganic fertilizers significantly increased fruit length, fruit diameter, yield per plant, and nutrient content compared to inorganic fertilizers or control.

Kumari *et al*. (2019) compared the effect of organic and inorganic fertilizers on the growth, yield, and quality of capsicum. Results showed that the application of organic fertilizers significantly increased yield and quality parameters such as vitamin C and total phenolics compared to inorganic fertilizers.

Abbas *et al*. (2019) investigated the impact of organic and inorganic fertilizers on the yield and nutrient uptake of capsicum under subtropical conditions. Results showed that the application of organic fertilizers significantly increased yield and nutrient uptake compared to inorganic fertilizers.

Zia-Ul-Haq *et al*. (2018) carried out a study to determine the impact of organic and inorganic fertilizers on the nutritional quality of capsicum. Results showed that the application of organic fertilizers significantly increased the nutritional quality parameters such as total phenolics, vitamin C, and antioxidant activity compared to inorganic fertilizers.

Islam *et al*. (2017) conducted a field experiment on sweet pepper for yield and quality of fruits using different types of organic and inorganic fertilizers. Inorganic and organic fertilizers treatments were tested on California variety of sweet pepper. The fertilization treatments were T_1 (Urea + TSP + MOP): (260 + 120 + 124) kg/ha; T_2 (Cowdung: 9 t/ha); T_3 (Poultry manure: 7 t/ha); T_4 (Urea + cowdung): (195 kg +2.5 t/ha); T_5 (Urea + poultry manure): (180 kg + 2 t/ha); T_6 (Urea + cowdung): (130 kg + 4.5 t/ha); T_7 (Urea + poultry manure): (140 kg +3 t/ha); T_8(Control: no manure and fertilizer). Obtained results showed that urea with cowdung (130kg + 4 t/ha) (T_6), increased sweet pepper production. Combined application of urea with cowdung showed a significant increase in leaves number per plant (174), leaf area (48.6 cm^2), root/canopy (15.2%), Plant fresh weight (378.5 g), No. of fruits/plant (16.6), fruit length (9.9 cm), fruit diameter (5.8 cm), Average green fruit weight (142.1 g), Average dry fruit weight (84.6 g), yield/replicate (38.5 kg), no. of branching (10.6). Urea with cowdung influenced the total yield per replicate and extended the period of pepper fruit production compared to other treatments.

Ahsan (2017) carried out a study on the influence of different organic and inorganic fertilizers on the growth, yield, and nutrient uptake of capsicum. This study investigated the influence of different organic and inorganic fertilizers on the growth, yield, and nutrient uptake of capsicum. Results showed that the application of organic fertilizers increased yield and nutrient uptake compared to inorganic fertilizers.

Alam *et al*. (2016) investigated the effect of integrated nutrient management on the yield and quality of sweet pepper. There were six treatments: T_1 = 100% recommended dose (RD) ($N_{115}P_{70}K_{125}S_{20}Zn_2$ kg/ha), T_2 = 75% RD + 5 t/ha cowdung (CD), T_3 = 75% RD + 5 t/ha CD Slurry, T_4 = 75% RD + 3 t/ha poultry manure (PM), T_5 = 75% RD + 3 t/ha PM Slurry, T_6 = Native fertility. The tested variety was BARI Misti Morich-1. The experiment was laid out in randomized complete block design with 3 replications. Results revealed that the T_5 (75% RD+ 3 t/ha PM Slurry) produced the highest fruit yield (25.29 and 23.55 t/ha) and the lowest yield (16.34 and 17.10 t/ha) was in control treatment (native fertility). An inclusion of 3 t PM Slurry/ha with 75% RD can reduce 25% of chemical fertilizer. Integrated use of PM Slurry at the rate of 3 t/ha with 75% RD was found as the best combination in respect of sweet pepper yield and probable of enriching the soil organic matter.

Aguoru *et al*. (2015) carried out an experiment to compare the efficacy of cowdung and NPK fertilizer on the growth of cowpea (*Vigna unguiculata*), soybean (*Glycine max*), tomato (*Lycopersicon esculentum*) and pepper (*Capsicum frutescens*). The treatments examined were 150 g of cowdung, 130 g of cowdung, and 25 g of NPK. For all experimental plants, cowpea under 150 g cowdung treatments responded best, followed by 130 g of cowdung. Soybean performance was enhanced by 150 g and 130g cowdung while its least weight was recorded under NPK treatment. Tomato to which NPK soil was applied recorded the highest plant weight with the least value recorded under 130 g and 150 g cowdung soil treatment. The performance of pepper was significantly low for all treatments. Therefore, cowdung has proven effective on the growth of cowpea, soybean, tomato, and pepper. The implications of the findings in this work to agricultural enhancement in Nigeria and generally are discussed.

Shahein *et al*. (2015) conducted a plastic house experiment during the two successive seasons of 2013/2014 and 2014/2015. This study aims to evaluate the organic production of two hybrids of sweet (bell) pepper using different sources of organic fertilizers under plastic house conditions. Five sources of organic fertilizers (quail, turkey chicken, rabbit manures and compost) as recommended dose of nitrogen for sweet pepper were investigated on vegetative growth, nutritional content, yield component, and fruit quality of two hybrids of sweet pepper (Bunjii red fruit and Shunghi yellow fruit). Obtained results showed that using compost produced the highest values of plant height, N% of bell pepper plants, as well as the maximum early, total yield and fruit length. Applying compost and chicken manure produced the highest values of fruit weight, total soluble sold and vitamin C content of pepper fruits. Compost, chicken and turkey manure treatments gave the maximum number of leaves per plant and chlorophyll reading of pepper leaves, percent of P and K in plants, fruit diameter and number of fruits/plant. There were no significant differences among all organic fertilizer treatments in firmness of pepper fruits. Generally, Bunjii hybrid was superior in the most of tested parameters compared to Shunghi hybrid of pepper.

Kacha *et al.* (2007) studied the effects of levels of spacing (60 ×60 and 90 × 60 cm), castor *(Ricinus emnunis).* cake (0 and 1 t/ha) and N (100. 150, 200 and 250 kg/ha) on the green fruit yield of green chilli (*C. annuum*) on a loamy sand soil. Transplanting chilli at the narrow spacing of 60 × 60 cm significantly decreased the number of secondary branches, green fruits per plant, plant height and green fruit yield compared to the wider spacing of 90 × 60 cm. Application of N at 150 kg/ha significantly increased the growth, yield, and yield components compared to the control; on the other hand, it was at par with the 200 and 250 kg/ha treatments. Transplanting chili at 60 × 60 cm spacing, and applying castor cake at 1.0 t/ha including 150 kg N t/ha (*Capsicum annuum* L.) increased the green fruit yield.

Hari *et al*. (2006) recommended the effects of nitrogen rate (50. 75 and 100%). In combination with neem cake (1 and 2 t/ha), poultry manure (5 and 10 t/ha) and sheep manure (6 and 12 t/ha) on the yield and nutrient uptake of paprika (*C. annum*) were determined in a field experiment conducted during the kharif season of 1998-2000. Application neem cake at 2 t/ha in combination with 75% recommended nitrogen rate resulted in the highest dry pod yield (4.078 g), dry plant weight (141.67 g), N uptake (168.43 kg/ha) and K uptake (177.80 kg/ha. Whereas application of poultry manure at 10 t/ha in combination with 75% recommended nitrogen fertilizer resulted in the highest P uptake (42.17 kg/ha) of the plant.

Ghoname *et al.* (2005) studied on the effects of different N fertilizer sources, i.e., organic (chicken manure at 4 and 8 cm^3), mineral (100-75-50 kg NPK/ha) and biofertilizer (rhizobacteria as commercial product called Microbin at 2 kg/greenhouse) on the growth and productivity of sweet pepper (C annum) grown on a sandy soil in a greenhouse. Application of organic fertilizer combined with bio fertilizer and mineral N resulted in vigorous plants growth, expressed as plant length, number of leaves and stems as well as shoots dry weight. In addition, it recorded the best values for total acidity, vitamin C content, total soluble solids percentage, dry matter and N, P, K, Fe, Mn, Zn, Cu, Ni and P contents of fruits.

CHAPTER III

MATERIALS AND METHODS

The experiment was carried out at the experimental field under the Department of Agricultural Chemistry of Sher-e-Bangla Agricultural University, Dhaka during November 2021 to March 2022 to study the effects of organic and inorganic fertilizers on growth, yield and nutrients content of capsicum (*Capsicum annuum,* L.). Details of different materials used and methodologies followed to conduct the experiments presented in this chapter.

3.1 Site description

The experiment was conducted at the Sher-e-Bangla Agricultural University research field, Dhaka, under the Agro-ecological zone of Modhupur Tract, AEZ-28. The land area is situated at 23°41´ N latitude and 90°22´ E longitude at an altitude of 8.6 meter above sea level. The experimental site is shown in the AEZ Map of Bangladesh in Appendix I.

3.2 Climate

The experimental area is under the sub-tropical climate that is characterized by high temperature, high humidity and heavy rainfall with occasional gusty winds in kharif season (April-September) and less rainfall associated with moderately low temperature during the Rabi season (October-March). The weather data during the study period of the experimental site is shown in Appendix II.

3.3 Soil

The farm belongs to the general soil type, shallow red brown terrace soils under Tejgaon Series. Top soils were clay loam in texture, olive-gray with common fine to 20 medium distinct dark yellowish-brown mottles. The experimental area was flat having available irrigation and drainage system. The land was above flood level and sufficient sunshine was available during the experimental period. Soil samples from 0-15 cm depths were collected from experimental field. The analyses were done by Soil Resources and Development Institute (SRDI), Dhaka. The physicochemical properties of the soil are presented in Appendix III.

3.4 Treatments

Single factor experiment consisting eight treatments of organic and inorganic fertilizers combinations including control was considered for the present study which is as follows:

1. T_0 = Control
2. T_1 = Recommended doses (RD) of inorganic fertilizer (Urea = 250 kg ha^{-1}, TSP = 350 kg ha^{-1}, MoP = 250 kg ha^{-1}, Gypsum – 110 kg ha^{-1}, ZnO = 5 kg ha^{-1})
3. T_2 = Vermicompost (only) - 3.5 t ha^{-1}
4. T_3 = Poultry manure (only) - 8 t ha^{-1}
5. T_4 = 50% vermicompost + 50% inorganic fertilizer
6. T_5 =25% vermicompost + 75% inorganic fertilizer
7. T_6 =50% poultry manure + 50% inorganic fertilizer
8. T_7 = 25% poultry manure + 75% inorganic fertilizer

3.5 Plant material and collection of seeds

The capsicum variety ASTHA F1 was used as plant materials for the present study. The seeds of this variety were collected from ACI Seed, Tejgaon, Dhaka, Bangladesh.

3.6 Experimental design and layout

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The layout of the experiment was prepared for distributing the treatments assigned. The 8 treatments of the experiment were assigned at random into 24 plots. The size of each unit plot 2 m × 1m (= 2 m^2). The distance between block to block and plot to plot were 0.5 m and 0.5 m respectively. The layout of the experiment field is presented in Figure 1.

3.7 Raising of seedlings

The land selected for nursery bed was well drained and sandy loam type soil. The area was well prepared and converted into loose friable and dried mass to obtain fine tilth. All weeds and dead roots were removed and the soil was mixed with well rotten cowdung at the rate of 5 kg/bed. Seed bed size was 3m × 1m raised above the ground level. One bed was prepared for raising the seedlings. Five (5) grams of seeds were sown in the seed bed on 5 November, 2021. After sowing, the seeds were covered with light soil. Complete germination of the seeds took place with 5 days after seed sowing. Necessary shading was made by bamboo mat (chatai) from scorching sunshine or rain. No chemical fertilizer was used in the seed bed.

3.8 Preparation of the main field

The plot selected for the experiment was opened in the first week of December, 2021 with a power tiller, and was exposed to the sun for a few days, after, which the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilth. Weeds and stubble were removed and finally obtained a desirable tilth of soil for transplanting the seedlings. The land operation was completed on 5 December, 2021. The individual plots were made by making ridges (20 cm high) around each plot to restrict lateral runoff of irrigation water.

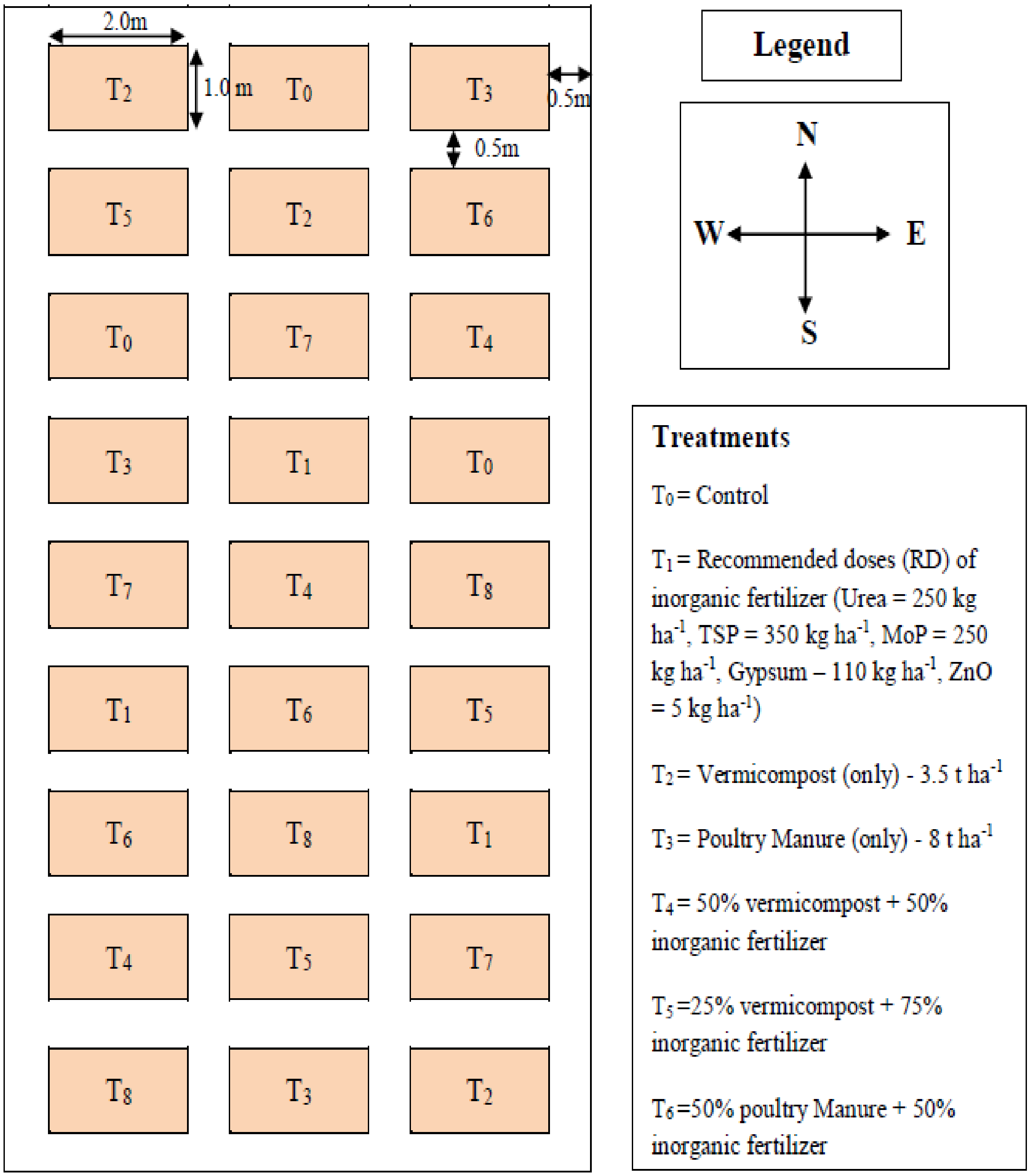

Figure 1. Layout of the experimental plot

3.9 Fertilizer application

The N, P, K, Zn and S fertilizer were applied through urea, TSP, MoP, ZnO and Gypsum, respectively. Vermicompost and poultry manure also used as organic manures.

The following doses of fertilizer were applied as recommended doses for cultivation of crop.

Fertilizer	Recommended doses (ha^{-1})
Vermicompost	3.5 t
Poultry manure	8 t
Urea	250 kg
TSP	350 kg
MoP	250 kg
ZnO	5 kg
Gypsum	110 kg

One third (1/3) of whole amount of Urea and full amount of TSP, MoP, Gypsum and ZnO were applied at the time of final land preparation. The remaining Urea was top dressed in two equal installments- at 25 days after transplanting (DAT) and 50 DAT respectively.

3.10 Transplanting of seedlings

Healthy and uniform sized 30 days old seedlings were taken separately from the seed bed and were transplanted in the experimental field on 5 December, 2021. The seed bed was watered before uprooting the seedlings so as to minimize the damage of the roots. This operation was carried out during late hours of the day i.e.in the evening. The seedlings were watered after transplanting. Shading was provided by piece of banana leaf sheath for three days to protect the seedlings from the direct sun. A strip of the same crop was established around the experimental field as border crop to do gap filling and to check the border effect.

3.11 Intercultural operation

After establishment of seedlings, various intercultural operations were accomplished for better growth and development of the capsicum.

3.11.1 Gap filling and weeding

When the seedlings were established, the soil around the base of each seedling was pulverized. A few gaps filling was done by healthy plants from the border whenever it was required. Weeds of different types were controlled manually as and when necessary.

3.11.2 Irrigation

Irrigation was done at three times. The first irrigation was given in the field at 25 days after transplanting (DAT) through irrigation channel. The second irrigation was given at the stage of maximum vegetative growth stage (35 DAT). The final irrigation was given at the stage of fruit formation (50 DAT).

3.11.3 Plant protection

The crop was infested with cutworm, leaf hopper and others. The insects were controlled successfully by spraying Malathion 57 EC @ 2ml /L water. The insecticide was sprayed fortnightly from a week after transplanting to a week before first harvesting. During foggy weather precautionary measures against fungal diseases of capsicum was taken by spraying Dithane M-45 @ 2 g/L.

3.12 Harvesting and cleaning

Fruits were harvested at 7 days intervals during maturity to ripening stage. Harvesting was started from 5 March, 2022 and completed by 28 March, 2022.

3.13 Data collection

Five plants were selected randomly from each unit plot for recording data on crop parameters and the yield of capsicum fruitswere taken plot wise. The following parameters were recorded during the study:

3.13.1 Growth parameters

1. Plant height (cm)
2. Number of leaves plant^{-1}
3. Number of branches plant^{-1}

3.13.2 Yield contributing parameters

1. Number of flowers plant^{-1}
2. Number of fruits plant^{-1}
3. Fruit length (mm)
4. Fruit diameter (mm)
5. Individual fruit weight (g)

3.13.3 Yield parameters

1. Number of fruits plot^{-1}
2. Yield plot^{-1} (g)
3. Yield (t ha^{-1})

3.13.4 Nutrient content of capsicum fruit

1. Nitrogen (N)
2. Phosphorus(P)
3. Potassium(K)

3.14 Procedures of recording data

A brief outline of the data recording procedure is given below:

Plant height (cm)

The height of plant was recorded in centimeter (cm) at different days after transplanting of crop duration. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot. The height was measured from the ground level to the tip of the leaves. Data was taken at 30, 60 DAT and at the time of final harvest.

Number of leaves plant^{-1}

Number of leaves plant^{-1} was counted at different days after sowing of crop duration. Leaves number plant^{-1} was recorded from pre-selected 5 plants by counting all leaves from each plot and mean was calculated. Data were taken at 30, 60 DAT and at the time of final harvest.

Number of branches per plant

At different days after transplanting (DAT) i.e., at 30, 60 DAT and at the time of final harvest, all the primary branches were counted from 5 plants of each plot and their average value was taken as number of branches per plant.

Number of flowers plant^{-1}

Number of flowers was counted from 5 selected plants from 1st to last harvest and average number was calculated as number of flowers per plant. Data were taken at 60, 100 and 125 DAT.

Number of fruits plant^{-1}

Total fruit number was counted from 5 selected plants from 1st to last harvest and average number was calculated as number of fruits per plant.

Fruit length

The length of the fruit was measured with a digital slide caliper in millimeter from the neck of the fruit to the bottom of the fruit. It was measured from each plot and their average was calculated in centimeter.

Fruit diameter

Breadth of the fruits were measured at the middle portion of 5 randomly selected marketable fruits from each plot with the digital slide calipers in millimeter and their average was taken as the diameter of the fruits.

Individual fruit weight

Average individual fruit weight (g) was measured from weighing of 10 randomly selected marketable fruits from each plot with the digital balance and their average was taken as the individual fruit weight.

Number of fruits plot^{-1}

It was measured by totaling of fruit number from 5 selected plants from each unit plot during the period from first to final harvest and then it converted to number of fruits per plot.

Fruit yield plot^{-1}

At first a digital balance was used to take the weight of fruits per plot measured each unit plot during the period from first to final harvest and then it converted to per plot yield and was expressed in gram.

Fruit yield ha^{-1}

To calculate fruit yield (t ha^{-1}); at first per plot yield was measured. After collection of per plot yield, it was converted to ton per hectare (t ha^{-1}) by the following formula:

$$\text{Fruit yield (t ha}^{-1}) = \frac{\text{Fruit yield per plot (kg)} \times 10000 \text{ m}^2}{\text{Plot size (m}^2) \times 1\,000 \text{ kg}}$$

3.15Chemical analysis of capsicum fruit samples

a) Digestion of samples with sulphuric acid for N

Nitrogen was determined by the procedure of Jackson, 1973. For the determination of nitrogen, an amount of 1 g raw capsicum fruit samples were taken in a micro Kjeldahl flask. 1.1 g catalyst mixture (K_2SO_4: $CuSO_4$ $5H_2O$: Se in the ratio of 100: 10: 1), and 10 mL conc. H_2SO_4 were added. The flasks were heated at 1600 ^{0}C and added 2 mL H_2O_2 then heating was continued at 3600 ^{0}C until the digests become clear and colorless. After cooling, the content was taken into a 100 mL volumetric flask and the volume was made up to the mark with de-ionized water. A reagent blank was prepared in a similar manner. Nitrogen in the digest was estimated by distilling the digest with 10 N NaOH followed by titration of the distillate trapped in H_3BO_3 indicator solution with 0.01N H_2SO_4.

The amount of N was calculated using the following formula:

$$\% N = (T-B) \times N \times 0.014 \times 100 / S$$

Where,

T = Sample titration (ml) value of standard H_2SO_4

B = Blank titration (ml) value of standard H_2SO_4

N = Strength of H_2SO_4

S = Sample weight in gram

b) Digestion of plant samples

An amount of 0.5 g of sample was taken into a dry clean 100 mL Kjeldahl flask, 10 mL of di-acid mixture (HNO_3, $HClO_4$ in the ratio of 2:1) was added and kept for few minutes (Jackson, 1973). Then the flask was heated at a temperature rising slowly to 200^0C. Heating was instantly stopped as soon as the dense white fumes of $HClO_4$ occurred and after cooling digested sample was filtered in a volumetric flask and add distilled water up to 100 mL. This digest was used for determining P, K.

c) Determination of elements in the digest

In the digest potassium concentration was determined directly by flame photometer. In the digest phosphorus concentrations was estimated by a spectrophotometer.

3.16 Statistical analysis

Collected data from the experiment field were statistically analyzed to find out the significant difference among the treatment by using the MSTAT-C computer package program. The mean values of all the characters were calculated and analysis of variance was performed. The significance of the difference among the treatments means was estimated by the Least Significant Difference Test (LSD) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

This study was conducted to explore the effects of organic and inorganic fertilizers on growth, yield, and nutrients content of capsicum (*Capsicum annuum* L.). Data were collected on different growth, yield and yield contributing parameters and present in this chapter through different Tables and Graph. The results and discussions and also possible interpretations have been given under the following headings:

4.1 Growth parameters

4.1.1 Plant height

Different doses of organic and inorganic fertilizers combinations showed significant influence on plant height of capsicum at different growth stages except at 30 DAT (Table 1 and Appendix IV). However, at 30 days after transplanting (DAT), the maximum capsicum plant height (24.73 cm) was recorded from the treatment T_5 (25% vermicompost + 75% inorganic fertilizer of RD) whereas the treatment T_0 (control) showed the minimum plant height (21.73 cm). Again, at 60 DAT, the maximum plant height (40.93 cm) was recorded from the treatment T_5 (25% vermicompost + 75% inorganic fertilizer of RD) which was statistically similar with the treatment T_1 (Recommended doses; RD of inorganic fertilizer), T_4 (50% vermicompost + 50% inorganic fertilizer of RD), T_6 (50% poultry manure + 50% inorganic fertilizer of RD) and T_7 (25% poultry manure + 75% inorganic fertilizer of RD). The minimum plant height at 60 DAT was recorded from the treatment T_0 (control) (33.47 cm) that was statistically similar to the treatment T_2 (Vermicompost - 3.5 t ha^{-1}) and T_3 (Poultry manure - 8 t ha^{-1}).

Table 1. Effect of organic and inorganic fertilizers on plant height of capsicum at different growth stages

Treatments	Plant height (cm)		
	30 DAT	60 DAT	Final harvest
T_0	21.73	33.47 c	41.40 c
T_1	24.40	38.13 ab	50.20 ab
T_2	23.87	35.60 bc	42.67 c
T_3	22.87	35.33 bc	43.47 c
T_4	23.20	40.33 a	48.00 b
T_5	24.73	40.93 a	51.93 a
T_6	23.13	37.47 ab	47.80 b
T_7	23.80	40.27 a	50.17 ab
$LSD_{0.05}$	3.462^{NS}	3.700	2.433
CV (%)	8.42	9.37	12.96

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

Here,

DAT = Days after transplanting

T_0 = Control

T_1 = Recommended doses (RD) of inorganic fertilizer (Urea = 250 kg ha^{-1}, TSP = 350 kg ha^{-1}, MoP = 250 kg ha^{-1}, Gypsum – 110 kg ha^{-1}, ZnO = 5 kg ha^{-1})

T_2 = Vermicompost (only) - 3.5 t ha^{-1}

T_3 = Poultry manure (only) - 8 t ha^{-1}

T_4 = 50% vermicompost + 50% inorganic fertilizer

T_5 =25% vermicompost + 75% inorganic fertilizer

T_6 =50% poultry manure + 50% inorganic fertilizer

T_7 = 25% poultry manure + 75% inorganic fertilizer

At the time of final harvest, the maximum plant height (51.93 cm) was recorded from the treatment T_5 (25% vermicompost + 75% inorganic fertilizer of RD) that was statistically similar to the treatment T_1 (Recommended doses; RD of inorganic fertilizer) and T_7 (25% poultry manure + 75% inorganic fertilizer of RD) whereas the treatment T_0 (control) showed the minimum plant height (41.40 cm) that was statistically identical to the treatment T_2 (Vermicompost - 3.5 t ha^{-1}) and T_3 (Poultry manure - 8 t ha^{-1}). Ahmed *et al*. (2020) reported that organic and inorganic fertilizers significantly increased plant height compared to control which supported the present study. Similar result was also observed by Rezaei-Chiyaneh *et al*. (2019) and Ullah *et al*. (2020).

4.1.2 Number of leaves plant^{-1}

Application of different doses of organic and inorganic fertilizers combinations to capsicum showed significant influence on number of leaves plant^{-1} at different growth stages (Table 2 and Appendix V). Results revealed that at 30 DAT, the treatment T_4 (50% vermicompost + 50% inorganic fertilizer of RD) showed the highest number of leaves plant^{-1} (17.94)whereas the lowest number of leaves plant^{-1} (10.93) was found from the control treatment T_0 (no nutrient application) which was similar to the treatment T_1 (Recommended doses; RD of inorganic fertilizer), T_2 (Vermicompost - 3.5 t ha^{-1}), T_3 (Poultry manure - 8 t ha^{-1}) and T_6 (50% poultry manure + 50% inorganic fertilizer of RD). Similarly, at 60 DAT, the treatment T_4 (50% vermicompost + 50% inorganic fertilizer of RD) gave the highest number of leaves plant^{-1} (49.20) which was statistically identical with the T_1 (Recommended doses; RD of inorganic fertilizer) whereas control treatment T_0 (no nutrient application) gave the the lowest number of leaves plant^{-1} (38.33) which was statistically similar to the treatment T_2 (Vermicompost - 3.5 t ha^{-1}) and T_5 (25% vermicompost + 75% inorganic fertilizer of RD).

Table 2. Effect of organic and inorganic fertilizers on number of leaves plant^{-1} of capsicum at different growth stages

Treatments	Number of leaves plant^{-1}		
	30 DAT	60 DAT	Final harvest
T_0	10.93 c	38.33 d	41.60 c
T_1	13.73 bc	48.73 a	49.67 a
T_2	12.80 bc	40.33 cd	43.27 bc
T_3	13.87 bc	43.20 bc	46.20 b
T_4	17.94 a	49.20 a	52.07 a
T_5	14.40 b	40.67 cd	44.73 bc
T_6	13.67 bc	42.27 bc	50.33 a
T_7	14.53 b	44.93 b	51.27 a
$LSD_{0.05}$	3.006	3.164	3.312
CV (%)	10.16	13.47	8.94

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

Here,

DAT = Days after transplanting

T_0 = Control

T_1 = Recommended doses (RD) of inorganic fertilizer (Urea = 250 kg ha^{-1}, TSP = 350 kg ha^{-1}, MoP = 250 kg ha^{-1}, Gypsum – 110 kg ha^{-1}, ZnO = 5 kg ha^{-1})

T_2 = Vermicompost (only) - 3.5 t ha^{-1}

T_3 = Poultry manure (only) - 8 t ha^{-1}

T_4 = 50% vermicompost + 50% inorganic fertilizer

T_5 =25% vermicompost + 75% inorganic fertilizer

T_6 =50% poultry manure + 50% inorganic fertilizer

T_7 = 25% poultry manure + 75% inorganic fertilizer

Again, at the time of final harvest, the highest number of leaves plant^{-1} (52.07) was also achieved from the treatment T_4 (50% vermicompost + 50% inorganic fertilizer of RD) which was statistically identical to the treatmentT_1 (Recommended doses; RD of inorganic fertilizer), T_6 (50% poultry Manure + 50% inorganic fertilizer of RD) and T_7 (25% poultry manure + 75% inorganic fertilizer of RD) whereas the lowest number of leaves plant^{-1} (41.60) was found from the control treatment T_0 (no nutrient application) which was statistically similar with the treatment T_2 (Vermicompost - 3.5 t ha^{-1}) and T_5 (25% vermicompost + 75% inorganic fertilizer of RD). Saeed *et al*. (2020) and Ullah *et al*. (2020) reported that combined application of organic and inorganic fertilizer significantly increased number of leaves compared to inorganic fertilizers and organic fertilizers which supported the present study.

4.1.3 Number of branches plant^{-1}

Application of different doses of organic and inorganic fertilizers combinations to capsicum showed significant influence on number of branches plant^{-1} at different growth stages except at 30 DAT (Table 3 and Appendix VI). Results revealed that at 60 DAT, the treatment T_4 (50% vermicompost + 50% inorganic fertilizer of RD) showed the highest number of branches plant^{-1} (8.07) whereas the lowest number of branches plant^{-1} (5.73) was found from the treatment T_3 (Poultry manure - 8 t ha^{-1}) which was statistically identical to the treatment T_0 (control) and T_2 (Vermicompost - 3.5 t ha^{-1}). Similarly, at the time of final harvest, the highest number of branches plant^{-1} (9.47) was also achieved from the treatment T_4 (50% vermicompost + 50% inorganic fertilizer of RD) which was statistically similar to the treatment T_5 (25% vermicompost + 75% inorganic fertilizer of RD) whereas the lowest number of branches plant^{-1} (7.53) was found from the treatment T_3 (Poultry manure - 8 t ha^{-1}) which was statistically identical with the treatment T_0 (control). Supported result was also observed by Ullah *et al*. (2020); they found significantly higher number of branches per plant with combined application of organic and inorganic fertilizer compared to organic or inorganic fertilizer.

Table 3. Effect of organic and inorganic fertilizers on number of branches plant^{-1} of capsicum at different growth stages

Treatments	Number of branches plant^{-1}		
	30 DAT	60 DAT	Final harvest
T_0	0.00	5.87 c	7.60 c
T_1	0.27	6.47 bc	8.20 bc
T_2	0.27	5.87 c	8.07 bc
T_3	0.20	5.73 c	7.53 c
T_4	0.47	8.07 a	9.47 a
T_5	0.60	6.53 bc	8.73 ab
T_6	0.20	6.00 bc	7.93 bc
T_7	0.40	6.73 b	8.27 bc
$LSD_{0.05}$	1.257^{NS}	0.844	0.801
CV (%)	12.83	8.67	12.81

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

Here,

DAT = Days after transplanting

T_0 = Control

T_1 = Recommended doses (RD) of inorganic fertilizer (Urea = 250 kg ha^{-1}, TSP = 350 kg ha^{-1}, MoP = 250 kg ha^{-1}, Gypsum – 110 kg ha^{-1}, ZnO = 5 kg ha^{-1})

T_2 = Vermicompost (only) - 3.5 t ha^{-1}

T_3 = Poultry manure (only) - 8 t ha^{-1}

T_4 = 50% vermicompost + 50% inorganic fertilizer

T_5 =25% vermicompost + 75% inorganic fertilizer

T_6 =50% poultry manure + 50% inorganic fertilizer

T_7 = 25% poultry manure + 75% inorganic fertilizer

4.2 Yield contributing parameters

4.2.1 Number of flowers plant^{-1}

Number of flowers plant^{-1} of capsicum differed significantly due to different doses of organic and inorganic fertilizers combinations (Table 4 and Appendix VII). It was observed that at 60 DAT, the treatment T_4 (50% vermicompost + 50% inorganic fertilizer of RD) gave the highest number of flowers plant^{-1} (3.00) which differed significantly to other treatments followed by T_5 (25% vermicompost + 75% inorganic fertilizer of RD), T_6 (50% poultry manure + 50% inorganic fertilizer of RD) and T_7 (25% poultry manure + 75% inorganic fertilizer of RD) whereas treatment T_0 (control) showed the lowest number of flowers plant^{-1} (2.10). At 100 DAT, the highest number of flowers plant^{-1} (6.13) was recorded from the treatment T_4 (50% vermicompost + 50% inorganic fertilizer of RD) that was statistically identical to the treatment T_5 (25% vermicompost + 75% inorganic fertilizer of RD) and T_7 (25% poultry manure + 75% inorganic fertilizer of RD) but the control treatment T_0 showed the lowest number of flowers plant^{-1} (5.20) which was statistically identical to the treatment T_1 (Recommended doses; RD of inorganic fertilizer) and T_3 (Poultry manure - 8 t ha^{-1}). At 125 DAT, highest number of flowers plant^{-1} (2.40) was also recorded from the treatment T_4 (50% vermicompost + 50% inorganic fertilizer of RD) that was statistically identical to the treatment T_5 (25% vermicompost + 75% inorganic fertilizer of RD) and T_7 (25% poultry manure + 75% inorganic fertilizer of RD) whereas the lowest number of flowers plant^{-1} (0.70) was recorded from the control treatment T_0 (no nutrient application) that was significantly different from other treatments. Similar result was also observed by Ahmed *et al*. (2020) and Hussain *et al*. (2021); they reported higher number of flowers obtained from organic fertilizers combined with inorganic fertilizers compared to control or inorganic fertilizers.

Table 4. Effect of organic and inorganic fertilizers on number of flowers plant^{-1} of capsicum at different growth stages

Treatments	Number of flowers plant^{-1}		
	60 DAT	100 DAT	125 DAT
T_0	2.10 d	5.20 d	0.70 d
T_1	2.33 c	5.33 d	2.00 b
T_2	2.33 c	5.50 c	1.33 c
T_3	2.33 c	5.33 d	1.33 c
T_4	3.00 a	6.13 a	2.40 a
T_5	2.67 b	6.10 a	2.36 a
T_6	2.50 b	5.80 b	2.10 b
T_7	2.50 b	6.00 a	2.33 a
$LSD_{0.05}$	0.102	0.152	0.124
CV (%)	6.34	9.22	12.47

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

Here,

DAT = Days after transplanting

T_0 = Control

T_1 = Recommended doses (RD) of inorganic fertilizer (Urea = 250 kg ha^{-1}, TSP = 350 kg ha^{-1}, MoP = 250 kg ha^{-1}, Gypsum – 110 kg ha^{-1}, ZnO = 5 kg ha^{-1})

T_2 = Vermicompost (only) - 3.5 t ha^{-1}

T_3 = Poultry manure (only) - 8 t ha^{-1}

T_4 = 50% vermicompost + 50% inorganic fertilizer

T_5 =25% vermicompost + 75% inorganic fertilizer

T_6 =50% poultry manure + 50% inorganic fertilizer

T_7 = 25% poultry manure + 75% inorganic fertilizer

4.2.2 Total number of flowers plant^{-1}

Application of organic and inorganic fertilizers combinations applied to capsicum showed significant variation on total number of flowers plant^{-1} (Table 5 and Appendix VIII). The treatment T_4 (50% vermicompost + 50% inorganic fertilizer of RD) gave the highest total number of flowers plant^{-1} (11.53) which was statistically similar to the treatmentT_5 (25% vermicompost + 75% inorganic fertilizer of RD), T_6 (50% poultry manure + 50% inorganic fertilizer of RD) and T_7 (25% poultry manure + 75% inorganic fertilizer of RD) whereas the control treatment T_0 (no nutrient application) showed the lowest total number of flowers plant^{-1} (8.00) which was statistically similar to T_2 (Vermicompost - 3.5 t ha^{-1}) and T_3 (Poultry manure - 8 t ha^{-1}). Similar result was also observed by Ahmed *et al*. (2020) and Hussain *et al*. (2021).

4.2.3 Number of fruits plant^{-1}

Number of fruits plant^{-1}of capsicum differed significantly due to different doses of organic and inorganic fertilizers combinations (Table 5 and Appendix VIII). It was observed that the highest number of fruits plant^{-1}(8.41) was given by the treatment T_4 (50% vermicompost + 50% inorganic fertilizer of RD) which was statistically identical to the treatment T_5 (25% vermicompost + 75% inorganic fertilizer of RD), T_6 (50% poultry manure + 50% inorganic fertilizer of RD) and T_7 (25% poultry manure + 75% inorganic fertilizer of RD). The lowest number of fruits plant^{-1}(4.00) was registered by the control treatment T_0 (no nutrient application) which was statistically similar to the treatment T_3 (Poultry manure - 8 t ha^{-1}). This result was in agreed with the findings of Hussain *et al*. (2021), Saeed *et al*. (2020) and Ullah *et al*. (2020); they reported that combined application of organic and inorganic fertilizers resulted higher fruit yield per plant compared to organic or inorganic fertilizers alone.

4.2.4 Fruit length

Different levels of organic and inorganic fertilizers combinations showed significant variation on fruit length (Table 5 and Appendix VIII). Results indicated that the treatment T_4 (50% vermicompost + 50% inorganic fertilizer of RD) gave the highest fruit length (89.93 mm) which was statistically similar to T_5 (25% vermicompost + 75% inorganic fertilizer of RD), T_6 (50% poultry manure + 50% inorganic fertilizer of RD) and T_7 (25% poultry manure + 75% inorganic fertilizer of RD). The lowest fruit length (82.53 mm) was recorded from the control treatment T_0 (no nutrient application) which was statistically similar with T_2 (Vermicompost - 3.5 t ha^{-1}) and T_3 (Poultry manure - 8 t ha^{-1}) treatments. Similar result was also observed by the findings of Bano *et al*. (2019) who reported higher fruit length from combined application of organic and inorganic fertilizers compared to inorganic fertilizers or control treatment.

4.2.5 Fruit diameter

Fruit diameter differed significantly due to different levels of organic and inorganic fertilizers combinations (Table 5 and Appendix VIII). Results showed that the treatment T_4 (50% vermicompost + 50% inorganic fertilizer of RD) gave the highest fruit diameter (67.27 mm) which was statistically similar to T_5 (25% vermicompost + 75% inorganic fertilizer of RD) and T_6 (50% poultry manure + 50% inorganic fertilizer of RD). The lowest fruit diameter (59.07 mm) was recorded from the control treatment T_0 (no nutrient application) which differed significantly to other treatments. Bano *et al*. (2019) reported higher fruit diameter from combined application of organic and inorganic fertilizers compared to inorganic fertilizers or control treatment which supported the present study.

Table 5. Effect of organic and inorganic fertilizer on yield contributing parameters of capsicum

Treatments	Yield contributing parameters				
	Total number of flowers plant^{-1}	Number of fruits plant^{-1}	Fruit length (mm)	Fruit diameter (mm)	Individual fruit weight (g)
T_0	8.00 d	4.00 d	82.53 c	59.07 c	72.13 d
T_1	9.67 bc	7.50 ab	85.40 bc	62.93 b	80.56 c
T_2	9.13 cd	6.00 bc	84.80 c	62.80 b	80.27 c
T_3	9.00 cd	5.29 cd	83.33 c	62.53 b	78.05 c
T_4	11.53 a	8.71 a	89.93 a	67.27 a	94.85 a
T_5	11.13 a	8.13 a	88.47 a	64.67 ab	93.53 a
T_6	10.40 ab	7.84 a	90.60 a	64.47 ab	84.84 b
T_7	10.87 ab	8.21 a	88.13 ab	64.00 b	80.69 c
$LSD_{0.05}$	1.262	1.667	2.925	2.930	3.975
CV (%)	12.25	10.49	5.13	7.85	8.94

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

Here,

DAT = Days after transplanting

T_0 = Control

T_1 = Recommended doses (RD) of inorganic fertilizer (Urea = 250 kg ha^{-1}, TSP = 350 kg ha^{-1}, MoP = 250 kg ha^{-1}, Gypsum – 110 kg ha^{-1}, ZnO = 5 kg ha^{-1})

T_2 = Vermicompost (only) - 3.5 t ha^{-1}

T_3 = Poultry manure (only) - 8 t ha^{-1}

T_4 = 50% vermicompost + 50% inorganic fertilizer

T_5 =25% vermicompost + 75% inorganic fertilizer

T_6 =50% poultry manure + 50% inorganic fertilizer

T_7 = 25% poultry manure + 75% inorganic fertilizer

4.2.6 Individual fruit weight

Different levels of organic and inorganic fertilizers combinations showed significant variation on individual fruit weight (Table 5 and Appendix VIII). Results indicated that the treatment T_4 (50% vermicompost + 50% inorganic fertilizer of RD) gave the highest individual fruit weight (94.85 g) which was statistically identical to T_5 (25% vermicompost + 75% inorganic fertilizer of RD). The lowest individual fruit weight (72.13 g) was recorded from the control treatment T_0 (no nutrient application) which was significantly different to other treatments. Similar result was also observed by Rezaei-Chiyaneh *et al*. (2019).

4.3 Yield parameters

4.3.1 Number of fruits plot^{-1}

Number of fruits plot^{-1} of capsicum differed significantly due to different doses of organic and inorganic fertilizers combinations (Table 6 and Appendix IX). It was observed that the treatment T_4 (50% vermicompost + 50% inorganic fertilizer of RD) gave the highest number of fruits plot^{-1} (40.67) followed by the treatment T_5 (25% vermicompost + 75% inorganic fertilizer of RD), T_6 (50% poultry manure + 50% inorganic fertilizer of RD) and T_7 (25% poultry manure + 75% inorganic fertilizer of RD). The lowest number of fruits plot^{-1} (19.33) was given by the control treatment T_0 (no nutrient application) which was significantly different from other treatments. Similar result was also observed by Ullah *et al*. (2020)

4.3.2 Yield plot^{-1}

Application of different organic and inorganic fertilizers combinations showed significant variation on capsicum yield plot^{-1} (Table 6 and Appendix IX). Treatment T_4 (50% vermicompost + 50% inorganic fertilizer of RD) registered the highest capsicum yield plot^{-1} (3859.00 g) which was significantly different to other treatments followed by T_5 (25% vermicompost + 75% inorganic fertilizer of RD). The lowest capsicum yield plot^{-1} (1394.00 g) was registered by control treatment T_0

(no nutrient application) which was significantly different from other treatments. Treatment T_3 (Poultry manure - 8 t ha^{-1}) also performed lower capsicum yield $plot^{-1}$ (1857.00 g) but significantly differed from control treatment. Supported result was also observed by the findings of Saeed *et al*. (2020), Ahmed *et al*. (2020), Kumari *et al*. (2019), Islam *et al*. (2017) and Alam *et al*. (2016).

Table 6. Effect of organic and/or inorganic fertilizers on yield parameters of capsicum

Treatments	Yield parameters		
	Number of fruits $plot^{-1}$	Yield $plot^{-1}$ (g)	Yield (t ha^{-1})
T_0	19.33 d	1394.00 g	6.97 e
T_1	32.00 b	2641.00 d	13.20 c
T_2	24.67 c	1997.00 e	9.99 d
T_3	23.33 c	1857.00 f	9.29 d
T_4	40.67 a	3859.00 a	19.30 a
T_5	34.33 b	3207.00 b	16.04 b
T_6	33.67 b	2718.00 c	13.59 c
T_7	33.00 b	2649.00 d	13.25 c
$LSD_{0.05}$	2.759	9.087	2.055
CV (%)	8.74	8.25	8.24

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

Here,

DAT = Days after transplanting

T_0 = Control

T_1 = Recommended doses (RD) of inorganic fertilizer (Urea = 250 kg ha^{-1}, TSP = 350 kg ha^{-1}, MoP = 250 kg ha^{-1}, Gypsum – 110 kg ha^{-1}, ZnO = 5 kg ha^{-1})

T_2 = Vermicompost (only) - 3.5 t ha^{-1}

T_3 = Poultry manure (only) - 8 t ha^{-1}

T_4 = 50% vermicompost + 50% inorganic fertilizer

T_5 =25% vermicompost + 75% inorganic fertilizer

T_6 =50% poultry manure + 50% inorganic fertilizer

T_7 = 25% poultry manure + 75% inorganic fertilizer

4.3.3 Yield t ha^{-1}

Application of different organic and inorganic fertilizers combinations showed significant variation on capsicum yield ha^{-1} (Table 6 and Appendix IX). Treatment T_4 (50% vermicompost + 50% inorganic fertilizer of RD) performed the highest capsicum yield (19.30 t ha^{-1}) which was significantly different to other treatments followed by T_5 (25% vermicompost + 75% inorganic fertilizer of RD) (16.04 t ha^{-1}). The lowest capsicum yield (6.97 t ha^{-1}) was recorded by control treatment T_0 (no nutrient application) that was significantly different to other treatments. Treatment T_2 (Vermicompost - 3.5 t ha^{-1}) and T_3 (Poultry manure - 8 t ha^{-1}) also performed lower capsicum yield (9.99 and 9.29 t ha^{-1}, respectively) but significantly differed with control treatment. This result was in agreed with the findings of Hussain *et al*. (2021), Ullah *et al*. (2020) and Rezaei-Chiyaneh *et al*. (2019) who reported higher capsicum yield from integrated use of organic and inorganic fertilizers compared to organic or inorganic fertilizers alone.

4.4 Nutrient content of capsicum

4.4.1 Nitrogen (N) content

N content of capsicum differed significantly due to different doses of organic and inorganic fertilizers combinations (Table 7 and Appendix X). It was observed that the treatment T_7 (25% poultry manure + 75% inorganic fertilizer of RD) gave the highest N content of capsicum (1.73%) which was statistically identical with T_6 (50% poultry manure + 50% inorganic fertilizer of RD) (1.62%). The control treatment T_0 (no nutrient application) showed the lowest N content of capsicum (0.57%) that was statistically identical with T_3 (Poultry manure - 8 t ha^{-1}). The result obtained from the present study was similar with the findings of Shahein *et al*. (2015) who observed significant variation of N content in capsicum fruits among different treatments of organic and inorganic fertilizers including control.

Table 7. Effect of organic and inorganic fertilizers on nutrient content of capsicum

Treatments	Nutrient content of capsicum		
	N (%)	P (ppm)	K (meq/100 g)
T_0	0.57e	0.127	0.113
T_1	1.34 b	0.173	0.117
T_2	0.92 d	0.137	0.117
T_3	0.63 e	0.171	0.127
T_4	1.12 c	0.150	0.123
T_5	1.07c	0.133	0.107
T_6	1.62 a	0.137	0.117
T_7	1.73 a	0.137	0.130
$LSD_{0.05}$	0.146	0.096^{NS}	0.099^{NS}
CV (%)	3.92	11.75	6.53

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

Here,

DAT = Days after transplanting

T_0 = Control

T_1 = Recommended doses (RD) of inorganic fertilizer (Urea = 250 kg ha^{-1}, TSP = 350 kg ha^{-1}, MoP = 250 kg ha^{-1}, Gypsum – 110 kg ha^{-1}, ZnO = 5 kg ha^{-1})

T_2 = Vermicompost (only) - 3.5 t ha^{-1}

T_3 = Poultry manure (only) - 8 t ha^{-1}

T_4 = 50% vermicompost + 50% inorganic fertilizer

T_5 =25% vermicompost + 75% inorganic fertilizer

T_6 =50% poultry manure + 50% inorganic fertilizer

T_7 = 25% poultry manure + 75% inorganic fertilizer

4.4.2 Phosphorus (P) content

Different doses of organic and inorganic fertilizers combinations showed non-significant variation on P content of capsicum (Table 7 and Appendix X). However, it was observed that the treatment T_1 (Recommended doses; RD of inorganic fertilizer) gave the highest P content of capsicum (0.173 ppm) whereas the control treatment T_0 (no nutrient application) showed the lowest P content of capsicum (0.127 ppm). Aguoru *et al*. (2015) also found similar result with the present study and found non-significant variation in P content of tomato and pepper fruit using organic and inorganic fertilizer combinations.

4.4.3 Potassium (K) content

Different doses of organic and inorganic fertilizers combinations showed non-significant variation on K content of capsicum (Table 7 and Appendix X). However, it was observed that the highest K content of capsicum (0.130 meq/100g) was recorded from the treatment T_7 (25% poultry manure + 75% inorganic fertilizer of RD) whereas the lowest K content of capsicum (0.107 meq/100g) was recorded from the control treatment T_0 (no nutrient application). Hari *et al*. (2006) also found result with Aguoru *et al*. (2015) also found similar result with the present study and reported non-significant variation of K content in pepper using organic and inorganic fertilizer combinations but the result from Hari *et al*. (2006) was not similar with the present findings.

CHAPTER V

SUMMARY AND CONCLUSION

Single factor experiment was considered for the present study with eight treatments *viz*. T_0 = control (no nutrient application), T_1 (Recommended doses; RD of inorganic fertilizer), T_2 (Vermicompost - 3.5 t ha^{-1}), T_3 (Poultry manure - 8 t ha^{-1}), T_4 (50% vermicompost + 50% inorganic fertilizer of RD), T_5 (25% vermicompost + 75% inorganic fertilizer of RD), T T_6 (50% poultry manure + 50% inorganic fertilizer of RD) and T_7 (25% poultry manure + 75% inorganic fertilizer of RD). The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The data on different crop characters and yields were recorded.

Significant variation was found for most of the parameters of the study influenced by different organic and inorganic fertilizers combinations. For growth parameters, at 30, 60 DAT, and at final harvest, treatment T_5 (25% vermicompost + 75% inorganic fertilizer of RD) exhibited the highest plant height (24.73, 40.93, and 51.93 cm, respectively) but the treatment T_4 (50% vermicompost+ 50% inorganic fertilizer) showed the highest number of leaves $plant^{-1}$ (17.94, 49.20 and 52.07 cm, at 30, 60 DAT, and at final harvest, respectively) and highest number of branches $plant^{-1}$ (8.07 and 9.47, at 60 DAT, and at final harvest, respectively) except 30 DAT whereas control treatment T_0 (no nutrient application) showed the lowest plant height (21.73, 33.47 and 41.40 cm, respectively), the lowest number of leaves $plant^{-1}$ (17.94, 49.20 and 52.07, respectively) and lowest number of branches $plant^{-1}$ (0.00, 5.87 and 7.06, respectively).

For yield contributing parameters and yield, treatment T_4 (50% vermicompost + 50% inorganic fertilizer) performed the highest number of flowers $plant^{-1}$ at 30, 60 DAT, and at final harvest (3.00, 6.13 and 2.40, respectively) and this treatment also performed the highest total number of flowers $plant^{-1}$ (11.53), number of fruits $plant^{-1}$ (8.71), fruit length (89.93 mm), fruit diameter (67.27 mm), individual fruit weight (94.85 g), number of fruits plot^{-1} (40.67), yield plot^{-1} (3859.00 g) and yield ha^{-1} (19.30 t) whereas the control treatment T_0 (no nutrient application) performed the lowest total number of flowers plant^{-1} (8.00), number of fruits plant^{-1} (4.00), fruit length (82.53 mm), fruit diameter (59.07 mm), individual fruit weight (72.13 g), number of fruits plot^{-1} (19.33), yield plot^{-1} (1394.00 g) and yield (6.97 t ha^{-1})

Regarding nutrient content of capsicum, N content differed significantly and the treatment T_7 (25% poultry manure + 75% inorganic fertilizer of RD) showed the maximum N content (1.73%) whereas control treatment T_0 (no nutrient application) performed the lowest N content (0.57%). Again, P and K content of fruit showed non-significant variation among the treatments, however, the maximum P and K content (0.173 ppm and 130 meq/100 g, respectively) were recorded from T_1 (Recommended doses; RD of inorganic fertilizer) and T_7 (25% poultry manure + 75% inorganic fertilizer of RD) respectively whereas the minimum P and K content (0.127 ppm and 113 meq/100 g, respectively) were recorded from control treatment T_0 (no nutrient application).

From the above results, it can be concluded that the organic and inorganic fertilizers combinations, T_4 (50% vermicompost + 50% inorganic fertilizer of RD) treatment was very much promising for higher capsicum production (ASTHA F1) compared to other treatment combinations followed by T_5 (25% vermicompost + 75% inorganic fertilizer of RD) whereas the control treatment T_0 (no nutrient application) showed the lowest performance. So, the treatment T_4 (50% vermicompost + 50% inorganic fertilizer of RD) was considered as the best under the present study compared to other treatment combinations for capsicum production.

The present research work was carried out at the Sher-e-Bangla Agricultural University in one season only. Further trial of this research work in different locations of the country is needed to justify the present results.

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APPENDICES

Appendix I. Agro-Ecological Zone of Bangladesh showing the experimental location

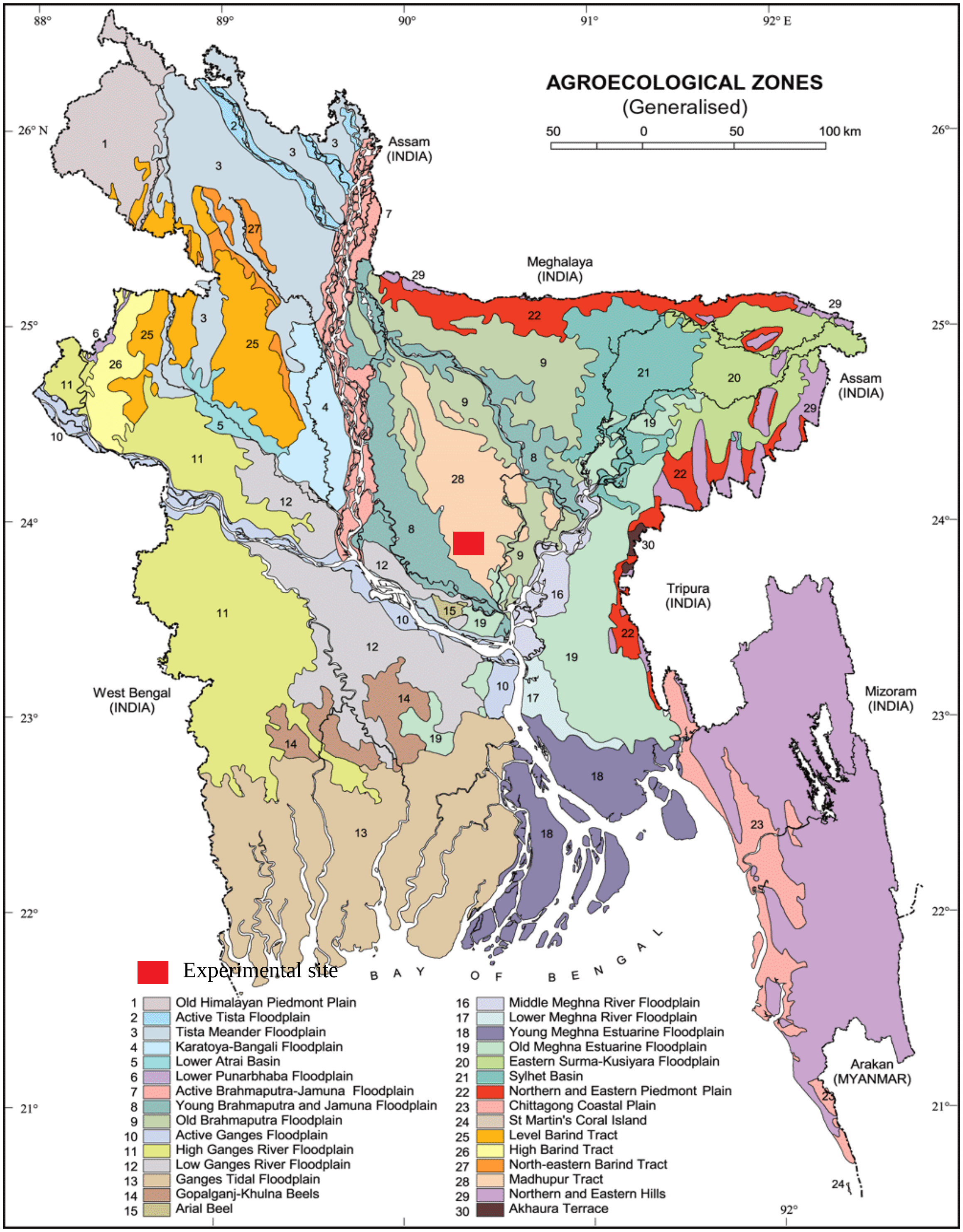

Figure2. Experimental site

Appendix II. Monthly records of air temperature, relative humidity and rainfall during the period from November 2021 to March 2022.

Year	Month	Air temperature (°C)			Relative humidity (%)	Rainfall (mm)
		Max	*Min*	*Mean*		
2021	November	28.60	8.52	18.56	56.75	14.40
2021	December	25.50	6.70	16.10	54.80	0.0
2022	January	23.80	11.70	17.75	46.20	0.0
2022	February	22.75	14.26	18.51	37.90	0.0
2022	March	35.20	21.00	28.10	52.44	20.4

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1212.

Appendix III. Characteristics of experimental soil analyzed at Soil Resources Development Institute (SRDI), Farmgate, Dhaka.

A. Morphological characteristics of the experimental field

Morphological features	**Characteristics**
Location	Agronomy Farm, SAU, Dhaka
AEZ	Modhupur 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
Cropping pattern	Not Applicable

Source: Soil Resource Development Institute (SRDI)

B. Physical and chemical properties of the initial soil

Characteristics	**Value**
Partical size analysis % Sand	27
%Silt	43
% Clay	30
Textural class	Silty Clay Loam (ISSS)
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20
Exchangeable K (me/100 g soil)	0.1
Available S (ppm)	45

Source: Soil Resource Development Institute (SRDI)

Appendix IV. Mean square effect of organic and inorganic fertilizers on plant height of Capsicum at different growth stages

Sources of variation	Degrees of freedom	Mean square of Plant height (cm)		
		30 DAT	60 DAT	Final harvest
Replication	2	10.75	52.972	47.970
Factor A	7	2.697^{NS}	22.350*	46.650*
Error	14	3.908	12.463	1.930

NS = Non-significant * = Significant at 5% level   ** = Significant at 1% level

Appendix V. Mean square effect of organic and inorganic fertilizers on number of leaves plant^{-1} of capsicum at different growth stages

Sources of variation	Degrees of freedom	Mean square of Number of leaves plant^{-1}		
		30 DAT	60 DAT	Final harvest
Replication	2	14.897	207.512	150.802
Factor A	7	11.565**	46.405*	47.034*
Error	14	7.947	34.264	80.577

NS = Non-significant * = Significant at 5% level   ** = Significant at 1% level

Appendix VI. Mean square effect of organic and inorganic fertilizers on number of branches plant^{-1} of capsicum at different growth stages

Sources of variation	Degrees of freedom	Mean square of Number of branches plant^{-1}		
		30 DAT	60 DAT	Final harvest
Replication	2	0.112	0.952	2.795
Factor A	7	0.212^{NS}	1.750**	1.192**
Error	14	0.215	1.432	1.109

NS = Non-significant * = Significant at 5% level   ** = Significant at 1% level

Appendix VII. Mean square effect of organic and inorganic fertilizers on number of branches plant^{-1} of capsicum at different growth stages

Sources of variation	Degrees of freedom	Mean square of Number of flowers plant^{-1}		
		60 DAT	100 DAT	125 DAT
Replication	2	6.324	8.376	5.294
Factor A	7	3.117**	14.23*	21.361*
Error	14	1.052	1.117	1.288

NS = Non-significant * = Significant at 5% level   ** = Significant at 1% level

Appendix VIII. Mean square effect of organic and inorganic fertilizer on yield contributing parameters of Capsicum

Sources of variation	Degrees of freedom	Mean square of Yield contributing parameters				
		Total number of flowers plant^{-1}	Number of fruits plant^{-1}	Fruit length (mm)	Fruit diameter (mm)	Individual fruit weight (g)
Replication	2	7.632	7.483	93.785	10.122	14.650
Factor A	7	4.457**	8.351*	27.778*	16.339*	178.28*
Error	14	4.919	2.906	19.789	24.800	55.153

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix IX. Mean square effect of organic and/or inorganic fertilizer on yield parameters of Capsicum

Sources of variation	Degrees of freedom	Mean square of Yield parameters		
		Number of fruits plot^{-1}	Yield plot^{-1} (g)	Yield ha^{-1} (t)
Replication	2	22.625	968.875	2.420
Factor A	7	148.09*	18487.71*	46.23*
Error	14	22.482	26.923	5.377

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix X. Mean square effect of organic and inorganic fertilizer on nutrient content of capsicum

Sources of variation	Degrees of freedom	Mean square of Nutrient content of capsicum		
		N (%)	P (ppm)	K (meq/100 g)
Replication	2	0.103	0.001	0.001
Factor A	7	1.324**	0.002^{NS}	0.001^{NS}
Error	14	0.012	0.001	0.001

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Plate 1. Sowing of seed in seed bed

Plate 2. Seedlings in seed bed

Plate 3. Uprooted seedlings

Plate 4. Seedling transplanting in the main field

Plate 5. Field visit with supervisor

Plate 6. Data collecting at vegetative stage

Plate 7. Data collecting at fruiting stage

Plate 8. Measurement of single fruit weight