GROWTH, SEED YIELD AND QUALITY OF CHILLI AS INFLUENCED BY FERTILIZER MANAGEMENT AND SPACING

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CERTIFICATE

*This is to certify that the thesis entitled **"GROWTH, SEED YIELD AND QUALITY OF CHILLI AS INFLUENCED BY FERTILIZER MANAGEMENT AND SPACING"** submitted to the Institute of Seed Technology, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (M.S.)** in **SEED TECHNOLOGY,** embodies the results of a piece of bona fide research work carried out by **MD. MEHEDI HASSAN,** Registration. No. 13-05342 under my supervision and guidance. No part of this 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:

Dhaka, Bangladesh

Prof. Dr. Jasim Uddain
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ABSTRACT

An experiment was conducted at the central farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207 during the period from October 2018 to April 2019 to determine the growth, seed yield and quality of chilli as influenced by fertilizer management and spacing. The experiment consisted of two factors Factor A: Different fertilizer management such as F_0: Control, F_1: Vermicompost (15 t ha^{-1}), F_2: 110 kg ha^{-1} N, 170 kg ha^{-1}, 100 kg ha^{-1} K and F_3: ½ Vermicompost + ½ $N_{110}P_{170}K_{100}$ kg ha^{-1}; Factor B: Different types of plant spacing such as S_1: 60 cm × 30 cm, S_2: 60 cm × 45 cm and S_3: 60 cm × 60 cm. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data on different growth and yield contributing characters were recorded. Results indicated that fertilizer management and spacing had a significant influence on most of the growth, seed yield and quality components of chilli. Under this investigation, it was revealed that plant height, number of branches per plant, number of leaves per plant, fruit length, the weight of dry fruits, number of dry fruits per plant, yield per plant dry fruits, number of seeds per fruit, thousand seed weight, germination percentage, root length, shoot length and seedling length were found to be maximum from F_3S_3 treatment combination and minimum from F_0S_1 treatment combination. Yield of dry fruits (3.06 t) and seed (353.35 kg) per hectare were found to be maximum from F_3S_2. By contrast minimum dry fruits (0.92 t) and seed yield (143.68 kg) were given from F_0S_3 and F_0S_1. Considering the yield of dry fruits and seed per hectare, F3 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$ kg ha^{-1}) along with S_2 (60 cm × 45 cm) could be the best production package for the production of chilli.

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AEZ	Agro-Ecological Zone
Anon.	Anonymous
BARC	Bangladesh Agricultural Research Council
BARI	Bangladesh Agricultural Research Institute
BAU	Bangladesh Agricultural University
BBS	Bangladesh Bureau of Statistics
BRRI	Bangladesh Rice Research Institute
CV %	Percent Coefficient of Variance
cv.	Cultivar (s)
DAT	Days After Transplanting
eds.	Editors
et al.	et alibi (And others)
etc.	et cetera (and other similar things)
FAO	Food and Agricultural Organization
i.e.	id est (that is)
LSD	Least Significant Difference
MoP	Muriate of Potash
TSP	Triple Super Phosphate

CHAPTER I

INTRODUCTION

Chilli (*Capsicum frutescens* L.) is an important spice belongs to the genus *Capsicum* of the family of Solanaceae. Chilli is cultivated as an annual crop in worldwide. Chilli is a native crop of central America and the West Indies (Pruthi, 1993). But the discovery of America and the West Indies, chilli spread rapidly throughout the Tropical countries in the world (Pruthi, 1993). The major chilli growing countries are India, Mexico, Japan, Ethiopia, Thailand, Turkey, Indonesia, China and Pakistan. Chilli is an unavoidable spice because of its pungency, spicy taste and its appealing colour add to the curry. In Bangladesh, chilli is one of the most important spices and cash crop which widely grown in almost all areas and seasons (Asaduzzaman *et al.*, 2010).

Chilli is an excellent source of high nutritive value with 1.29 mg/100 g protein, 11 mg/100 g calcium, 870 I.U vitamins-A, 175 mg ascorbic acid, 0.06 mg thiamine, 0.03 mg riboflavin, 0.55 niacin per 100 g edible fruit and 321mg per 100 g of vitamin C (Agarwal *et al.*, 2007). Sometimes chilli referred to as capsule of vitamin C because of the richest source of vitamin C (Durust *et al.*, 1997).

Chilli occupies 1.01 lakh hectares of land and the production of chilli is about 1.41 lakh metric tons during the year of 2017-18 (BBS, 2019 and FAO, 2018). But about 60% of yields could be lost due to improper time of weeding and management (BBS, 2012). In Bangladesh, the harvest price of chilli is about Tk. 133530/M. Ton (BBS, 2018). With the increase of population, the demand for crop has been increasing day by day and the traditional varieties could not fulfill the demand due to their inherent low yield potential. The main reasons for low yield are lacking high yielding varieties and use of an appropriate dose of fertilizer. Nutrient supply is an important aspect of the improved technologies developed and whose widespread adoption continues to ensure higher fruit yields, better quality and yield stability (Khan *et al.*, 2010). The high quality of seed in terms of viability and vigour are the essential factors, which determine the seedling development in nursery and plant establishment in the field to get a higher yield with the high-quality seed (Kodalli, 2006).

Production of high-quality seed is possible only by adopting scientific, cultural and improved agronomic management practices. Among several agronomic and management practices, the mother plant nutrition plays an important role in increasing the production of quality seed (Kulkarni *et al.*, 2002).

Fertilizers contain various macro and micronutrients that are being used in vegetables. The key functions of micronutrients are to favour the photosynthesis and the synthesis of chlorophyll in green plants (Naz *et al.*, 2012). Fertilizers offer the best means of increasing yield, quality and maintaining soil fertility. Three major nutrients viz., nitrogen (N), phosphorous (P) in general and potassium (K) in particular are essential for increasing yield and quality of chillies (Irutharayaraj and Kulandaivelu, 1973). Fertilizer application is widely used to achieve optimum plant growth and more yield from the unit area with increased input use efficiency (Senger and Kothari, 2008).

A high input of chemical fertilizer leading to a qualitative deterioration of soil as well as agricultural yield. However, a growing awareness of the adverse impacts of inorganic fertilizers on crop production as well as increasing environmental and ecological concerns have stimulated greater interest in the utilization of organic amendments for crop production (Ullah *et al.*, 2008). Organic manures act not only as a source of nutrients and organic matter but also increase microbial diversity and activity in the soil, which influences soil structure and nutrients turnover, in addition to improvement in other physical and biological properties of the soil (Albiach *et al.*, 2000). Thus organic manures are environmentally benign and help in maintaining soil fertility as well as agricultural productivity (Khanam *et al.*, 2009).

Among various organic products, vermicompost has been recognized as a potential soil amendment. Vermicompost is a product of non-thermophilic biodegradation of organic material by the combined action of earthworms and associated microbes. It is a highly fertile, finely divided peat-like material with high porosity, aeration, water holding capacity and low C: N ratios. So, vermicompost is very essential for the growth and yield of chilli and other winter vegetables (Goutam *et al.*, 2011 and Ushakumari *et al.*, 2006).

Optimum plant spacing ensures proper growth and development of plant resulting maximum yield of the crop and economic use of land. The yield of chilli has been reported to be dependent on the number of plants accommodated per unit area of land (Duimovik *et al.*, 2009). Plant height, number of branches/plant, number of leaves/plant, Stem girth, flower initiation, number of fruits/plant, fruit weight were significantly influenced by plant spacing (Islam *et al.*, 2011 and Maya *et al.*, 1997). The increase in plant yield with higher plant spacing results in the increase of numbers of fruit per ha in chilli (Nasto *et al.*, 2009 and Cavero *et al.*, 2001).

From the above-mentioned facts, this study was undertaken by the following objectives:

1. To find out the suitable fertilizer on growth, seed yield and quality of chilli.
2. To identify the optimum plant spacing on growth, seed yield and quality of chilli.
3. To determine the combined effect of fertilizer and suitable spacing on growth, seed yield and quality of chilli.

CHAPTER II

REVIEW OF LITERATURE

An attempt was made in this section to collect and study relevant information available in the country and abroad regarding the growth, seed yield and quality of chilli influenced by spacing and fertilizer management to gather knowledge helpful in conducting the present research work.

Ali *et al.* (2011) conducted an experiment to investigate the effect of Panchagavya and Sanjibani, liquid organic manure on the yield of green gram, *Vigna radiata*, chilli, *Capsicum frutescens* (Chili) and mustard, *Brassica campestris*. Their influence was compared by evaluating the yield contributing attributes like plant height, primary branch/plant, secondary branch/plant, number of seed/fruit, fruit length, the weight of 100 seed, yield/plant, yield m^{-2}. From the results of the experiment showed that the Sanjibani and Panchagavya treated crops were higher than the control. Liquid manure specifically Sanjibani used in this experiment was pre-analyzed to evaluate the variation in microbial population between two Sanjibani samples prepared by using raw materials (Cow dung and Cow urine) obtained from two different sources of cow breed (i.e., Native breed and Jersey breed) and the best source of the breed can be recommended for the further research work. Meanwhile, the effect of organic farming practice in soil-health was also evaluated by analyzing the basic parameters of soil in the field. The result shows increased microbial population, oxidisable organic carbon, nitrogen, phosphate, potash. The pH and E.C were observed to be close to neutral.

Kattimani and Shashidhara (2006) carried out a field experiment during Kharif 2002, in Dharwad, Karnataka, India, to evaluate the response of chilli genotypes to integrated nutrient management (INM). Results from the experiment showed that, among the genotypes, Vietnam-2 produced significantly higher yield (932 kg ha^{-1}) contrast with Byadagi dabbi and Byadagi kaddi. The result of the experiment stated that the values of growth and yield contributing characters were also significantly higher in Vietnam-2. Application of FYM at 10 t ha^{-1} along with 100% recommended dose of fertilizer (RDF) observed in higher fruit yield (919 kg ha^{-1}) compared to RDF alone. Similarly, application of FYM at 10 t ha^{-1} with 100% RDF increased oleoresin content and yield by 17.5 and 16.0%, respectively, over 100% RDF alone. Application of FYM at 10 t ha^{-1} along with 100% RDF enhanced the uptake of nutrients like N, P, K, Ca, S and Fe by 14.1, 44.9, 37.4, 15.5, 20.3 and 26.7%, respectively, over RDF alone in Vietnam-2. A similar result was also observed in other genotypes. The maximum net returns (Rs. 28522 ha^{-1}) was obtained with the application of FYM at 10 t ha^{-1} + 100% RDF followed by FYM at 5 t ha^{-1} + chilli stalk at 5 t ha^{-1} + 100% RDF + secondary and micronutrient + biofertilizer (Rs. 25638 ha^{-1}) in Vietnam-2 contrasted to Byadagi kaddi and Byadagi dabbi.

Biswas *et al.* (2017) were conducted an experiment at the field laboratory of Horticulture Department, Sylhet Agricultural University during the winter season from October 2013 to March 2014 with a view to evaluate fruit and seed production potentiality of tomato genotypes. Eight tomato genotypes namely C-11, C-21, C-41, C-51, C-71, FP-5, WP-10 and HT-025 were used for this study. The experiment was laid out in a Randomized Complete Block (RCB) Design with three replications. A remarkable variation was observed among the tomato genotypes at the seedling stage of hypocotyls color, stem length, root length and number of leaves at 1st inflorescences of seedlings etc. The genotype C-41 produced the highest number of fruits (48.00 $plant^{-1}$) but its corresponding individual fruit weight was the lowest (34.33 g). The lowest number of fruits $plant^{-1}$ was harvested from the line WP-10 (22.33 $plant^{-1}$), and it had the highest individual fruit weight (66.67 g). Significant variation was observed in weight of fruit $plant^{-1}$. The highest fruit yield $plant^{-1}$ was recorded from the genotype HT-025 (2.02 kg $plant^{-1}$) and the lowest was recorded from the line FP-5 (1.17 $kgplant^{-}$

^{1}). Corresponding hectare^{-1} fruit yield was the highest in HT-025 (68.68 tones) followed by the line C11 (68.0 tones). The highest number of seeds fruit^{-1} was counted from the genotype C-51 (85.42) very closely followed by C-11 (81.67). The genotype C-41 produced the lowest number of seeds (49.28 fruit^{-1}) identical to that of C-21 (51.72). The genotype HT-025 had the highest 1000-seed weight (2.90 g) which was identical to that of C-41 (2.80 g). The lowest 1000-seed weight was recorded from WP-10 (2.20 g). Seed yield plant^{-1} was varied from 3.64 g to 9.41 g. Among the genotypes, C-11 produced the maximum amount of seeds (319.94 kg ha^{-1}) and lowest seed production recorded from WP-10 (123.76 kg ha^{-1}).

A field experiment was conducted by Hangarge *et al.* (2004) during the Kharif and rabi seasons of 1996-97 to evaluate the influence of vermicompost and other organics on the fertility and productivity of soil (Vertisol) under chilli-spinach cropping system. The application of vermicompost at 5 t ha^{-1} + organic booster at 1 litre m^{-2} and soil conditioner (Tera care) at 2.5 t ha^{-1} + organic booster at 1 litre m^{-2} enhanced the availability of N, P, K and organic C content in the soil. There did not have any significant impact on recommended rates of NPK and organic sources each alone. The interaction effect of organic + organic sources resulted to be better than either organic alone or the interaction of organic + inorganic fertilizer.

A field experiment was conducted by Hanifah *et al.* (2016) to compare two different cultivation systems, conventional and fertigation on plant growth, fruit yield and physical fruit qualities of two commercial varieties (151 and 461) and two local varieties (MC11 and Kulai) of chili and seed yield among local varieties. In conventional system, plants were grown in peat soil area with two times of fertilizer applications, basal and top dressing following recommended dose (18 g N, 3 g P and 15 g K/plant in total). In fertigation system, fertilizer was supplied with irrigation water. Dependent variables on plant growth were taken at the first harvest meanwhile data on fruit quality and seed yield were taken at the second harvest. Stem height was taken weekly from 1 to 10 weeks after transplant. Results showed that cultivation system does not have significant effect on fruit yield all varieties but type of variety does ($P<0.001$). Type of variety also had significant effect on stem height, number of fruit per kilogram and all fruit physical qualities at $P<0.0001$. Type of cultivation system had significant effect on number of fruit per kilogram at $P<0.0001$ and fruit length at $P<0.001$. Among all varieties tested, variety of 461 abled to produce highest fruit yield and all physical fruit qualities especially when grown conventionally in peat soil. Therefore, it is recommended to use variety of 461 and growing conventionally in peat soil area for high fresh fruit production. Seed yield of MC11 was recorded the highest when grown under conventional system while vice versa for Kulai. Therefore, for high production of MC11 seeds, it is recommended to grow the plants under conventional system, however, fertigation system for Kulai. This study also would like to suggest repeating this study with a modification on fertilizer rate of fertigation system.

Maheswari *et al.* (2004) were carried out a study to assess the effects of foliar organic fertilizers on sandy loam soil (amino acid at 0.5 and 0.75%; humic acid at 0.1 and 0.2%; and vermiwash at 1:3 and 1:5 at vermiwash and water ratios) on the quality and economic considerations of chilli (*C. annuum*). The recommended fertilizer dose was applied as basal and top dressing (complete dose; N: P: K at 160:60:30 kg ha^{-1}), and as basal application alone (80:60:30 kg ha^{-1}). The highest ascorbic acid content (175.23 mg/100 g) was recorded in the treatment combination of vermiwash at 1:5 and basal and top fertilizer dressing. Capsaicin content and seed number were maximum (0.49%) with 0.75% amino acid + complete fertilizer dose. The amino acid at 0.75% + complete fertilizer dose produced the best returns.

Malawadi *et al.* (2004) was carried out a field experiment conducted in Dharwad, Karnataka, India, chilli (*Capsicum annuum*), planted on 19th July 2001, was subjected to the following treatments: NPK alone; NPK+farmyard manure (FYM); NPK+Fe; NPK+S; NPK+Ca; NPK+S+Fe; NPK+Ca+Fe; NPK+Ca+S; and NPK+Ca+S+Fe. N, P and K (100:50:50 kg ha^{-1}) were applied in the form of urea, diammonium phosphate and muriate of potash, respectively. Half of the recommended NPK was applied at transplanting, and the other half was applied after 6 weeks. FYM at 10 t ha^{-1}, Ca at 30 kg ha^{-1} (calcium carbonate) and S at 60 kg ha^{-1} (elemental sulfur) were applied 10 days before transplanting. Fe at 12 kg ha^{-1} (iron chloride) was applied at 6 weeks after transplanting. NPK+FYM produced the maximum fruit yield (844.39 kg ha^{-1}), followed by NPK+S+Fe, NPK+Ca+S and NPK+Ca+Fe (843.36, 841.20 and 840.42 kg ha^{-1}, respectively), compared to NPK alone (695 kg ha^{-1}). NPK+FYM also produced the maximum fruit weight $hill^{-1}$ (86.60 g) and 100 fruit weight (200.50 g), while NPK alone produced the maximum value for the weight of discolored fruits (112.00 kg ha^{-1}). No significant variation was observed in these parameters among different treatments. NPK+Ca+Fe produced the maximum oleoresin yield (109.41 kg ha^{-1}), followed by NPK+Ca+S+Fe and NPK+S+Fe (108.08 and 107.08 kg ha^{-1}, respectively). The maximum ascorbic acid content was observed for NPK+Ca+S+Fe (81.67 mg/100 g), followed by NPK+Ca+S and NPK+S (79.83 and 78.73 mg/100 g, respectively) compared with NPK alone (59.50 mg/100 g). Increased N, P, K, Ca, S and Fe uptake was achieved with the application of FYM or interactions of secondary and micronutrients along with NPK.

A pot culture experiment was conducted by Yadav and Vijayakumari (2004) at Avinashilingam University, Coimbatore, Tamil Nadu, India, to evaluate the effect of vermicomposted vegetable waste, alone and in combination with different organic manures and chemical fertilizer, on the biochemical characters of chilli (*Capsicum annuum*). From the results of the pot, the experiment showed that the reducing sugar, free amino acid and phenol contents were higher in the vermicompost treatment on 30 (70.27, 7.98, 14.62 mg/g), 60 (95.51, 17.66, 22.32 mg/g) and 90 days after sowing (33.67, 3.17, 11.85 mg/g). The protein content was higher in vermicompost treatment on 60 and 90 days after sowing (113.37 and 79.69 mg/g, respectively), whereas it was higher in vermicompost + farmyard manure (FYM) treatment on 30 (35.73 mg/g) days after sowing. The carbohydrate content was higher in vermicompost + FYM treatment on 30 and 90 (4.67 and 6.46 mg/g, respectively) days after sowing, while on 60 days after sowing; it was higher in the vermicompost treatment (15.34 m/g). Chlorophyll a (0.23 mg/g), chlorophyll b (0.38 mg/g) and total chlorophyll (0.62 mg/g) were higher in vermicompost + neem cake treatment on 30 days after sowing. On 60 days after sowing, higher chlorophyll b (2.61 mg/g) and total chlorophyll (3.62 mg/g) contents were observed in the treatment containing vermicompost alone. On 90 days after sowing, chlorophyll a (1.01 mg/g) and total chlorophyll (1.92 mg/g) content were higher in vermicompost alone, and chlorophyll b (1.07 mg/g) in the vermicompost + FYM treatment.

An experiment was conducted by Idan (2016) to investigate the effect of potassium on the yield of pepper (*Capsicum annuum L.*) cv. charisma under protected cultivation. There were 4 treatments used *viz.* T_1 (0), T_2 (10), T_3 (15), T_4 (20) kg potassium sulfate (K_2SO_4) per poly house (504 m^2). The maximum number of fruits (22.10), the weight of fruit (184.10 g), yield per plant (4.07 kg) and total yield per poly house (3.25 tones) was achieved in T_4 treatment.

An experiment was carried out by Khan *et al.* (2014) to study the influence of nitrogen and potassium levels on chillies (*Capsicum annuum L.*). In this experimentation, different levels of nitrogen (0, 60, 120 and 180 kg ha^{-1}) and potassium (0, 30, 40 and 50 kg ha^{-1}) were assessed. The highest number of fruits $plant^{-1}$ (47.7), length of fruit (5.76 cm), seeds $fruit^{-1}$ (109) and yield (7.10 tons ha^{-1}) were observed with 50 kg K ha^{-1} which was statistically similar with 40 kg K ha^{-1}

except for the length of fruit. Application of 180 kg N with 40 kg K_2O ha^{-1} is recommended for better growth and yield of chillies.

Bhuvaneswari *et al.* (2013) were conducted an experiment to evaluate the effects of nitrogen and potassium on the growth and yield of capsicum. In this experiment, 4 levels of N (0, 25, 50 and 75 kg ha^{-1} were designated as treatment N_0 , N_1, N_2, and N_3, respectively) and 3 levels of K (0, 30 and 60 kg ha^{-1} designated as K_0, K_1 and K_2, respectively). Results from the experiment showed that Plant height at first flowering and branches number at first harvest increased significantly increasing levels of K up to the treatment K_1 (30 kg K ha^{-1}), whereas plant height and branches number at final harvest and number of fruits yield $plant^{-1}$ enhanced significantly up to the treatment K_2 (60 kg K ha^{-1}). Considering the interaction effect of nitrogen and potassium, the highest plant height at final harvest were achieved from N_3K_2 (75 kg N + 60 kg K ha^{-1}). The maximum number of fruits $plant^{-1}$ was also observed in the treatment combination N_3K_2 (75 kg N + 60 kg K ha^{-1}).

El-Tohamy *et al*. (2006) was carried out an experiment to improve the productivity of chilli plants grown under unheated greenhouse conditions by foliar application of nutrients. Application of different nutrient treatments including two levels of each of superphosphate, calcium chloride and potassium chloride were applied while control plants were not treated. The results showed that all fertilization treatments significantly influenced chilli growth attributes (plant height, number of branches $plant^{-1}$, number of leaves $plant^{-1}$ and fresh weight of plants) and yield compared to control plants, especially at the higher levels. The results remarked that additional foliar application of nutrients, especially by phosphorus, calcium and potassium, can enhance growth and yield of chilli plants grown under sandy soil conditions during the winter season.

Shivaprasad *et al*. (2009) was carried out a field experiment to assess the effects of secondary and micronutrients on yield and quality of chilli cv. Bydagi. The Recommended doses of inorganic NPK Fertilizers (RDF) at 100:50:50 kg ha^{-1} was applied along with various doses of secondary and micronutrients (Ca at 25 and 50, S at 25 and 50, Fe at 10 and 20 kg ha^{-1}). The results of the experiment reported that RDF+Ca+S+Fe at 50+50+20 kg ha^{-1} observed significantly higher chilli yield (1189 kg ha^{-1}) compared to the rest of the treatments, except for RDF+Ca+S at 50+50 kg ha^{-1} (1119 kg ha^{-1}) and RDF+Ca+S+Fe at 25+25+10 kg ha^{-1} (1176 kg ha^{-1}). From the pooled results of the experiment also showed that, significantly higher benefit: cost ratio (2.56) was achieved with RDF+Ca+S+Fe at 25+25+10 kg ha^{-1} compared to the rest of the treatments. However, it was statistically similar with RDF+Ca+S+Fe at 50+50+20 kg ha^{-1} and RDF+Ca+S at 50+50 kg ha^{-1} (2.45 and 2.29, respectively).

Bahuguna *et al*. (2016) were conducted a field experiment to evaluate the effects of optimum levels of fertilizer on growth and yield components of capsicum (*C. annuum* L.). The experimental treatments consisted of 4 levels of nitrogen (0, 40, 80 & 120 kg ha^{-1}), 3 levels of phosphorus (0, 40 & 70 kg ha^{-1}), 3 levels of potash (0, 30 & 60 kg ha^{-1}) and one level of vermicompost (200 q ha^{-1}) along with control on sweet pepper in randomized block design with three replications. Results revealed that plant height at harvest, the number of fruits $plant^{-1}$, fruits maturity and fruits yield increased significantly with T_{20} treatment (nitrogen, phosphorus, potash and vermicompost 120:40:60:20000 kg ha^{-1}). However, fruits length, fruits width and fruits weight increased significantly with increasing T_{10} treatment (nitrogen, phosphorus and potash 120:40:60 kg ha^{-1}) level.

A field experiment was carried out by Roy *et al*. (2011) to evaluate the effects of nitrogen and phosphorus on the fruit size and yield of Capsicum (*C. annuum* L.) In the experimentation, the treatments were comprised of 4 levels of N (0, 50, 100 & 150 kg ha^{-1}) and 3 levels of P (0, 30 & 60 kg ha^{-1}). Length of fruit, breadth of fruit and number of fruits plant^{-1} increased significantly with increasing nitrogen doses up to 100 kg N ha^{-1}. Along with, the average weight of fruit content increased significantly up to 150 kg N ha^{-1}. On the other hand, the average weight of fruit and yield increased significantly with the increasing levels of P up to the treatment 30 kg P ha^{-1}, whereas the length of fruit and number fruits plant^{-1} was increased significantly up to the 60 kg P ha^{-1}. Considering the interaction effect of nitrogen and phosphorus, the maximum significant length of capsicum, breadth of capsicum, number of fruits plant^{-1} and, average weight of fruit, as well as yield, were observed in the treatment combination of 150 kg N and 30 kg P ha^{-1}.

In a field experiment, Hasan *et al*. (1993) revealed that Green pepper (*Capsicum annuum* L. cv. Lady Bell) was grown for 7 weeks and transplanted into the field. Treatments of the experiment comprised of the following rates of N: 112, 224, 336 and 448 kg ha^{-1}. Results showed that, as N rates increased, plants exhibited poor early growth and produced lower early and total fruit yields. But doubling the N rate from 112 to 224 kg ha^{-1} resulted in a 21 per cent increase in flowerbeds, but the percentage of fruit set decreased as N rates increased. Results of the experiment revealed that fruit set correlated negatively with total leaf N and positively with plant weight, suggesting that a high leaf N content and a lower plant weight were detrimental to fruit set and yield of green pepper.

In a preliminary experiment, Aldana (2005) evaluate the effects of P and K fertilization on chilli growth and fruit quality. In the experimentation, 4 levels of P (0.25, 1.0, 1.75, and 2.5 mM) and 4 levels of K (0.75, 1.75, 2.75, and 3.75 mM) were assessed in hydroponic culture with a factor randomized design. Results from the experiment showed that the dry root weights of plants grown with the highest K rate (K_4) were significantly higher than the lowest k rate (K_1). Phosphorus and potassium rates significantly influenced plant growth, increasing plant height, weight, stem diameter, leaf area and dry weights of plant sections with increasing rates in the nutrient solution. For the fruit quality experiment, all plants were grown until the flowering stage with the same nutrient solution (2 mM P; and 3.75 mM K). Increasing P and K rates significantly affected plant yield and some fruit quality variables. Results were similar for most of the variables but recommended that the 0.25 mM concentration for both P and K was insufficient for pepper production. Concentrations higher than 1.25 mM and close to 2.5 mM are the most appropriate for hydroponic pepper production.

Lal *et al.* (2014) were conducted an experiment during Kharif 2012 to find out optimum planting density and training system for seed production of bell pepper, *Capsicum annuum* L under protected conditions using cultivar Solan Bharpur. The treatment combinations comprised of three planting densities (S) *viz* S_1 (45× 15 cm), S_2 (45 × 30 cm) and S_3 (45 × 45 cm) and four training levels (T) *viz* T_1 (single shoot), T_2 (two shoots), T_3 (three shoots) and T_4 (four shoots). The observations were recorded in the field on plant height (cm), days to ripe fruit harvest, ripe fruit weight (g), number of ripe fruits/plant, ripe fruit yield/plant (kg), number of seeds/fruit, per cent seed recovery, seed yield/plant (g), seed yield/m^2 (g) and seed yield/ha (kg). Analysis of variance showed that the combination S_2T_2 (plants spaced at 45 × 30 cm and trained to two shoots) was found superior over all other treatments in terms of economic characters such as total fruit yield/plant and seed yield (per plant, per m^2 and per hectare).

Aminifard *et al*. (2012) was conducted an experiment to find out the response of paprika pepper (*Capsicum annuum* L.) to nitrogen (N) fertilizer under field conditions. Nitrogen was supplied in four levels (0, 50, 100 and 150 kg ha^{-1}). The results revealed that plant height, lateral stem length and leaf chlorophyll content were affected by N fertilizer. Data revealed that fertilization with 50 kg N ha^{-1} resulted in the best yield and quality components at the ripening stage. Thus, these results noted that fertilization with 50 kg N ha^{-1} had a strong influence on vegetative and reproductive growth of paprika pepper under field conditions.

Murugan (2001) did an experiment and found that nitrogen and phosphorus application increased the ascorbic acid content and capsaicin content in green, ripe and dry chilli. Under this observation, he found that there was no significant effect on sources of the ascorbic acid content. The maximum ascorbic acid content was observed in green fruit which decreased gradually with the maturity of the fruit, observing the lowest value in a dry pod, while capsaicin content was lowest in green fruit and maximum in a dry pod.

Khan *et al*. (2014) revealed that the influence of different levels of nitrogen (0, 60, 120 and 180 kg ha^{-1}) and potassium (0, 30, 40 and 50 kg ha^{-1}) on all growth and yield parameters. Nitrogen application at the rate of 180 kg ha^{-1} significantly influenced on plant height (68.3 cm), number of leaves plant^{-1} (294), number of branches plant^{-1} (18.3), stem thickness (2.43 cm), number of fruits plant^{-1} (59.4), fruit length (6.83 cm), number of seeds fruit^{-1} (152) and yield (8.80 tons ha^{-1}). The maximum fruits number plant^{-1} (47.7), fruit length (5.76 cm), number of seeds fruit^{-1} (109), chlorophyll content (78.02) and higher yield (7.10 tons ha^{-1}) were observed with 50 kg K ha^{-1} which was statistically similar with 40 kg K ha^{-1} except for fruit length. Application of 180-40 kg N-K_2O is recommended for better growth and yield of chillies under the agro-climatic conditions of Dargai, Malakand, Pakistan.

An experiment was conducted by Subhasmita *et al.* (2004) to evaluate the effects of vermicompost based on karanj, niger, mahua, Indian mustard, groundnut or neem oilseed cake, and NPK (120:80:60 kg/ha) as control, on leaf damage by L. trifolii and on the yield of chilli cv. Suryamukhi. Results showed that leaf damage varied from 20.0 to 53.3%, whereas fruit yield per plant ranged from 9.7 to 21.3%. The vermicompost based on mahua oilseed cake resulted in the lowest percentage of leaf damage (16.7%), whereas the vermicompost based on groundnut oilseed cake recorded the highest fruit yield (21.3 g per plant).

Patil and Biradar (2001) conducted a field experiment in Dharwad, Karnataka, India, during Kharif 1997 on Vertisols to determine the nutrient uptake by chilli cv. Byadgi Kaddi as influenced by plant population and nutrient levels. The treatments consisted of 5 plant populations, i.e. 37037, 55555, 74074, 111111, and 148148 plants/ha, and 4 nutrient levels, i.e. 100% recommended dose of fertilizer (RDF, 150:75:75 NPK kg/ha) + farmyard manure (FYM) at 10 tonnes/ha, 100% RDF + FYM + vermicompost (VC) at 2.5 tonnes/ha, 150% RDF + FYM + VC, 200% RDF + FYM + VC. The dry chilli yield and total uptake of nutrient by plant varied significantly with respect to plant population and nutrient levels. A wider spaced plant population of 55555 plants/ha recorded significantly higher dry chilli yield (20.71 q/ha), followed by 37037 plants/ha (18.68 q/ha) and further decreased with the increase in plant population. Similarly, higher total N uptake (129.6 kg/ha) was recorded at a wider spacing of 37037 plants/ha and decreased with the increasing plant population. The trend was similar to P and K uptake. The yield of chilli also increased significantly with the increase in nutrient supply. The highest fruit yield (19.12 q/ha) was recorded with the application of 200% RDF + FYM + VC. Similarly, N, P and K uptake increased with the increase in nutrient levels.

An experiment was conducted by Naeem *et al*. (2002) to find out the effect of different levels of nitrogen (0, 30, 60, 90 kg ha^{-1}) and phosphorus (0, 30, 60 kg ha^{-1}) with a constant dose of potash (30 kg ha^{-1}) on the growth and yield of chilli cultivar Sanam. Results showed that minimum days to flowering (42 days) and days to flowering (54 days) were observed in plots fertilized with (30-60-30 kg NPK ha^{-1}) and (30-30-30 kg NPK ha^{-1}), respectively. Maximum brunches number plant^{-1} (10.00), plant height (98.27 cm), fruits number plant^{-1} (51.73) and total yield (7679.66 kg ha^{-1}) was obtained in plots fertilized with 90-60-30 kg NPK ha^{-1}. However, maximum fruits number was obtained at the fertilized level of 60-30-30 kg NPK ha^{-1}. It is recommended that chilli *cv.* Sanam should be fertilized with 90-60-30 kg NPK ha^{-1}.

Barik *et al.* (2017) experimented to examine the effect of planting time and spacing days to flowering, fruit maturity, net assimilation rate and plant growth efficiency of king chilli (*Capsicum chinense*) under poly-house condition. Under this experiment, 4 planting times viz. November 30th, December 19th, January 7th and January 26th were considered as factor A and 3 spacings *viz.* 60 × 60 cm, 60 × 45 cm and 45 × 45 cm were considered as factor B. The outcomes of the experiment showed that days to first flowering, 50% flowering and 80% fruiting significantly varied with the variation of planting time, but not with spacing. But minimum days for first flowering (84.93 days), 50% flowering (92.47 days) and 80% fruiting (126.06 days) were observed by January 7th planting with a spacing of 45 × 45 cm. On the other hand, maximum net assimilation rate (NAR) of 0.03858 gm^{-2}/day and 0.09871 gm^{-2}/day during 60-90 DAP AND 90-120 DAP respectively. Highest plant growth efficiency (PGE) (44.61%) was achieved by November 30th planting with a spacing of 60 × 60 cm during 60-90 DAP, followed by planting time December 19th with a spacing of 60 × 45 cm (82.42%) during 90-120 DAP.

Alam *et al.* (2011) were experimented to investigate yield and yield contributing attributes of sweet pepper as influenced by plant spacing and sowing time at the Olericulture field of Horticulture Research Centre of BARI, Joydebpur, Gazipur during September 2006 to April 2007. The results of the experiment showed that majority of the yield and yield contributing attributes significantly varied with the variation of spacing and sowing time. The number of branches plant^{-1}, fruits number plant^{-1}, fruit length, individual fruit weight and yield plant^{-1} were observed significantly increased with the increasing plant spacing but other parameters were observed to be significantly increased with the decreasing plant spacing. The interaction effect of sowing date and plant spacing also had a significant influence on different growth and yield contributing parameters and yield. The highest yield

(19.36 t ha^{-1}) of fruit was recorded from the earlier sowing (1 October) with the closest spacing (50 × 30 cm).

An experiment was conducted by Kumar and Rana (2018) to observe optimum crop geometry and nitrogen level in bell pepper with three levels of nitrogen (N_1-100, N_2-125 and N_3-150 kg N ha^{-1}) and two of spacing (S_1-45 × 45 cm and S_2-60 × 45 cm). Results of the experiment showed that a higher number of branches $plant^{-1}$ was achieved from 60 × 45 cm (S_2). Wider spacing of 60 × 45 cm (S_2), the crop took 3 and 4 days more to flowering and fruiting. Length of fruit (4.67 cm), fruit width (4.50 cm), fruits $plant^{-1}$ (8.51), weight of fruit (28.21 g) and fruit weight $plant^{-1}$ (212.77g) were maximum at 60 × 45 cm (S_2) spacing. But the total yield was noteworthy maximum at a closer spacing of 45 × 45 cm (S_1) during 2012 only. Net returns were Indian Net Rupees (INR) 4487 more with 60 × 45 cm (S_2) crop geometry compared to 45 × 45 cm (S_1). B: C was also higher under wider spacing 60 × 45 cm (S_2) than closer spacing 45 × 45 cm (S_1). Level of nitrogen increasing from recommended to 150% of recommended significantly influenced the number of days taken to 50% flowering and fruiting. Length of fruit (4.63 cm), fruit width (4.62 cm), fruits number $plant^{-1}$ (9.05), the weight of fruit (28.71g) and fruit weight $plant^{-1}$ (215.53 g) were maximum at 150% of recommended N (N_3) followed by 125% N (N_2). The net returns increased by 31,154 INR and 14,889 INR with the application of 150 (N_3) and 125% N (N_2), respectively over present recommended N application (N_1-100 kg N, 60 kg each of P_2O_5 and K_2O). From the results stated that B: C also increased with the increase in N dose.

A field experiment was carried out at the Horticultural farm of the Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur, during September 2006 to April 2007 to investigate growth and yield of sweet pepper as influenced by spacing. There were three levels of spacing viz. 50×50 cm, 50×40 cm, 50×30 cm. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Data were recorded on various parameters and subjected to statistical analysis. The plant spacing had significant variation in almost all the growth and yield contributing characters except pericarp thickness. Branches number plant^{-1}, leaves number plant^{-1}, stem girth, fruits number plant^{-1}, days to the first harvest, fruit length, individual fruit weight, yield per plant were found to be significantly increased with the increasing of plant spacing but plant height at different stages, fruits number plot^{-1}, days to 50% flowering, fruit breadth, yield plot^{-1} and yield ha^{-1} were marked to be significantly increased with the decreasing plant spacing. Considering the yield of fruits ha^{-1}, cost of production and net return, 50×30cm spacing appeared to be recommendable for the cultivation of sweet pepper (BARI, 2011).

An experiment was conducted by Pundir and Porwal (1999) to investigate the effect of spacing and fertilizers on growth, yield and physical fruit quality of chilli *(Capsicum annum)* cultivars. The cultivar Local Desi produced significantly higher plant height, dry weight plant^{-1}, weight and volume fruit^{-1}. However, cultivar NP 46 produced the maximum number of fruits plant^{-1}, fruit yield plant^{-1} and fruit yield ha^{-1}. Application of 100 kg N in combination with 25 kg P and 50 kg K ha^{-1} produced the highest fruits plant^{-1}. Maximum plant height, fresh weight and dry weight plant^{-1}, fruits number and yield of fruits plant^{-1} were observed in the widest spacing (55 cm x 55 cm); closest spacing (25 cm x 25 cm) produced highest fruit yield ha^{-1}. The quality of fruits was influenced by spacings. The combined effect of spacing, fertilizers and cultivars were non-significant to affect growth, yield and fruit quality attributes.

Sharma and Kumar (2017) were conducted a field study to evaluate the effect of spacing and growing conditions on Chilli during 2011-12 and 2012-13 to evaluate growth and yield of Chilli as influenced by growing conditions and spacing. In this experiment, there were two different growing conditions viz. low tunnel and open field conditions and three levels of spacing viz. 60×30cm, 60×45 cm, 60×60 cm. Two years average data marked that maximum yield was achieved when Chilli was grown under low tunnel as compared to open field condition. The yield increases to an extent of 38% in addition to better fruit quality was achieved under a low tunnel. The plant spacing had significantly influenced almost all the growth and yield components when variation in different spacing. The number of branches plant^{-1}, the number of fruits plant^{-1} and yield plant^{-1} was increased with the increasing of plant spacing but plant height was observed to be significantly increased with the decreasing plant spacing.

Bhuvaneswari *et al.* (2014) were carried out a study to examine the response of *Bell peppers* (*Capsicum annuum* L.) to plant density and nitrogen fertilizer under field conditions. Plant density at four levels (20×50 cm, 30×50 cm, 20×100 cm and 30×100 cm) and nitrogen treatments at four levels (0, 50, 100 and 150 kg N ha^{-1}) were used as factor A and factor B. Plant height, the number of lateral stems, leaf chlorophyll content and yield were evaluated at immature and mature stages. The outcomes of the results showed that vegetative growth attributes (plant height, the number of lateral stem and dry matter of leaf) and reproductive factors (volume of fruit and weight of fruit) declined with increasing plant density, but total yield (kg ha^{-1}) increased with increasing plant density. The highest and lowest total yields were achieved by plant density 20×50 cm and 30×100 cm respectively. Nitrogen fertilizer was significantly influenced by plant height, the number of lateral stem and leaf chlorophyll content. It was found that fertilization with 150 kg N ha^{-1} resulted to the highest volume of fruit and plant yield. There were significant variations between the volume of fruit and weight of fruit by the combination of plant density and nitrogen treatments.

Thakur *et al.* (2018) was carried out an experiment to evaluate the effect of plant spacing on growth, flowering, fruiting and yield of Capsicum (*Capsicum annuum* L.) hybrid buffalo under naturally ventilated polyhouse during September 2016 to February 2017 at Hi-Tech Horticulture, Dr. R. P. C. A. U Pusa, Samastipur, Bihar. Under this experimentation, there were 3 levels of spacing 45 cm × 30 cm (4.4

plants/m^2), 45 cm × 45 cm (2.94 plants/m^2) and 45 cm × 60 cm (2.22 plants/m^2) and 3 levels of numbers of shoots plant^{-1} *viz.* 2 shoots, 3 shoots and 4 shoots. The experiment was laid out in a factorial randomized block design with three replications. Among the different spacing level, the spacing S_1 (45 cm × 30 cm) marked maximum plant height (137.46 cm), yield (82.13 t ha^{-1}) and spacing S_1 (45 cm × 30 cm) indicated the early flower initiation as well as 50% flowering (52.24 days). Maximum number of leaves (122.29), leaf area (97.24 dm^2), number of branches (9.39), number of flower plant^{-1} (10.74), number of days for fruit set (66.20), least number of days to the first harvest (89.06 days), fruit weight (185.31g), number of fruit plant^{-1} (18.48), yield plant^{-1} (3.38 kg.) was observed under S_3(45 cm × 60 cm). But higher B: C ratio (5.60) was found under S_2 rest of treatments.

Bai and Sudha (2015) were conducted an experiment to evaluate the optimum spacing requirement of chilli grown inside the greenhouse. Under this experimentation, three levels of spacing *viz.*, 45 × 45 cm, 50 × 50 cm and 55 × 55 cm were used as treatments in the greenhouse condition and it was contrasted with chilli grown under open field condition with a spacing of 45 × 45 cm. Results showed that chilli performed better under greenhouse condition than under open condition during the rainy season. From the result showed that Spacing had a significant influence on the growth and yield of chilli under greenhouse condition. The spacing of 50 × 50 cm observed the highest yield followed by 55 × 55 cm.

An experiment was carried out by Fatemi *et al. (*2012) to evaluate the response of sweet pepper (*Capsicum annuum L.*) to plant density under field conditions. There were four levels of plant density *viz.* (20 × 50 cm, 30 × 50 cm, 20 × 100 cm and 30 × 100 cm). The results indicated that vegetative growth attributes (plant height, the number of lateral stem and dry matter of leaf) and reproductive characters (volume of fruit, the weight of fruit and plant yield) declined with increasing plant density but total yield increased with increasing plant density. The highest and lowest total yields were achieved by plant density 20 × 50 cm and 30 ×100 cm, respectively.

A field experiment was conducted by Islam *et al.* (2011) to evaluate growth and yield of sweet pepper as influenced by spacing. Three levels of spacing viz. 50×50 cm, 50×40 cm and 50×30 cm were used as treatments. The plant spacing had significantly influenced in almost all the growth and yield contributing characters except pericarp thickness. Number of branches plant^{-1}, number of leaves plant^{-1}, stem girth, number of fruits plant^{-1}, days to the first harvest, length of fruit, individual fruit weight, yield plant^{-1} were remarked to be significantly influenced with the increasing of plant spacing but plant height at different stages, number of fruits plot^{-1}, days to 50 per cent flowering, fruit breadth, yield plot^{-1} and yield ha^{-1} were recorded to be significantly increased with the decreasing plant spacing. Considering the yield of fruits ha^{-1}, cost of production and net return, 50×30 cm spacing recommended for the cultivation of sweet pepper.

Aminifard *et al.* (2010) was carried out an experiment to evaluate the effects of different plant densities (20 × 50 cm, 30 × 50 cm, 20 × 100 cm and 30 × 100 cm) on plant growth attributes and fruit yield of paprika pepper (*Capsicum annuum L.*) in the open field. Plant height, leaf chlorophyll content, flower number, yield, numbers of fruit and seed, 1000 seed weight and vitamin C were recorded at the immature and mature stage. The results showed that vegetative growth attributes *viz.* plant height, lateral stem length and leaf chlorophyll content decreased as plant density increased. The maximum lateral stem number and leaf number were achieved in plant density 30 × 100 cm. Plant density influenced the flowering factors *viz.* node number to first flower, days to first flowering and flower number. Results showed that the days to first flowering increased as plant density increased. It was found that volume of fruit, fruit average weight, plant yield and seed number decreased with increasing plant density but total yield ha^{-1} increased with increasing plant density. The maximum and minimum of yield ha^{-1} were achieved by 20 × 50 cm and 30 × 100 cm spacing, respectively. Also, plant density significantly influenced the vitamin C content. The highest and lowest vitamin C content was achieved in 30 × 100 cm and 30 × 50 cm spacing, respectively.

An experiment was carried out with three plant densities (30,000; 42,000, and 78,000 plants ha^{-1}) with an in-row spacing of 0.45, 0.30 or 0.15 m between plants in rows 0.8 m apart. The 42,000 plants ha^{-1} density produced suitable vegetative growth, best yield and did not have any significant negative influences on bell pepper quality (Khasmakhi *et al.*, 2009).

Lee *et al.* (2006) were carried out an experiment to investigate the effects of planting distance (in-row spacings of 30, 45, 60 and 70 cm) on jalapeno pepper **(***Capsicum annuum* cv**.** *Sierra fuego*) and the effects of plant types (erect, semispreading and spreading). They revealed that there were no significant variation in fruit characteristics such as length of fruit, width of fruit and sugar contents. The number of fruits and yield $plant^{-1}$ increased with increase in row spacings but the total yield per unit area was maximum at the lowest in-row spacing of 30 cm regardless of plant type.

A field experiment was carried out by Faiza *et al.* (2002) to evaluate the effects of different plant spacing (25, 30, 35, 40 and 45 cm) on the growth and yield of sweet pepper cv. Yellow Wonder. Plant spacing significantly influenced plant height (41.00 cm), branches number (7.78) and fruits number (18.61) at 45 cm spacing, while lowest values of these parameters were observed when plants were spaced at 25 cm. Highest (25.98 t ha^{-1}) and lowest (20.17 t ha^{-1}) yield were achieved in plants spaced 35 and 45 cm apart, respectively. The results stated that better performance in growth and yield were achieved when plants were spaced at 35 cm.

Dobromilska (2000) experimented to evaluate the effect of spacing and planting method in a 3 year-long experiment under the unheated plastic tunnel on the yield of sweet pepper. The seedlings were planted at a density of 50 × 40 cm, 50 × 50 cm and 50 × 60 cm in single or double rows. Plants grown at 50 × 40 cm in double rows produced the highest total fruit yields and yields of first-class fruits. However, the commercial quality of fruits based on mean weight and thickness of pericarp was lower at the highest planting density.

Maya *et al.* (1999) conducted an experiment in a field with *Capsicum annuum var*. *grossum cv*. California Wonder which was planted at different densities (60 × 30, 60 × 45 and 60 × 60 cm spacing) and was supplied with 4 different N levels (0, 50, 100 and 150 kg ha^{-1}) and 3 different P levels (0, 50 and 100 kg ha^{-1}). From the experiment, the result showed that the leaf area index (LAI) was highest at 60 × 45 cm spacing. Net assimilation rate (NAR), relative growth rate (RGR) and crop growth rate (CGR) increased as population densities increased and observed that highest at 60 × 30 cm spacing. Harvest index was highest at 60 × 60 cm spacing. Leaf area index (LAI), total chlorophyll content and harvest index were highest when 150 kg N ha^{-1} + 100 kg P ha^{-1} was applied. NAR, RGR and CGR were not influenced by N and P rates.

CHAPTER III

MATERIALS AND METHODS

This chapter deals with the materials and methods that were used in the experiment. It includes a short description of the location of the experimental plot, characteristic of soil, climate, materials of the experiment, raising of seedlings, treatments, layout and design, land preparation, manuring and fertilizing, transplanting, intercultural operations, harvesting, collection of data and statistical analysis which are given below:

3.1 Location of the experimental field

The research work was conducted at Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, during the period from October 2018 to April 2019. The location of the site was 23°74′ N Latitude and 90°35′ E Longitude with an elevation of 8.2 meters from the sea level (Anon, 1987) and presented in Appendix I.

3.2 Agro-ecological region

The experimental site belongs to the agro-ecological zone of "Madhupur Tract", AEZ-28 (Anon., 1988a). This was an area of complex alleviation and soils created over the Madhupur clay, where floodplain sediments covered the analyzed edges of the Madhupur Tract leaving little hillocks of red soils as 'islands' encompassed by floodplain (Anon., 1988b). For better understanding, the experimental site is shown in the AEZ Map of Bangladesh in Appendix I.

3.3 Climate of the experimental area

The geographical location of the experimental site was situated in the subtropical zone; the macroclimate was characterized by heavy rainfall during the months from April to September (Kharif season) and scantly rainfall during the rest month of the year (Rabi season). Information regarding average monthly the maximum and minimum temperature, rainfall and relative humidity and sunshine hour as recorded by the weathering yard, Bangladesh Meteorological

Department (Climate Division), Agargaon, during the period of study has been presented in Appendix II.

3.4 Soil characteristics

The experiment was done in a typical crop growing soil belonging to the Madhupur Tract. Topsoil was silty clay in texture, red-brown terrace soil type, olive-grey with common fine to medium particular dark yellowish brown mottles. Soil pH was 5.6 and had organic carbon 0.45%. The experimentation land was well-drained with good irrigation facilities. The experimental site was a medium high land. It was above flood level. Sufficient sunshine was available during the experimental period. The morphological characters of the soil of the experimental plots are as following - Soil series: Tejgaon, General soil: Non-calcareous dark grey (Appendix III). The physicochemical properties of the soil are presented in Appendix III.

3.5 Plant materials used

The variety of chilli used in the experiment was ‘BARI morich-2’. The seed was collected from the Bangladesh Agricultural Research Institute (BARI).

3.6 Raising the seedlings

Chilli seedlings were raised in the seedbed of 1.8 m × 1.5 m size. The soil was well prepared and converted into loose friable condition to obtain good tilth. All weeds, stubbles and dead root were removed. 20 grams of seeds were sown in two seedbeds. The seeds were sown in the seedbed on 22 October 2018. Seeds were then covered with finished light soil and shading was provided by polythene bags to protect the young seedlings from scorching sunshine and rainfall. Light watering weeding and mulching were done as and when necessary to provide seedlings of a good condition for growth.

3.7 Treatments of the experiment

The experiment consisted of two factors as follows:-

Factor A: It included four different levels of fertilizer management which are mentioned below with the alphabetic symbol.

F_0: control

F_1: Vermicompost (15 t/ha)

F_2: N- 110 kg/ha, P- 170 kg/ha, K- 100 kg/ha

F_3: ½ Vermicompost + ½ $N_{110}P_{170}K_{100}$ kg/ha kg/ha

Factor B: It consisted of three levels of plant spacing which are mentioned below with the alphabetic symbol.

S_1: 60cm × 30cm

S_2: 60cm × 45cm

S_3: 60cm × 60cm

There were total 12 treatment combinations were such as: F_0S_1, F_0S_2, F_0S_3, F_1S_1, F_1S_2, F_1S_3, F_2S_1, F_2S_2, F_2S_3, F_3S_1, F_3S_2 and F_3S_3.

3.8 Layout and design of the experiment

The two-factor experiment was laid out in the Randomized Complete Block Design (RCBD) with three replications. Each block consisted of 12 plots where 12 treatments combination of fertilizer management and plant spacing were assigned randomly as per the design of the experiment. There were 36 unit plots altogether in the experiment. The size of the plot was 1.8 m × 1.5 m. Block to block distance was 1 m and plot to plot was 0.5 m. Seedlings were transplanted on the plots with different spacing as per mentioned on the treatment.

3.9 Cultivation procedure

3.9.1 Land preparation

The selected plot was fallow at the time of period of land preparation. The land was opened on 02 November 2018 with the help of the power tiller and then it was kept open to the sun for seven days before further ploughing, cross ploughing followed by laddering. The weeds and stubbles were removed after each laddering. Simultaneously the clods were broken and the soil was made into good tilth for transplanting.

3.9.2 Application of fertilizers

Fertilizers were applied in the main field based on their treatments. The entire amount of TSP and MoP were applied during final land preparation. Vermicompost were applied one week before transplanting. Urea was applied in three equal installments at after 25, 50 and 70 days, respectively.

3.9.3 Transplanting the seedlings

Thirty days old healthy and uniform sized seedlings were transplanted in the experimental plots on 24 November 2018. The seedbed was watered one hour before uprooting the seedlings to minimize the damage to the roots of the seedlings. Transplanting was done in the afternoon. During transplanting of seedling, 60 cm × 30 cm, 60 cm × 45 cm and 60 cm × 60 cm spacing were followed. 12 plants were transplanted in each unit plot. The seedlings were watered immediately after transplanting. To protect from scorching sunshine and unexpected rain, banana leaf sheath pieces were used over the transplanted seedlings. Shading and watering were continued until the seedlings were well established and it required for 6 days. Some treated seedlings were planted on the border of the experimental plots for gap filling.

3.9.4 Gap filling

Very few seedlings were damaged after transplanting and such seedling was replaced by new seedlings from the same stock planted earlier on the border of the experimental plots. The seedlings were transplanted with a mass of root attached with soil ball to avoid transplanting shock.

3.9.5 Intercultural operations

The plants were kept under careful observation. Light watering was done every morning and afternoon following transplanting and was continued for 6 days for the early and well-established of the seedlings. Weeding and other intercultural operations were done as and when required. Earthing up was done on both sides of rows after 60 days of transplanting, using the soil from the space between the rows.

3.9.6 Control of pest and disease

Insect attack was a serious problem at the time of the establishment of the seedling. Mole cricket, field cricket and cut warm attacked the young transplanted seedlings. Ripcord was applied for controlling the soil-born insects. Cutworms were controlled both mechanically and spraying by Dursban 20 EC @ 3%. Some of the plants were attacked by aphids and were controlled by spraying Diazinon 60 EC@ 560 ml/ha. Few plants were infected by Alternaria leaf spot disease caused by *Alternaria brasicae.* To prevent the spread of disease Emitaf 20 SL were sprayed.

3.9.7 Harvesting

The crop was harvested during the period from 20 March 2015 to 20 April 2015 when the chilli was completely mature. Harvesting was done plot-wise after testing the maturity of the chilli by the thumb.

3.10 Data collection

When the fruit was well mature, the fruits were harvested at random from each unit plot. Plants were randomly selected from each plot and data were recorded according to the characters were studied. However, for yield per plot, all plants of each unit plot were considered.

3.10.1 Plant height

Plant height was taken to the length between the base of the plant and the shoot tip. The plant height was recorded at 30, 60 and 90 days after transplanting (DAT).

3.10.2 Number of branches per plant

The number of branch per plant was manually counted at 30 and 60 days after transplanting from tagged plants. The average of five plants was computed and expressed in the average number of branch per plant.

3.10.3 Number of leaves per plant

The number of leaves per plant was manually counted at 30, and 60 days after transplanting on tagged plants. The average of five plants was computed and expressed in the average number of leaves per plant.

3.10.4 Length of fruit

The length of fruit was measured with a meter scale from the neck of the fruit to the bottom of 10 randomly selected marketable fruits from each plot and there average was taken and expressed in cm.

3.10.5 Weight of dry fruits

The weight of dry fruit was measured with a digital weighing machine from 10 randomly selected marketable dried fruits from each unit plot and there average was taken and expressed in gram.

3.10.6 Number of dry fruits per plant

The total number of dry fruits produced in a plant was counted and recorded.

3.10.7 Yield per plant dry fruits

The yield per plant dry fruits was measured by totalling the head yield of each plant separately during the period from first to final harvest and was recorded in gram (g).

3.10.8 Yield per plot dry fruits

The yield per plot dry fruits was measured by totalling the head yield of each unit plot separately during the period from first to final harvest and was recorded in gram (g).

3.10.9 Yield per hectare dry fruits

The yield per hectare dry fruits was calculated from per plot dry fruits yield data and their average was taken. It was measured by the following formula,

$$\text{Yield per hectare dry fruits (ton)} = \frac{\text{Yield per plot dry fruits (kg)} \times 10000}{\text{Area of plot in square meter} \times 1000}$$

3.10.10 Number of seeds per fruit

The number of seeds per fruit from five randomly selected fruits of each plant were counted at harvest and mean values were calculated.

3.10.11 Weight of 1000 seeds

500 seeds were counted from the tagged plant of each of the plot and weight was taken with the help of electrical balance then the weight of 500 seeds was multiplied by 2 to get 1000 seed weight.

3.10.12 Seed yield per plant

The ripe fruits were harvested per plant as experimental treatments and seeds were collected and threshed. Seeds were cleaned and properly dried under the sun. Then seed yield per plant was recorded at 12% moisture level and weighted as gram.

3.10.13 Seed yield per plot

The ripe fruits were harvested per plot as experimental treatments and seeds were collected and threshed. Seeds were cleaned and properly dried under the sun. Then seed yield per plot was recorded at 12% moisture level and weighted as gram.

3.10.14 Seed yield per hectare

The ripe fruits were harvested per plot as experimental treatments and seeds were collected and threshed. Seeds were cleaned and properly dried under the sun. Then seed yield per plot was recorded at 12% moisture level and converted into ha^{-1}.

3.10.15 Germination percentage

After harvesting germination test was done in the central laboratory of Sher-e-Bangla Agricultural University. Twenty five seeds were placed in each petri dish and germinated seedlings were counted. Finally, total number was converted as percentage.

3.10.16 Root length (cm) plant^{-1}

The root length of five seedlings from each sample was recorded finally at 15 DAS. Measurement was done using a meter scale and unit was expressed in centimeter (cm).

3.10.17 Shoot length (cm) plant^{-1}

The shoot length of five seedlings from each sample was measured finally at 15 DAS. Measurement was done using the unit centimeter (cm) by a meter scale.

3.10.18 Seedling length (cm)

Plant heights of five randomly selected plants from each petridish were measured at 15 days after sowing (DAS).

3.11 Statistical analysis

The data obtained for different characters were statistically analyzed to find out the significance of variance resulting from the experimental treatments. All mean data were analyzed two way ANOVA via SPSS software version 20. Comparisons of the mean data and standard error (S.E) were determined by DMRT (Duncuns multiple range tests) at $p \leq 0.5$ level significance (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

This chapter comprises of the presentation and discussion of the results obtained from the present study. The results have been presented, discussed and possible interpretations were given in tabular and graphical forms. The results obtained from the experiment have been presented under separate headings and sub-headings as follows:

4.1 Plant height

There was marked variation was observed on plant height due to fertilizer management under the experiment (Table 1). From the results of the experiment showed that at 30 DAT, the highest plant height (32.65 cm) was recorded from F_3 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$) treatment where the lowest plant height (24.16 cm) was observed from F_0 (control) treatment which was statistically identical with F_1 (Vermicompost (15 t/ha)) and F_2(N-110 kg/ha, P-170 kg/ha, K-100 kg/ha) treatment. At 60 DAT, the highest plant height (45.39 cm) from F_3 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$) treatment where the lowest plant height (35.62 cm) was obtained from F_0 (control) treatment. At 90 DAT, the highest and lowest plant height (94.28 cm and 81.84 cm) was obtained from treatment F_3 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$) and F_0 (control) treatment. Application of proper fertilizer increases the plant height. Similar results also found by Bai and Sudha (2015), Thakur *et al.* (2018), Fatemi *et al. (*2012) and Kattimani and Shashidhara (2006).

A significant effect was observed on plant height due to variation in spacing (Table 1). From the result of the experiment showed that at 30 DAT, highest plant height (30.63 cm) was obtained from S_3 (60cm × 60cm) treatment which was statistically identical with treatment S_2 (60cm × 45cm) and the lowest plant height (23.28 cm) was recorded from S_1 (60cm × 30cm) treatment. At 60 DAT, the highest plant height (43.75 cm) was found from S_3 (60cm × 60cm) treatment where the lowest plant height (35.75 cm) was observed from S_1 (60cm × 30cm) treatment. At 90 DAT, the highest plant height (92.68 cm) was recorded from S_3 (60cm × 60cm) treatment which was statistically identical with treatment S_2 (60cm × 45cm) where the lowest plant height (81.25 cm) was observed from treatment S_1 (60cm × 30cm). Similar results also observed by Sharma and Kumar (2017), Bhuvaneswari *et al.* (2014) and Bai and Sudha (2015).

Table 1. Effect of fertilizer management and spacing on plant height (cm) at different days after transplanting (DAT) of chilli

Treatments	Plant height (cm) at		
	30 DAT	60 DAT	90 DAT
Fertilizer management			
F_0	24.16 ± 1.65 b	35.62 ± 1.73 c	81.84 ± 1.72 c
F_1	27.44 ± 1.44 b	40.02 ± 1.49 b	86.87 ± 1.82 bc
F_2	25.38 ± 0.56 b	38.08 ± 0.77 bc	89.14 ± 1.76 b
F_3	32.65 ± 1.08 a	45.39 ± 1.23 a	94.28 ± 1.79 a
Level of significance	*	*	*
Spacing			
S_1	23.28 ± 1.29 b	35.75 ± 1.39 c	81.25 ± 1.38 b
S_2	28.31 ± 0.89 a	39.83 ± 1.04 b	90.16 ± 1.44 a
S_3	30.63 ± 1.11 a	43.75 ± 1.26 a	92.68 ± 1.39 a
Level of significance	*	*	*

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

F_0: control

F_1: Vermicompost (15 t/ha)

F_2: N-110 kg/ha, P-170 kg/ha, K-100 kg/ha

F_3: ½ Vermicompost + ½ $N_{110}P_{170}K_{100}$

S_1: 60cm × 30cm

S_2: 60cm × 45cm

S_3: 60cm × 60cm

Significant influence was observed on plant height due to the combined effect of fertilizer management and spacing (Table 2). From the result of the experiment showed that at 30 DAT, the highest plant height (36.44 cm) was observed from F_3S_3 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$ + 60cm × 60cm) treatment combination where the lowest plant height (17.72 cm) was observed from F_0S_1 (control + 60cm × 30cm) treatment combination. At 60 DAT, the highest plant height (50.14 cm) was observed from F_3S_3 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$ + 60cm × 60cm) treatment combination where the lowest plant height (29.50 cm) was observed from F_0S_1 (control + 60cm × 30cm) treatment combination. At 90 DAT, the highest plant height (98.75 cm) was observed from F_3S_3 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$ + 60cm × 60cm) treatment combination which was statistically identical to F_3S_2 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$ + 60cm × 45 cm) treatment combination. On the other hand, at 90 DAT, the lowest plant height (75.01 cm) was found from F_0S_1 (control + 60cm×30cm) treatment combination.

Table 2. Combined effect of fertilizer management and spacing on plant height (cm) at different days after transplanting (DAT) of chilli

Treatments	Plant height (cm) at		
	30 DAT	**60 DAT**	**90 DAT**
F_0S_1	17.72 ± 0.64 i	29.50 ± 0.56 e	75.01 ± 0.55 h
F_0S_2	26.53 ± 0.58 ef	36.36 ± 1.23 d	84.15 ± 0.87ef
F_0S_3	28.26 ± 0.37 de	41.09 ± 0.86 c	86.56 ± 0.54 de
F_1S_1	22.04 ± 0.54 h	34.54 ± 0.54 d	79.56 ± 0.65 g
F_1S_2	29.51 ± 1.15 cd	41.56 ± 0.91 bc	89.15 ± 1.44 cd
F_1S_3	30.83 ± 0.73 bc	44.34 ± 1.15 b	91.49 ± 0.87 bc
F_2S_1	24.07 ± 0.84 gh	37.12 ± 1.21 d	82.50 ± 0.49 fg
F_2S_2	25.17 ± 0.71 fg	37.25 ± 1.01d	91.15 ± 1.07 bc
F_2S_3	27.12 ± 0.53 ef	40.11 ± 1.44c	93.75 ± 1.01 b
F_3S_1	29.41 ± 0.55 cd	42.03 ± 0.58bc	87.57 ± 0.56 d
F_3S_2	32.11 ± 0.87 b	44.16 ± 0.66b	96.52 ± 1.15 a
F_3S_3	36.44 ± 0.51 a	50.14 ± 0.48a	98.75 ± 0.44 a
Level of significance	*	*	*

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

4.2 Number of branches per plant

Significant variation was marked on the number of branches per plant due to the influence of fertilizer management (Table 3). From the results of the study showed that at 30 DAT, the maximum number of branches (10.53) per plant was achieved from F_3 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$) treatment which was statistically similar with the treatment F_2 (N-110 kg/ha, P-170 kg/ha, K-100 kg/ha) where the minimum number of branches (4.11) per plant was recorded from F_0 (control) treatment. At 60 DAT, the maximum number of branches (11.26) was found from treatment F_3 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$) treatment which was statistically similar with F_2 (N-110 kg/ha, P-170 kg/ha, K-100 kg/ha) treatment where the minimum number of branches (5.17) per plant was recorded from F_0 (control) treatment. Similar trends also observed by Khan *et al.* (2014), Idan (2016), El-Tohamy *et al*. (2006) and Bhuvaneswari *et al.* (2013).

There was a marked significant effect on the number of branches per plant due to different spacing (Table 3). At 30 DAT, the maximum number of branches (10.12) per plant was observed from S_3 (60cm × 60cm) treatment which was statistically identical to S_2 (60cm × 45cm) treatment where the minimum number of branches (4.58) per plant was observed from S_1 (60cm × 30cm) treatment. At 60 DAT, the maximum number of branches (11.13) per plant was observed from treatment S_3 (60cm × 60cm) which was statistically identical to S_2 (60cm × 45cm) treatment where the minimum number of branches (5.63) per plant was observed from S_1 (60cm × 30cm) treatment. Yield and yield contributing characters were significantly influenced by spacing. Similar trends were observed by Alam *et al.* (2011), Kumar and Rana (2018), Sharma and Kumar (2017), Bhuvaneswari *et al.* (2014) and Thakur *et al*. (2018).

Table 3. Effect of fertilizer management and spacing on the number of branches per plant at different days after transplanting (DAT) of chilli

Treatments	Number of branches per plant at	
	30 DAT	60 DAT
Fertilizer management		
F_0	4.11 ± 0.59 c	5.17 ± 0.66 c
F_1	7.33 ± 0.93 b	8.49 ± 0.83 b
F_2	8.36 ± 0.78 ab	9.48 ± 0.72 ab
F_3	10.35 ± 1.10 a	11.26 ± 1.02 a
Level of significance	*	*
Spacing		
S_1	4.58 ± 0.51 b	5.63 ± 0.55 b
S_2	7.91 ± 0.84 a	9.02 ± 0.83 a
S_3	10.12 ± 0.78 a	11.13 ± 0.79 a
Level of significance	*	*

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

F_0: control

F_1: Vermicompost (15 t/ha)

F_2: N-110 kg/ha, P-170 kg/ha, K-100 kg/ha

F_3: ½ Vermicompost + ½ $N_{110}P_{170}K_{100}$

S_1: 60cm × 30cm

S_2: 60cm × 45cm

S_3: 60cm × 60cm

There was marked variation was observed on the number of branches per plant due to the combined effect of fertilizer management and spacing (Table 4). From the results of the experiment showed that at 30 DAT, the maximum number of branches (13.16) per plant was achieved from F_3S_3 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$ + 60cm × 60cm) treatment combination which was statistically similar to F_3S_2 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$ + 60cm × 45 cm) treatment combination where the minimum number of branches (2.33) per plant was obtained from F_0S_1 (control + 60cm×30cm) treatment combination which was statistically identical to F_0S_2 (control + 60cm×45cm) and F_1S_1 (Vermicompost (15 t/ha) + 60cm×30cm) treatment combination. At 60

DAT, the maximum number of branches (14.03) per plant was achieved from F_3S_3 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$ + 60cm × 60cm) treatment combination which was statistically similar with F_3S_2 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$ + 60cm × 45 cm) treatment combination where the minimum number of branches (3.16) per plant was recorded from F_0S_1 (control + 60cm×30cm) treatment combination.

Table 4. Combined effect of fertilizer management and spacing on the number of branches per plant at different days after transplanting (DAT) of chilli

Treatments	Number of branches per plant at	
	30 DAT	**60 DAT**
F_0S_1	2.33 ± 0.44 e	3.16 ± 0.60 f
F_0S_2	4.66 ± 0.57 e	5.13 ± 0.69 e
F_0S_3	6.45 ± 0.58 d	7.20 ± 0.61 d
F_1S_1	4.24 ± 0.65 e	5.17 ± 0.59 e
F_1S_2	8.11 ± 0.59 c	9.14 ± 0.74 c
F_1S_3	10.13 ± 0.64 b	11.18 ± 0.56 b
F_2S_1	6.05 ± 0.55 d	7.09 ± 0.59 d
F_2S_2	8.13 ± 0.51 c	9.21 ± 0.61 c
F_2S_3	11.17 ± 0.53 b	12.15 ± 0.66 b
F_3S_1	6.01 ± 0.45 d	7.10 ± 0.57 d
F_3S_2	11.67 ± 0.48 ab	12.63 ± 0.32 ab
F_3S_3	13.16 ± 0.49 a	14.03 ± 0.51 a
Level of significance	*	*

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

4.3 Number of leaves per plant

Significant influence was observed on the number of leaves per plant due to the variation of fertilizer management (Table 5). From the results of the study showed that at 30 DAT, the maximum number of leaves (24.25) per plant was recorded from F_3 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$) treatment where the minimum number of leaves (19.73) per plant was observed from F_0 (control) treatment which was statistically similar with F_1 (Vermicompost (15 t/ha)) treatment. At 60 DAT, the maximum number of leaves (42.75) was found from F_3 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$) treatment where the minimum number of leaves (28.74) per plant was observed from F_0 (control) treatment. Similar trends found by Ali *et al.* (2011), Khan *et al.* (2014), Bhuvaneswari *et al.* (2013), El-Tohamy *et al*. (2006) and Aminifard *et al*. (2012).

A significant effect was observed on the number of leaves per plant due to different spacing under the study (Table 5). At 30 DAT, the maximum number of leaves (26.83) per plant was observed from S_3 (60cm × 60cm) treatment which was statistically identical to S_2 (60cm × 45cm) treatment where the minimum number of leaves (19.98) per plant was observed from S_1 (60cm × 30cm) treatment. At 60 DAT, the maximum number of leaves (38.82) per plant was recorded from S_3 (60cm × 60cm) treatment which was statistically identical to S_2 (60cm × 45cm) treatment where the minimum number of leaves (30.05) per plant was observed from S_1 (60cm × 30cm) treatment. Similar results also found by Islam *et al.* (2011) and Maya *et al.* (1999).

Table 5. Effect of fertilizer management and spacing on the number of leaves per plant at different days after transplanting (DAT) of chilli

Treatments	Number of leaves per plant at	
	30 DAT	**60 DAT**
Fertilizer management		
F_0	19.73 ± 1.09 c	28.74 ± 0.98 c
F_1	21.87 ± 0.79 bc	35.27 ± 0.86 b
F_2	24.25 ± 0.84 b	36.35 ± 0.93 b
F_3	28.73 ± 1.45 a	42.75 ± 1.13 a
Level of significance	*	*
Spacing		
S_1	19.98 ± 0.94 b	30.05 ± 0.85 b
S_2	24.12 ± 0.92 a	35.97 ± 0.95 a
S_3	26.83 ± 1.29 a	38.82 ± 1.18 a
Level of significance	*	*

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

F_0: control
F_1: Vermicompost (15 t/ha)
F_2: N-110 kg/ha, P-170 kg/ha, K-100 kg/ha
F_3: ½ Vermicompost + ½ $N_{110}P_{170}K_{100}$

S_1: 60cm × 30cm
S_2: 60cm × 45cm
S_3: 60cm × 60cm

There was a marked difference was observed on the number of leaves per plant due to the combined effect of fertilizer management and spacing (Table 6). From the results of the experiment showed that at 30 DAT, the maximum number of leaves (33.75) per plant was recorded from F_3S_3 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$ + 60cm × 60cm) treatment combination where the minimum number of leaves (15.66) per plant was obtained from F_0S_1 (control + 60cm×30cm) treatment combination. At 60 DAT, the maximum number of leaves (43.75) per plant was obtained from F_3S_3 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$ + 60cm × 60cm) treatment combination where the minimum number of leaves (23.64) per plant was obtained from F_0S_1 (control + 60cm×30cm) treatment combination which was statistically similar with F_0S_2 (control + 60cm×45cm) and F_1S_1 (Vermicompost (15 t/ha) + 60cm×30cm) treatment combination.

Table 6: Combined effect of fertilizer management and spacing on the number of leaves per plant at different days after transplanting (DAT) of chilli

Treatments	Number of leaves per plant at	
	30 DAT	**60 DAT**
F_0S_1	15.66 ± 0.56 h	23.64 ± 0.47 h
F_0S_2	20.76 ± 0.54 g	31.78 ± 0.54 gh
F_0S_3	22.75 ± 0.56 ef	34.53 ± 0.56 ef
F_1S_1	19.10 ± 0.88 g	27.43 ± 0.59 f-h
F_1S_2	22.31 ± 0.57 e-g	33.31 ± 0.55 ef
F_1S_3	24.22 ± 0.67 de	35.29 ± 0.53 de
F_2S_1	21.26 ± 0.69 e	31.26 ± 0.65 e
F_2S_2	24.93 ± 0.46 d	33.91 ± 0.58 de
F_2S_3	26.64 ± 0.41 c	35.55 ± 0.77 c
F_3S_1	23.96 ± 0.96 d-f	34.94 ± 0.72 de
F_3S_2	28.54 ± 0.31 b	37.54 ± 0.45 b
F_3S_3	33.75 ± 0.37 a	43.75 ± 0.41 a
Level of significance	*	*

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

4.4 Fruit length (cm)

Significant variation was found on fruit length influenced by the variation of different fertilizer management (Table 7). Results showed that the highest fruit length (7.11 cm) was obtained from F_3 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$) treatment which was statistically similar to F_2 (N-110 kg/ha, P-170 kg/ha, K-100 kg/ha) treatment where the lowest fruit length (4.88 cm) was obtained from F_0 (control) treatment. Khan *et al.* (2014), Bahuguna *et al*. (2016), Naeem *et al*. (2002), Ali *et al.* (2011), Idan (2016) and Roy *et al*. (2011) were also observed the similar results.

Significant variation was observed on fruit length due to variation in spacing (Table 7). Results showed that highest fruit length (6.80 cm) was found from treatment S_3 (60cm × 60cm) treatment which was statistically similar with S_2 (60cm × 45cm) treatment where the lowest fruit length (5.89 cm) was achieved from S_1 (60cm × 30cm) treatment. Alam *et al.* (2011), Kumar and Rana (2018), Sharma and Kumar (2017), Bhuvaneswari *et al.* (2014), Lee et *al.* (2006) and Thakur *et al.* (2018) also found the similar results.

There was marked variation was observed on fruit length due to the combined effect of fertilizer management and spacing (Table 8). From the results of the experiment showed that highest fruit length (7.43 cm) was obtained from F_3S_3 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$ + 60cm × 60cm) treatment combination which was statistically similar with F_3S_2 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$ + 60cm × 45 cm) and F_2S_3 (N-110 kg/ha, P-170 kg/ha, K-100 kg/ha + 60cm × 60cm) treatment combination where the lowest fruit length (4.50 cm) was obtained from F_0S_1 (control + 60cm×30cm) treatment combination which was statistically similar with F_0S_2 (control + 60cm×45cm) treatment combination.

4.5 Weight of dry fruits (g)

Significant variation was found on the weight of dry fruits influenced by the variation of different fertilizer management (Table 9). Results showed that highest weight of dry fruits (0.84 g) was obtained from F_3 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$)

treatment which was statistically identical to F_1 (Vermicompost (15 t/ha)) treatment and F_2 (N-110 kg/ha, P-170 kg/ha, K-100 kg/ha) treatment where the lowest weight of dry fruits (0.59 g) was obtained from the treatment of F_0 (control). Idan (2016), Khan *et al*. (2014), Bahuguna *et al*. (2016), Naeem *et al*. (2002) and Roy *et al*. (2011) were also observed the similar results.

Significant variation was found on the weight of dry fruits due to variation in spacing (Table 9). Results showed that highest weight of dry fruits (0.81 g) was obtained from S_3 (60cm × 60cm) treatment which was statistically identical to S_2 (60cm × 45cm) treatment where the lowest weight of dry fruits (0.68 g) was obtained from S_1 (60cm × 30cm) treatment. Sharma and Kumar (2017), Thakur *et al.* (2018) and Bai and Sudha (2015) were also showed similar results from the experiment.

There was marked variation was observed on the weight of dry fruits per plant due to the combined effect of fertilizer management and spacing (Table 10). From the results of the experiment showed that highest weight of dry fruits (0.89 g) per plant was obtained from F_3S_3 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$ + 60cm × 60cm) treatment combination which was statistically identical to F_3S_2 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$ + 60cm × 45 cm), F_2S_3 (N-110 kg/ha, P-170 kg/ha, K-100 kg/ha + 60cm × 60cm), F_2S_2 (N-110 kg/ha, P-170 kg/ha, K-100 kg/ha + 60cm × 45cm), F_1S_3 (Vermicompost (15 t/ha) + 60cm×60cm) and F_1S_2 (Vermicompost (15 t/ha) + 60cm×45cm) treatment combination where the lowest weight of dry fruits (0.50 g) per plant was obtained from F_0S_1 (control + 60cm×30cm) treatment combination which was statistically dissimilar with other treatments under the present study.

Table 7. Effect of fertilizer management and spacing on the fruit length and weight of dry fruits of chilli

Treatments	Fruit length (cm)	Weight of dry fruits (g)
Fertilizer management		
F_0	4.88 ± 0.14 c	0.59 ± 0.03 b
F_1	6.87 ± 0.16 b	0.82 ± 0.2 a
F_2	6.57 ± 0.20 ab	0.81 ± 0.1 a
F_3	7.11 ± 0.12 a	0.84 ± 7.42 a
Level of significance	*	*
Spacing		
S_1	5.89 ± 0.27 b	0.68 ± 0.03 b
S_2	6.41 ± 0.26 ab	0.80 ± 0.02 a
S_3	6.80 ± 0.0.32 a	0.81 ± 0.03 a
Level of significance	*	*

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

F_0: control
F_1: Vermicompost (15 t/ha)
F_2: N-110 kg/ha, P-170 kg/ha, K-100 kg/ha
F_3: ½ Vermicompost + ½ $N_{110}P_{170}K_{100}$

S_1: 60cm × 30cm
S_2: 60cm × 45cm
S_3: 60cm × 60cm

Table 8. Combined effect of fertilizer management and spacing on fruit length (cm) and weight of dry fruits of chilli

Treatment	Fruit length (cm)	Weight of dry fruits (g)
F_0S_1	4.5 ± 0.35 g	.52 ± 0.03 d
F_0S_2	4.93 ± 0.12 fg	.61 ± 0.02 c
F_0S_3	5.23 ± 0.13 f	.68 ± 0.01 b
F_1S_1	6.33 ± 0.89 de	.73 ± 0.01 b
F_1S_2	6.9 ± 0.58 bc	.88 ± 0.03 a
F_1S_3	7.4 ± 0.60 ab	.85 ± 0.02 a
F_2S_1	5.86 ± 0.14 e	.75 ± 0.02 b
F_2S_2	6.73 ± 0.24 cd	.82 ± 0.03 a
F_2S_3	7.23 ± 0.12 a-c	.84 ± 0.01 a
F_3S_1	6.86 ± 0.17 c	.74 ± 0.02 b
F_3S_2	7.16 ± 0.19 a-c	.85 ± 0.03 a
F_3S_3	7.43 ± 0.20 a	.89 ± 0.01 a
Level of significance	*	*

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

4.6 Number of dry fruits per plant

There was marked variation was observed on the number of dry fruits per plant influenced by the variation of different fertilizer management (Table 9). Results showed that the maximum number of dry fruits (87.22) per plant was obtained from F_3 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$) treatment which was statistically identical to F_1 (Vermicompost -15 t/ha) and F_2 (N-110 kg/ha, P-170 kg/ha, K-100 kg/ha) treatment where the minimum number of dry fruits (59.11) per plant was obtained from the treatment F_0 (control). Idan (2016), Khan *et al.* (2014), Bahuguna *et al*. (2016), Naeem *et al*. (2002) and Roy *et al*. (2011) were also observed the similar results.

Significant influence was observed on the number of dry fruits per plant due to variation in spacing under the present study (Table 9). Results showed that the maximum number of dry fruits (91.42) per plant was obtained from S_3 (60cm × 60cm) treatment which was statistically identical to S_2 (60cm × 45cm) treatment where the minimum number of dry fruits (60.50) per plant was obtained from treatment S_1 (60cm × 30cm). A similar result was observed by Khan *et al.* (2014), Sharma and Kumar (2017), Thakur *et al.* (2018) and Bai and Sudha (2015).

Significant influence was observed on the number of dry fruits per plant due to the combined effect of fertilizer management and spacing (Table 10). From the results of the experiment showed that the maximum number of dry fruits (100.78) per plant was obtained from F_3S_3 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$ + 60cm × 60cm) treatment combination which was statistically identical to F_3S_2 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$ + 60cm × 45 cm), F_2S_3 (N-110 kg/ha, P-170 kg/ha, K-100 kg/ha + 60cm × 60cm), F_2S_2 (N-110 kg/ha, P-170 kg/ha, K-100 kg/ha + 60cm × 45cm), F_1S_3 (Vermicompost (15 t/ha) + 60cm×60cm) and F_1S_2 (Vermicompost (15 t/ha) + 60cm×45cm) treatment combination where the minimum number of dry fruits (49.66) per plant was obtained from F_0S_2 (control + 60cm×45cm) treatment combination which was statistically similar with F_0S_1 (control + 60cm×30cm) treatment combination under the present study.

4.7 Yield per plant dry fruits (g)

Significant variation was observed on yield per plant dry fruits influenced by the variation of different fertilizer management (Figure 3). Results showed that highest yield per plant dry fruits (74.11 g) were obtained from F_3 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$) treatment where the lowest yield per plant dry fruits (35.14 g) was obtained from F_0 (control) treatment. Khan *et al.* (2014), Bahuguna *et al*. (2016), Naeem *et al*. (2002), Ali *et al.* (2011), Idan (2016) and Roy *et al*. (2011) were also observed the similar results.

Significant variation was observed on yield per plant dry fruits due to variation in spacing (Figure 4). Results showed that maximum yield per plant dry fruits (75.44 g) were obtained from S_3 (60cm × 60cm) treatment which was statistically identical to S_2 (60cm × 45cm) where the minimum yield per plant dry fruits (41.33 g) was obtained from S_1 (60cm × 30cm) treatment. Alam *et al.* (2011), Pundir and Porwal (1999), Sharma and Kumar (2017), Bhuvaneswari *et al.* (2014), Thakur *et al.* (2018), Fatemi *et al. (*2012) and Islam *et al.* (2011) also found the similar results

Significant influence was observed on yield per plant dry fruits per plant due to the combined effect of fertilizer management and spacing (Table 11). From the results of the experiment showed that maximum yield per plant dry fruits (91.25 g) were obtained from F_3S_3 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$ + 60cm×60cm) treatment combination which was statistically similar with F_3S_2 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$ + 60cm×45cm) and F_1S_3 (Vermicompost (15 t/ha) + 60cm×60cm) treatment combination where the minimum yield per plant dry fruits (28.65 g) was obtained from F_0S_1 (control + 60cm×30cm) treatment combination which was statistically identical to F_0S_2 (control + 60cm×45cm) treatment combination under the present study.

4.8 Yield per plot dry fruits (kg)

Significant variation was found on yield per plot dry fruits influenced by the variation of different fertilizer management (Figure 7). Results showed that highest yield per plot dry fruits (0.71 kg) were obtained from F_3 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$) treatment where the lowest yield per plot dry fruits (0.38 kg) was obtained from F_0 (control) treatment. Similar results also achieved by Naeem *et al*. (2002), Ali *et al.* (2011), Idan (2016) and Roy *et al*. (2011).

Significant influence was observed on yield per plot dry fruits due to variation in spacing (Figure 8). Results showed that maximum yield per plot dry fruits (0.73 kg) were recorded from S_2 (60cm × 45cm) treatment where the minimum yield per plot dry fruits (0.45 kg) was achieved from S_3 (60cm×60cm) treatment. Sharma and

Kumar (2017), Bhuvaneswari *et al.* (2014) and Fatemi *et al.* (2012) were also found the similar results relevant to the experiment.

There was significant variation was observed on yield per plot dry fruits due to the combined effect of fertilizer management and spacing (Table 11). From the results of the experiment showed that maximum yield per plot dry fruits (0.87 kg) were obtained from F_3S_2 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$ + 60cm × 45 cm) treatment combination where the minimum yield per plot dry fruits (0.25 kg) was obtained from F_0S_3 (control + 60cm×60cm) treatment combination under the present study.

4.9 Yield per hectare dry fruits (t)

Significant variation was found on yield per hectare dry fruits influenced by the variation of different fertilizer management (Figure 11). Results showed that highest yield per hectare dry fruits (2.65 t) were obtained from F_3 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$) treatment where the lowest yield per hectare dry fruits (1.39 t) was obtained from F_0 (control) treatment. Khan *et al.* (2014), Bahuguna *et al*. (2016), Naeem *et al*. (2002), Ali *et al.* (2011), Idan (2016) and Roy *et al*. (2011) were also observed the similar results.

Significant influence was observed on yield per hectare dry fruits due to variation in spacing (Figure 12). Results showed that maximum yield per hectare dry fruits (2.69 t) were recorded from S_2 (60cm × 45cm) treatment where the minimum yield per hectare dry fruits (1.69 t) was achieved from S_3 (60cm × 60cm) treatment. Alam *et al.* (2011), Pundir and Porwal (1999), Sharma and Kumar (2017), Bhuvaneswari *et al.* (2014), Fatemi *et al. (*2012) and Islam *et al.* (2011) also found the similar results.

There was marked variation was observed on yield per hectare dry fruits due to the combined effect of fertilizer management and spacing (Table 12). From the results of the experiment showed that maximum yield per hectare dry fruits (3.21 t) were obtained from F_3S_2 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$ + 60cm×45cm) treatment combination where the minimum yield per hectare dry fruits (0.92 t) was obtained from F_0S_3 (control + 60cm×60cm) treatment combination.

Table 9. Effect of fertilizer management and spacing on the number number of dry fruits per plant, yield per plant dry fruits, yield per plot dry fruits and yield per hectare dry fruits of chilli

Treatments	Number of dry fruits per plant	Yield per plant dry fruits (g)	Yield per plot dry fruits (kg)	Yield per hectare dry fruits (t)
Fertilizer management				
F_0	59.11 ± 3.77 b	35.14 ± 3.39 c	0.38 ± 0.04 c	1.39 ± 0.17 c
F_1	86.44 ± 6.10 a	70.33 ± 1.55 b	0.64 ± 0.02 b	2.38 ± 0.08 b
F_2	85.33 ± 6.31 a	69.22 ± 2.31 b	0.63 ± 0.03 b	2.33 ± 0.07 b
F_3	87.22 ± 6.52 a	74.11 ± 2.11 a	0.71 ± 0.02 a	2.65 ± 0.13 a
Level of significance	*	*	*	*
Spacing				
S_1	60.50 ± 1.05 b	41.33 ± 8.37 b	0.62 ± 0.03 b	2.29 ± 0.12 b
S_2	86.58 ± 6.65 a	71.66 ± 6.46 a	0.73 ± 0.04 a	2.69 ± 0.18 a
S_3	91.42 ± 3.95 a	75.44 ± 5.83 a	0.45 ± 0.03 c	1.69 ± 0.13 c
Level of significance	*	*	*	*

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

F_0: control

F_1: Vermicompost (15 t/ha)

F_2: N-110 kg/ha, P-170 kg/ha, K-100 kg/ha

F_3: ½ Vermicompost + ½ $N_{110}P_{170}K_{100}$

S_1: 60cm × 30cm

S_2: 60cm × 45cm

S_3: 60cm × 60cm

Table 10. Combined effect of fertilizer management and spacing on the number of dry fruits per plant, yield per plant dry fruits, yield per plot dry fruits and yield per hectare dry fruits of chilli

Treatments	Number of dry fruits per plant (no.)	Yield per plant dry fruits (g)	Yield per plot dry fruits (kg)	Yield per hectare dry fruits (t)
F_0S_1	57.00 ± 2.08 cd	28.65 ± 2.41e	.43 ± 0.02 e	1.59 ± 0.04 e
F_0S_2	49.66 ± 6.48 d	34.34 ± 3.79 e	.44 ± 0.01 e	1.65 ± 0.02 e
F_0S_3	70.33 ± 3.84 b	42.12 ± 1.2 d	.25 ± 0.02 f	0.92 ± 0.04 f
F_1S_1	62.67 ± 2.18 bc	46.44 ± 1.85 d	.69 ± 0.03 bc	2.55 ± 0.05 bc
F_1S_2	98.75 ± 3.05 a	83.75 ± 1.15 bc	.81 ± 0.02 b	2.98 ± 0.03 b
F_1S_3	97.66 ± 2.90 a	86.67 ± 0.88 ab	.52 ± 0.01 cd	1.92 ± 0.05 cd
F_2S_1	61.23 ± 2.51 bc	44.38 ± 2.33 d	.66 ± 0.03 bc	2.44 ± 0.04 bc
F_2S_2	98.09 ± 3.1 a	83.36 ± 2.91 bc	.80 ± 0.02 b	3.01 ± 0.05 b
F_2S_3	97.17 ± 4.36 a	79.81 ± 1.17 c	.48 ± 0.01 d	1.77 ± 0.03 d
F_3S_1	61.33 ± 0.33 bc	46.11 ± 1.13 d	.69 ± 0.02 bc	2.55 ± 0.04 bc
F_3S_2	99.69 ± 2.40 a	85.33 ± 0.85 a-c	.87 ± 0.02 a	3.21 ± 0.05 a
F_3S_3	100.78 ± 1.20 a	91.25 ± 2.02 a	.55 ± 0.02 cd	2.03 ± 0.04 cd
Level of significance	*	*	*	*

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

4.10 Number of seeds per fruit (no.)

There was marked variation was observed on the number of seeds per fruit influenced by the variation of different fertilizer management (Table 17). Results showed that the maximum number of seeds per fruit (75.34) was obtained from F_3 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$) treatment which was statistically identical to F_1 (Vermicompost -15 t/ha) and F_2 (N-110 kg/ha, P-170 kg/ha, K-100 kg/ha) treatment where the minimum number of seeds per fruit (64.15) was obtained from F_0 (control) treatment. Khan *et al.* (2014), Bahuguna *et al*. (2016), Naeem *et al*. (2002) and Roy *et al*. (2011) were also observed similar results.

Significant influence was observed on the number of seeds per fruit due to variation in spacing under the present study (Table 17). Results showed that the maximum number of seeds per fruit (74.16) was obtained from S_3 (60cm × 60cm) treatment which was statistically identical to S_2 (60cm × 45cm) treatment where the minimum number of seeds per fruit (68.67) was obtained from S_1 (60cm × 30cm) treatment. Similar trends were observed by Alam *et al.* (2011), Kumar and Rana (2018), Sharma and Kumar (2017), Bhuvaneswari *et al.* (2014) and Thakur *et al.* (2018).

Significant influence was observed on the number of seeds per fruit due to the combined effect of spacing and fertilizer management (Table 18). From the results of the experiment showed that the maximum number of seeds per fruit (80.44) was obtained from F_3S_3 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$ + 60cm × 60cm) treatment combination which was statistically similar with F_1S_2 (Vermicompost (15 t/ha) + 60cm×45cm), F_1S_3 (Vermicompost (15 t/ha) + 60cm×60cm) and F_2S_3 (N-110 kg/ha, P-170 kg/ha, K-100 kg/ha + 60cm × 60cm) treatment combination where the minimum number of seeds per fruit (60.33) was obtained from F_0S_1 (control + 60cm×30cm) treatment combination under the present study.

4.11 1000 seed weight (g)

There was significant variation was observed in 1000 seeds weight influenced by the variation of different fertilizer management (Table 17). Results showed that maximum 1000 seed weight (5.92 g) was obtained from F_3 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$) treatment where the minimum 1000 seed weight (4.51 g) was obtained from F_0 (control) treatment which was statistically identical to F_1 (Vermicompost (15 t/ha) treatment. Similar results also found by Khan *et al.* (2014).

The significant influence was observed on 1000 seed weight due to variation in spacing under the present study (Table 17). Results showed that maximum 1000 seeds weight (5.61 g) was obtained from S_3 (60cm × 60cm) treatment which was statistically identical to S_2 (60cm × 45cm) treatment where the minimum 1000 seed weight (4.51 g) was obtained from S_1 (60cm × 30cm) treatment. Similar trends were observed by Alam *et al.* (2011), Kumar and Rana (2018), Sharma and Kumar (2017), Bhuvaneswari *et al.* (2014) and Thakur *et al.* (2018).

Significant influence was observed on 1000 seeds weight due to the combined effect of spacing and fertilizer management (Table 18). From the results of the experiment showed that the maximum 1000 seed weight (6.19 g) was obtained from F_3S_3 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$ + 60cm × 60cm) treatment combination which was statistically similar with F_3S_2 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$ + 60cm × 45cm) treatment combination where the minimum 1000 seed weight (3.80 g) was obtained from F_0S_1 (control + 60cm×30cm) treatment combination which was statistically similar with F_1S_1 (Vermicompost (15 t/ha) + 60cm×30cm) treatment combination.

Table 11. Effect of fertilizer management and spacing on number of seeds per fruit and 1000 seed weight of the chilli

Treatments	Number of seeds per fruit	1000 seed weight (g)
Fertilizer management		
F_0	64.15 ± 0.95 b	4.51 ± 0.18 c
F_1	74.89 ± 0.91 a	4.85 ± 0.22 c
F_2	72.11 ± 1.41 a	5.38 ± 0.21 b
F_3	75.34 ± 1.69 a	5.92 ± 0.09 a
Level of significance	*	*
Spacing		
S_1	68.67 ± 1.49 b	4.51 ± 0.22 b
S_2	71.58 ± 1.34 ab	5.39 ± 0.14 a
S_3	74.16 ± 1.91 a	5.61 ± 0.16 a
Level of significance	*	*

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

F_0: control

F_1: Vermicompost (15 t/ha)

F_2: N-110 kg/ha, P-170 kg/ha, K-100 kg/ha

F_3: ½ Vermicompost + ½ $N_{110}P_{170}K_{100}$

S_1: 60cm × 30cm

S_2: 60cm × 45cm

S_3: 60cm × 60cm

Table 12. Combined effect of fertilizer management and spacing on number of seeds per fruit and 1000 seed weight of the chilli

Treatment	Number of seeds per fruit	1000 seed weight (g)
F_0S_1	62.33 ± 1.45 e	3.80 ± 0.06 h
F_0S_2	65.14 ± 1.15 e	4.83 ± 0.08 fg
F_0S_3	64.67 ± 2.33 de	4.90 ± 0.07ef
F_1S_1	72.33 ± 1.35 bc	4.10 ± 0.11 h
F_1S_2	76.25 ± 1.53 ab	5.10 ± 0.13 e
F_1S_3	76.33 ± 0.89 ab	5.45 ± 0.09 d
F_2S_1	68.12 ± 1.73 cd	4.60 ± 0.09 g
F_2S_2	73.32 ± 1.22 bc	5.70 ± 0.06 cd
F_2S_3	75.33 ± 2.40 ab	5.86 ± 0.07 bc
F_3S_1	72.22 ± 3.05 bc	5.63 ± 0.04 cd
F_3S_2	72.33 ± 1.55 bc	5.96 ± 0.08 ab
F_3S_3	80.44 ± 0.75 a	6.19 ± 0.10 a
Level of significance		*

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

4.12 Seed yield per plant (g)

Significant variation was found on seed yield per plant influenced by the variation of different fertilizer management (Table 13). Results showed that highest seed yield per plant (9.41 g) were obtained from F_3 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$) treatment which was statistically identical to F_1 (Vermicompost (15 t/ha)) and F_2 (N-110 kg/ha, P-170 kg/ha, K-100 kg/ha) treatments where the lowest seed yield per plant (5.62 g) was obtained from F_0 (control) treatment. Khan *et al.* (2014) also found similar results.

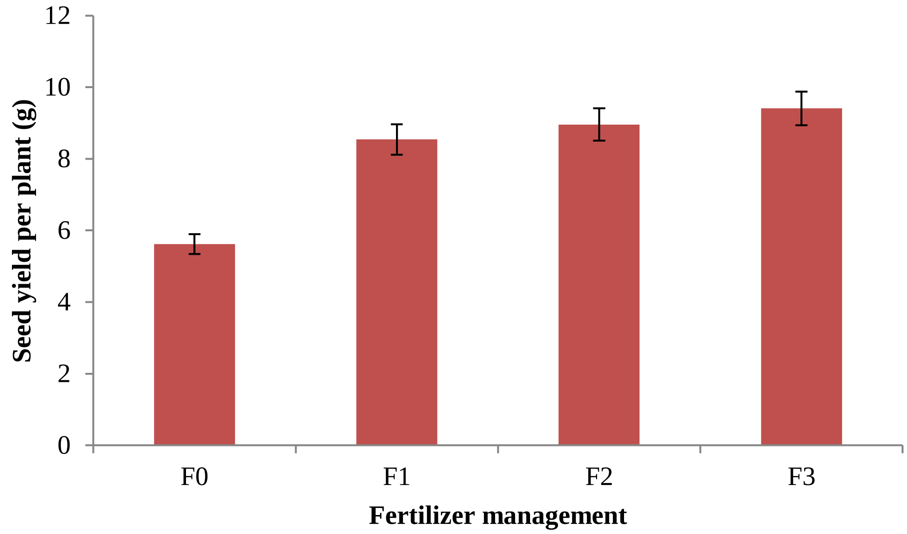

Figure 1. Effect of fertilizer management on seed yield per plant of chilli

F_0: control, F_1: Vermicompost (15 t/ha), F_2: N-110 kg/ha, P-170 kg/ha, K-100 kg/ha and F_3: ½ Vermicompost + ½ $N_{110}P_{170}K_{100}$

Significant influence was observed on seed yield per plant due to variation in spacing (Figure 2). Result showed that maximum seed yield per plant (10.07 g) was observed from S_3 (60cm × 60cm) treatment which was statistically similar with S_2 (60cm × 60cm) treatment where the minimum seed yield per plant (5.32 g) was achieved from S_1 (60cm × 60cm) treatment. Sharma and Kumar (2017), Islam *et al.* (2011) and Lee *et al.* (2006) also observed similar results.

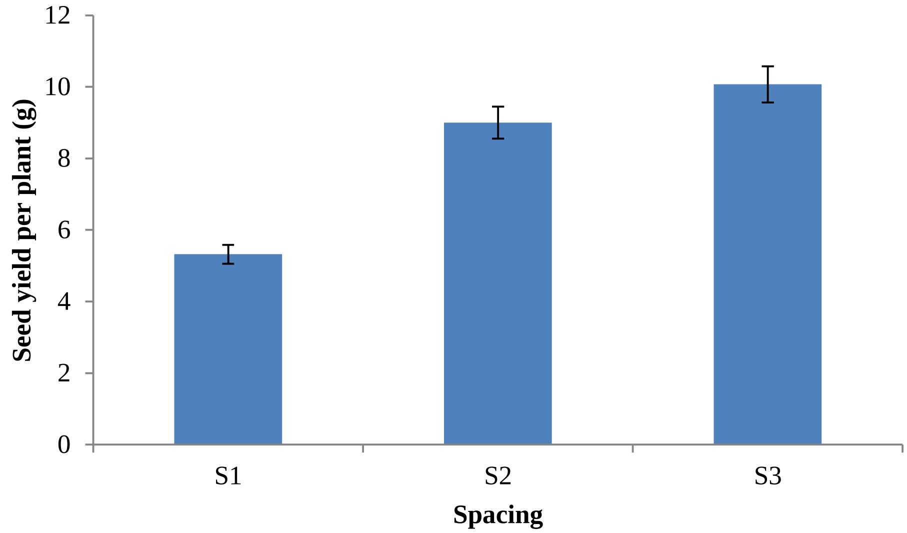

Figure 2. Effect of spacing on seed yield per plant of chilli

S_1: 60cm × 30cm, S_2: 60cm × 45cm and S_3: 60cm × 60cm

There was marked variation was observed on seed yield per plant due to the combined effect fertilizer management and spacing (Table 13). From the results of the experiment showed that maximum seed yield per plant (11.31 g) were obtained from F_3S_3 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$ + 60cm × 60cm) treatment combination which was statistically similar with F_1S_3 (Vermicompost (15 t/ha) + 60cm×60cm) and F_2S_3 (N-110 kg/ha, P-170 kg/ha, K-100 kg/ha + 60cm × 60cm) treatment combinations where the minimum seed yield per plant (2.76 g) was obtained from F_0S_1 (control + 60cm×30cm) treatment combination.

4.13 Seed yield per plot (g)

Significant variation was found on seed yield per plot influenced by the variation of different fertilizer management (Figure 3). Results showed that highest seed yield per plot (86.21 g) were obtained from F_3 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$) treatment which was statistically identical to F_1 (Vermicompost (15 t/ha) and F_2 (N-110 kg/ha, P-170 kg/ha, K-100 kg/ha) treatments where the lowest seed yield per plot (49.60 g) was obtained from F_0 (control) treatment. Khan *et al*. (2014) also found similar results.

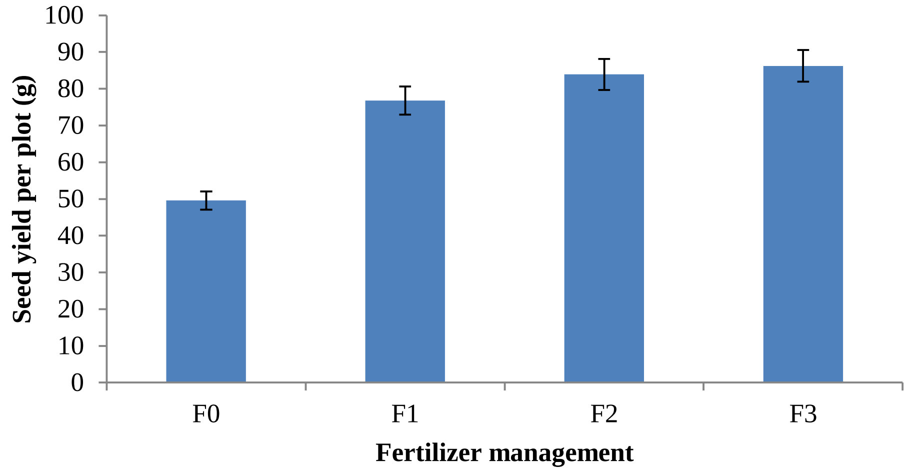

Figure 3. Effect of fertilizer management on seed yield per plot of chilli

F_0: control, F_1: Vermicompost (15 t/ha), F_2: N-110 kg/ha, P-170 kg/ha, K-100 kg/ha and F_3: ½ Vermicompost + ½ $N_{110}P_{170}K_{100}$

Significant influence was observed on seed yield per plot due to variation in spacing (Figure 4). Result showed that maximum seed yield per plot (84.73 g) was observed from S_2 (60cm × 45cm) treatment which was statistically similar with S_1 (60cm × 30cm) treatment where the minimum seed yield per plot (61.25 g) was achieved from S_3 (60cm × 60cm) treatment. Sharma and Kumar (2017) and Islam *et al.* (2011) also observed similar results.

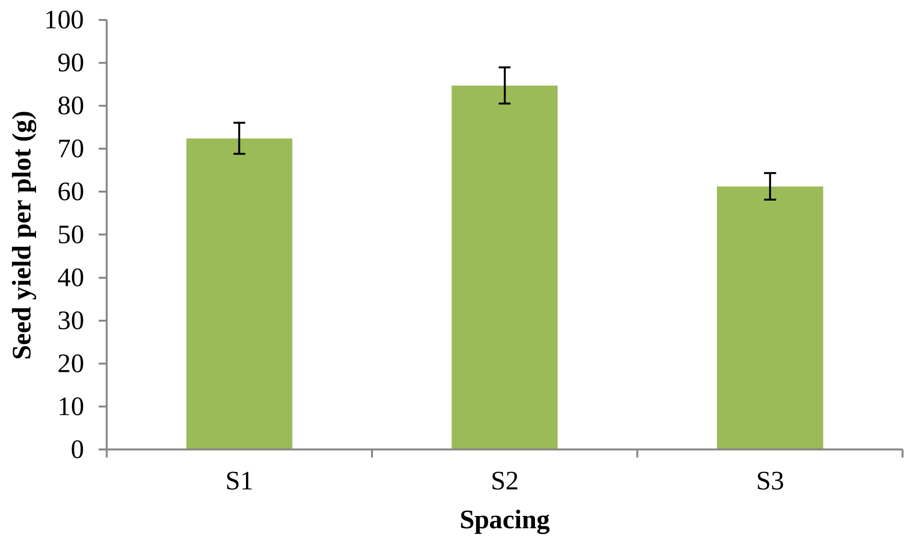

Figure 4. Effect of spacing on seed yield per plot of chilli

S_1: 60cm × 30cm, S_2: 60cm × 45cm and S_3: 60cm × 60cm

There was marked variation was observed on seed yield per plot due to the combined effect of fertilizer management and spacing (Table 13). From the results of the experiment showed that maximum seed yield per plot (95.91 g) were obtained from F_3S_2 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$ + 60cm×45 cm) treatment combination where the minimum seed yield per plot (38.83 g) was obtained from F_0S_1 (control + 60cm×30cm) treatment combination which was statistically identical to F_0S_3 (control + 60cm×60cm) treatment combination.

4.14 Seed yield per hectare

Significant variation was found on seed yield per hectare influenced by the variation of different fertilizer management (Figure 5). Results showed that highest seed yield per hectare (318.98 kg) were obtained from F_3 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$) treatment which was statistically similar with F_1 (Vermicompost (15 t/ha) and F_2 (N-110 kg/ha, P-170 kg/ha, K-100 kg/ha) treatments where the lowest seed yield per hectare (183.52 kg) was obtained from F_0 (control) treatment. Similar results also observed by Khan *et al*. (2014).

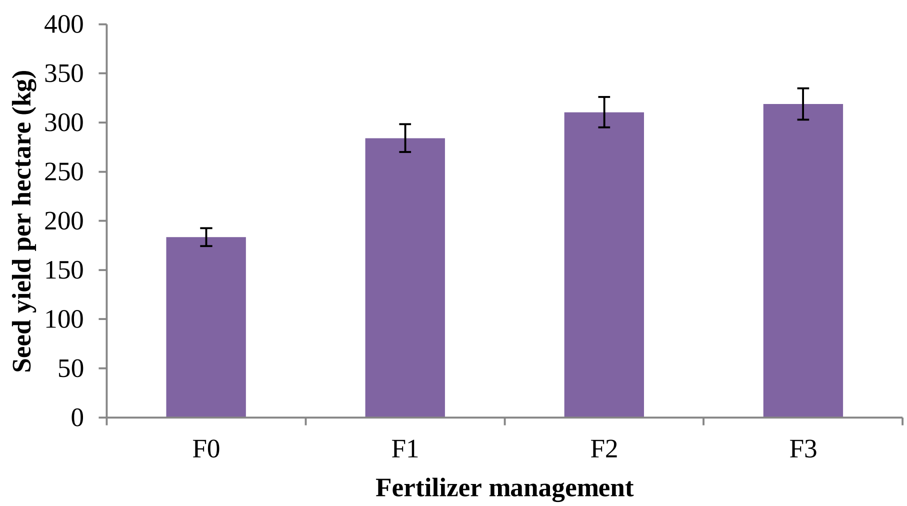

Figure 5. Effect of fertilizer management on seed yield per hectare of chilli

F_0: control, F_1: Vermicompost (15 t/ha), F_2: N-110 kg/ha, P-170 kg/ha, K-100 kg/ha and F_3: ½ Vermicompost + ½ $N_{110}P_{170}K_{100}$

Significant influence was observed on seed yield per hectare due to variation in spacing (Figure 6). Results showed that maximum seed yield per hectare (313.48 kg) were recorded from S_2 (60cm × 45cm) treatment which was statistically similar with S_1 (60cm × 30cm) treatment where the minimum seed yield per hectare (226.63 kg) was achieved from the treatment S_3 (60cm × 60cm). Sharma and Kumar (2017) and Islam *et al.* (2011) also observed similar results.

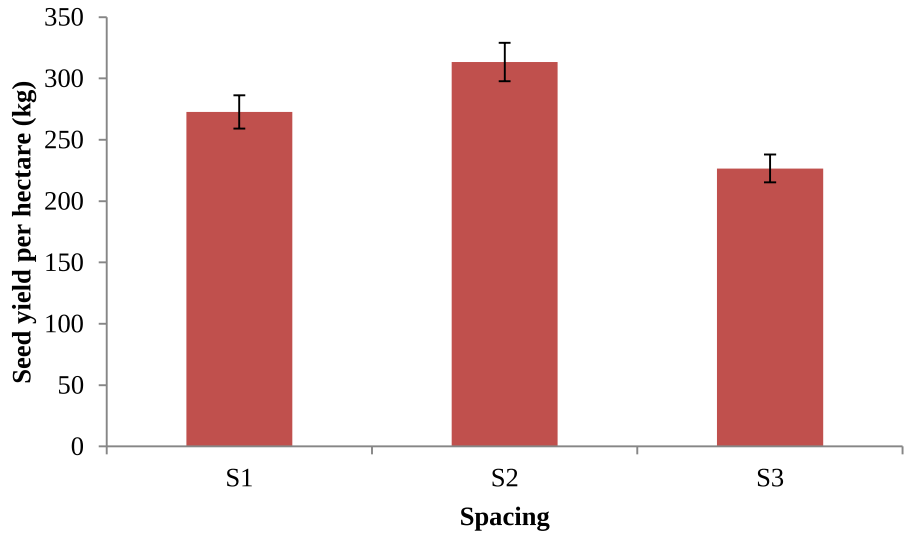

Figure 6. Effect of spacing on seed yield per hectare of chilli

S_1: 60cm × 30cm, S_2: 60cm × 45cm and S_3: 60cm × 60cm

There was marked variation was observed on seed yield per hectare due to the combined effect of fertilizer management and spacing (Table 13). From the results of the experiment showed that maximum seed yield per hectare (353.35 kg) were obtained from F_3S_2 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$ + 60cm×45 cm) treatment combination where the minimum seed yield per hectare (143.68 kg) was obtained from F_0S_1 (control + 60cm×30cm) treatment combination which was statistically identical to F_0S_3 (control + 60cm×60cm) treatment combination.

Table 13. Combined effect of fertilizer management and spacing on seed yield per plant (g), seed yield per plot (g) and seed yield per hectare (kg) of chilli

Treatments	Seed yield per plant (g)	Seed yield per plot (g)	Seed yield per hectare (kg)
F_0S_1	2.76 ± 0.15 g	38.83 ± 1.42 e	143.68 ± 5.26 e
F_0S_2	7.10 ± 0.06 e	65.96 ± 0.03 d	244.07 ± 3.12 d
F_0S_3	7.04 ± 0.05 e	44.07 ± 0.07 e	162.81 ± 2.04 e
F_1S_1	5.48 ± 0.04 f	79.33 ± 0.67 c	293.53 ± 2.47 c
F_1S_2	9.06 ± 0.12 d	84.26 ± 0.82 bc	311.78 ± 3.03 bc
F_1S_3	11.09 ± 0.02 ab	66.81 ± 1.07 d	247.16 ± 3.92 d
F_2S_1	6.46 ± 0.09 e	83.32 ± 1.95 bc	312.21 ± 6.20 bc
F_2S_2	9.50 ± 0.76 cd	90.17 ± 2.33 b	334.72 ± 6.32 b
F_2S_3	10.90 ± 0.05 ab	65.26 ± 2.71 cd	241.48 ± 4.38 cd
F_3S_1	6.60 ± 0.03 e	85.22 ± 2.11 bc	315.54 ± 4.79 bc
F_3S_2	10.33 ± 0.62 bc	95.91 ± 2.63 a	353.35 ± 3.84 a
F_3S_3	11.31 ± 0.11 a	68.93 ± 1.18 d	255.05 ± 4.37 d
Level of significance	*	*	*

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

4.15 Germination percentage (%)

There was significant variation was observed on germination percentage influenced by the variation of different fertilizer management (Table 14). Results showed that maximum germination percentage (76.88 %) was obtained from F_3 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$) treatment where the minimum germination percentage (64.55 %) was obtained from F_0 (control) treatment which was statistically identical to F_1 (Vermicompost-15 t/ha) and F_2 (N-110 kg/ha, P-170 kg/ha, K-100 kg/ha) treatment. Khan *et al*. (2014), Bahuguna *et al*. (2016), Naeem *et al*. (2002) and Roy *et al*. (2011) were also observed similar results.

Significant influence was observed on germination percentage due to variation in spacing under the present study (Table 14). Results showed that maximum germination percentage (74.41 %) was obtained from S_3 (60cm × 60cm) treatment where the minimum germination percentage (63.66 %) was obtained from S_1 (60cm

× 30cm) treatment. Similar trends were observed by Alam *et al.* (2011), Kumar and Rana (2018) and Sharma and Kumar (2017).

Significant influence was observed on germination percentage due to the combined effect of fertilizer management and spacing (Table 15). From the results of the experiment showed that the maximum germination percentage (81.33 %) was obtained from F_3S_3 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$ + 60cm × 60cm) treatment combination which was statistically similar with F_3S_2 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$ + 60cm × 45cm) treatment combination where the minimum germination percentage (58.66 %) was obtained from F_0S_1 (control + 60cm×30cm) treatment combination.

4.16 Root length (cm)

Significant variation was found on root length influenced by the variation of different fertilizer management (Table 14). Results showed that highest root length (6.37 cm) was obtained from F_3 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$) treatment where the lowest root length (3.98 cm) was obtained from F_0 (control) treatment which was statistically identical to F_1 (Vermicompost (15 t/ha) and F_2 (N-110 kg/ha, P-170 kg/ha, K-100 kg/ha) treatments. Hangarge *et al.* (2004) also observed similar results.

Significant variation was observed on root length due to variation in spacing (Table 14). Results showed that highest root length (6.02 cm) was found from S_3 (60cm × 60cm) treatment which was statistically similar with S_2 (60cm × 45cm) treatment where the lowest root length (4.97 cm) was achieved from S_1 (60cm × 30cm) treatment. Similar results also observed by Kumar and Rana (2018) and Pundir and Porwal (1999).

There was marked variation was observed on root length due to the combined effect of fertilizer management and spacing (Table 15). From the results of the experiment showed that highest root length (7.26 cm) was obtained from F_3S_3 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$ + 60cm × 60cm) treatment combination which was statistically similar with F_3S_2 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$ + 60cm × 45cm) treatment combination where the lowest root length (3.28 cm) was obtained from F_0S_1 (control + 60cm×30cm) treatment combination which was statistically similar with F_0S_2 (control + 60cm×45cm) treatment combination.

4.17 Shoot length (cm)

Significant variation was found on shoot length influenced by the variation of different fertilizer management (Table 14). Results showed that highest shoot length (8.11 cm) was obtained from F_3 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$) which was statistically identical to F_1 (Vermicompost (15 t/ha) and F_2 (N-110 kg/ha, P-170 kg/ha, K-100 kg/ha) treatments where the lowest shoot length (5.98 cm) was obtained from F_0 (control) treatment. Khan *et al.* (2014), Bahuguna *et al*. (2016), Naeem *et al*. (2002), Ali *et al.* (2011), Idan (2016) and Roy *et al*. (2011) were also observed the similar results.

Significant influence was observed on shoot length due to variation in spacing (Table 14). Results showed that highest shoot length (7.99 cm) was found from S_3 (60cm × 60cm) treatment which was statistically similar with S_2 (60cm × 45cm) treatment where the lowest shoot length (6.99 cm) was achieved from S_1 (60cm × 30cm) treatment. Kumar and Rana (2018) and Pundir and Porwal (1999) also found similar trends.

There was marked variation was observed on shoot length due to the combined effect of fertilizer management and spacing (Table 15). From the results of the experiment showed that highest shoot length (8.82 cm) was obtained from F_3S_3 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$ + 60cm × 60cm) treatment combination which was statistically similar F_3S_2 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$ + 60cm × 45cm), F_2S_3 (N-110 kg/ha, P-170 kg/ha, K-100 kg/ha + 60cm × 60cm), F_1S_2 (15 t/ha) + 60cm×45cm) and F_1S_3 (15 t/ha) + 60cm×30cm) treatment combination where the lowest shoot length (6.86 cm) was obtained from F_0S_1 (control + 60cm×30cm) treatment combination.

4.18 Seedling length (cm)

Significant variation was found on seedling length influenced by the variation of different fertilizer management (Table 14). Results showed that highest seedling length (14.28 cm) was obtained from treatment F_3 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$) which was statistically identical to F_1 (Vermicompost (15 t/ha) and F_2 (N-110 kg/ha, P-170 kg/ha, K-100 kg/ha) treatments where the lowest seedling length (10.02 cm) was obtained from the treatment F_0 (control). Khan *et al.* (2014), Bahuguna *et al*. (2016), Naeem *et al*. (2002) observed similar results.

Significant variation was observed on seedling length due to variation in spacing (Table 14). Results showed that highest seedling length (14.05 cm) was found from S_3 (60cm × 60cm) treatment which was statistically similar with S_2 (60cm × 45cm) treatment where the lowest seedling length (11.96 cm) was achieved from S_1 (60cm × 30cm) treatment. Sharma and Kumar (2017), Bhuvaneswari *et al.* (2014) and Fatemi *et al.* (2012) were also found the similar results relevant to the experiment.

There was marked variation was observed on seedling length due to the combined effect of fertilizer management and spacing (Table 15). From the results of the experiment showed that highest seedling length (15.92 cm) was obtained from F_3S_3 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$ + 60cm × 60cm) treatment combination which was statistically similar with F_3S_2 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$ + 60cm × 45cm), F_2S_3 (N-110 kg/ha, P-170 kg/ha, K-100 kg/ha + 60cm × 60cm), F_1S_2 (15 t/ha) + 60cm×45cm) and F_1S_3 (15 t/ha) + 60cm×30cm) treatment combination where the lowest seedling length (8.51 cm) was obtained from F_0S_1 (control + 60cm×30cm) treatment combination.

Table 14. Effect of fertilizer management and spacing on fruit length (cm), germination percentage (%), root length (cm), shoot length (cm) and seedling length (cm) of chilli

Treatments	Germination percentage (%)	Root length (cm)	Shoot length (cm)	Seedling length (cm)
Fertilizer Management				
F_0	64.55 ± 2.07 b	3.98 ± 0.22 b	5.98 ± 0.22 b	10.02 ± 0.45 b
F_1	66.21 ± 1.21 b	5.94 ± 0.20 b	8.08 ± 0.14 a	14.25 ± 0.29 a
F_2	68.88 ± 1.67 b	5.73 ± 0.21 b	7.81 ± 0.18 a	13.58 ± 0.37 a
F_3	76.88 ± 1.65 a	6.37 ± 0.31 a	8.11 ± 0.23 a	14.28 ± 0.44 a
Level of significance	*	*	*	*
Spacing				
S_1	63.66 ± 1.35 c	4.97 ± 0.34 c	6.99 ± 0.33 c	11.96 ± 0.64 c
S_2	69.33 ± 1.88 b	5.54 ± 0.29 ab	7.45 ± 0.27 ab	13.07 ± 0.53 ab
S_3	74.41 ± 1.28 a	6.02 ± 0.32 a	7.99 ± 0.24 a	14.05 ± 0.52 a
Level of significance	*	*	*	*

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

F_0: control

F_1: Vermicompost (15 t/ha)

F_2: N-110 kg/ha, P-170 kg/ha, K-100 kg/ha

F_3: ½ Vermicompost + ½ $N_{110}P_{170}K_{100}$

S_1: 60cm × 30cm

S_2: 60cm × 45cm

S_3: 60cm × 60cm

Table 15. Combined effects of fertilizer management and spacing on germination percentage (%), root length (cm), shoot length (cm) and seedling length (cm) of chilli

Treatments	Germination percentage (%)	Root length (cm)	Shoot length (cm)	Seedling length (cm)
F_0S_1	58.66 ± 0.58 g	3.28 ± 0.17 f	5.21 ± 0.17 e	8.51 ± 0.38 f
F_0S_2	62.66 ± 1.15 f	4.15 ± 0.09 ef	6.06 ± 0.09 d	10.25 ± 0.19 e
F_0S_3	72.33 ± 0.61 cd	4.88 ± 1.12 de	6.66 ± 0.08 d	11.61 ± 0.17 d
F_1S_1	62.66 ± 0.55 f	5.96 ± 0.19 bc	7.76 ± 0.03 bc	13.79 ± 0.47 bc
F_1S_2	65.33 ± 0.48 e	5.84 ± 0.42 bc	8.10 ± 0.31 a-c	14.28 ± 0.29 ab
F_1S_3	70.66 ± 0.45 d	6.01 ± 0.50 bc	8.38 ± 0.25 ab	14.86 ± 0.04 ab
F_2S_1	62.66 ± 1.19 f	5.29 ± 0.42 cd	7.62 ± 0.32 c	12.92 ± 0.64 c
F_2S_2	70.66 ± 0.53 d	5.79 ± 0.15 bc	7.73 ± 0.18 bc	13.57 ± 0.36 bc
F_2S_3	73.33 ± 1.24 c	6.15 ± 0.39 bc	8.11 ± 0.40 a-c	14.29 ± 0.82 a-c
F_3S_1	70.66 ± 0.64 d	5.44 ± 0.25 cd	7.40 ± 0.25 c	12.88 ± 0.07 c
F_3S_2	78.66 ± 1.28 ab	6.45 ± 0.33 ab	8.13 ± 0.15 a-c	14.64 ± 0.62 ab
F_3S_3	81.33 ± 1.42 a	7.06 ± 0.31 a	8.82 ± 0.04 a	15.92 ± 0.53 a
Level of significance	*	*	*	*

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

CHAPTER V

SUMMARY AND CONCLUSION

The field experiment was conducted at the central farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207 during the period from October 2018 to April 2019 to find out the growth, seed yield and quality of chilli as influenced by fertilizer management and spacing. The experiment consisted of two factors Factor A: Different fertilizer management such as F_0: Control, F_1: Vermicompost (15 t ha^{-1}), F_2: 110 kg ha^{-1} N, 170 kg ha^{-1}, 100 kg ha^{-1} K and F_3: ½ Vermicompost + ½ $N_{110}P_{170}K_{100}$; Factor B: Different levels of spacing such as S_1: 60 cm × 30 cm, S_2: 60 cm × 45 cm and S_3: 60 cm × 60 cm. Data on different growth and yield contributing characters were recorded.

The two factors experiment was laid out in a Randomized Complete Block (RCBD) design containing twelve treatments with 3 replications. The unit plot size was 1.8 m × 1.5 m. There were twelve numbers of treatments and total numbers of plots were thirty-six. Data were collected based on the following parameters- plant height, number of branches per plant, number of leaves per plant, fruit length, the weight of dry fruits, number of dry fruits per plant, yield per plant dry fruits, yield per plot dry fruits, yield per hectare dry fruits, number of seeds per fruit, thousand seed weight, seed yield per plant, seed yield per plot, seed yield per hectare, germination percentage, root length, shoot length and seedling length. The collected data were analyzed statistically by two way ANOVA via SPSS software version 23 and comparison mean data were determined by DMRT at 0.05 level of probability.

Most of the parameters significantly influenced by different fertilizer management and spacing that was revealed the result of the experiment.

Different levels of fertilizer management showed a significant effect on plant height, the number of branches per plant, number of leaves per plant, fruit length, weight of dry fruits, number of dry fruits per plant, yield per plant dry fruits, yield per plot dry fruits, yield per hectare dry fruits, number of seeds per fruit, thousand seed weight, seed yield per plant, seed yield per plot, seed yield per hectare, germination percentage, root length, shoot length and seedling length. The maximum plant height (94.28 cm), number of branches per plant (11.26), leaves per plant (42.75), fruit length (7.11 cm), the weight of dry fruits (0.84 g), number of dry fruits per plant (87.22 g), yield per plant dry fruits (74.11 g), dry fruits per plot (0.69 kg), dry fruits per hectare (2.55 t), number of seeds per fruit (75.34), 1000 seed weight (5.92 g), seed yield per plant (9.41 g) and plot (86.21 g), the yield of seeds per hectare (318.98 kg), germination percentage (76.88), root length (6.37 cm), shoot length (8.11 cm), seedling length (14.28 cm) were recorded from F_3 (½ vermicompost + ½ $N_{110}P_{170}K_{100}$) fertilizer management.

On the other hand, The minimum plant height (81.84 cm), number of branches per plant (5.17), leaves per plant (28.74), fruit length (4.88 cm), the weight of dry fruits (0.59 g), number of dry fruits per plant (59.11 g), yield per plant dry fruits (35.14 g), dry fruits per plot (0.38 kg), dry fruits per hectare (1.39 t), number of seeds per fruits (64.15), 1000 seed weight (4.51 g), seed yield per plant (5.62 g) and plot (49.60 g), the yield of seeds per hectare (183.52 kg), germination percentage (64.55), root length (3.98 cm), shoot length (5.98 cm) and seedling length (10.02 cm) were recorded from F_0 (control) fertilizer management.

Different levels of spacing showed a significant effect on plant height, the number of branches and the number of leaves per plant, fruit length, dry fruit weight, number of dry fruits per plant, yield per plant, plot and per hectare of dry fruits, number of seeds per fruit, 1000 seed weight, seed yield per plant, plot and per hectare, germination percentage, root length, shoot length and seedling length. The maximum plant height (92.68 cm), number of branches (11.13), number of leaves per plant (38.82), fruit length (6.80 cm), weight of dry fruits (0.81 g), number of dry fruits per plant (91.42), yield per plant dry fruits (75.44 g), number of seeds per fruit (74.16), 1000 seed weight (5.61 g), seed yield per plant (10.07 g), germination percentage (74.41), root length (6.02 cm), shoot length (7.99 cm), seedling length (14.05 cm) were recorded from S_3 (60cm × 60cm) spacing. The maximum yield per plot dry fruits (0.73 kg), yield per hectare dry fruits (2.69 t), seed yield per plot (84.73 g) and seed yield per hectare (313.48 kg) were recorded from S_2 (60cm × 45 cm).

On the other hand, The minimum plant height (81.25 cm), number of branches (5.17), number of leaves per plant (30.05), fruit length (5.89 cm), weight of dry fruits (0.68 g), number of dry fruits per plant (60.50), yield per plant dry fruits (41.33 g), number of seeds per fruit (68.67), 1000- seed weight (4.51 g), seed yield per plant (5.32 g), germination percentage (63.66), root length (4.97 cm), shoot length (6.99 cm), seedling length (11.96 cm) were recorded from S_3 (60cm × 60cm) spacing. The minimum yield per plot dry fruits (0.45 kg), yield per hectare dry fruits (1.69 t), seed yield per plot (61.25 g) and seed yield per hectare (226.63 kg) were recorded from S_1 (60cm × 30cm).

Interaction of fertilizer management and spacing had a significant effect on plant height, the number of branches per plant, number of leaves per plant, fruit length, weight of dry fruits, number of dry fruits per plant, yield per plant dry fruits, yield per plot dry fruits, yield per hectare dry fruits, number of seeds per fruit, thousand seed weight, seed yield per plant, seed yield per plot, seed yield per hectare, germination percentage, root length, shoot length and seedling length. The maximum plant height (98.75 cm), number of branches per plant (14.03), leaves per plant (43.75), fruit length (7.43 cm), weight of dry fruits (0.89 g), number of dry fruits per plant (100.78), yield per plant dry fruits (91.25 g), number of seeds per fruit (80.44), thousand seed weight (6.19 g), seed yield per plant (11.31 g), germination percentage (81.33), root length (7.06 cm), shoot length (8.82 cm) and seedling length (15.92 cm) were recorded from F_3S_3 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$ + 60cm × 60cm) treatment combination. The maximum yield per plot dry fruits (0.55

kg), yield per hectare dry fruits (0.25 t), seed yield per plot (95.91 g) and seed yield per hectare (353.35 kg) were recorded from F_3S_2 (½ Vermicompost + ½ $N_{110}P_{170}K_{100}$ + 60cm × 45 cm) treatment combination.

On the other hand, the minimum plant height (75.01 cm), number of branches per plant (3.16), leaves per plant (23.64), fruit length (4.5 cm), weight of dry fruits (0.52 g), yield per plant dry fruits (28.65 g), number of seeds per fruit (62.33), thousand seed weight (3.80 g), seed yield per plant (2.76 g), seed yield per plot (38.33 g), seed yield per hectare (143.68 kg), germination percentage (58.66), root length (3.28 cm), shoot length (5.21 cm) and seedling length (8.51 cm) were recorded from F_0S_1 (control + 60cm×30cm) treatment combination. The minimum number of dry fruits per plant (49.66) was recorded from F_0S_2, yield per plot dry fruits (0.25 kg) and per hectare dry fruits (0.92 t) were recorded from F_0S_3 (control + 60cm×60cm) treatment combination.

CONCLUSION

This study showed that fertilizer management and spacing had a positive effect on growth, seed yield and quality of chilli. The combination of fertilizer management F_3 (½ vermicompost + ½ $N_{110}P_{170}K_{100}$) along with spacing S_3 (60cm × 60cm) provided better performance for all growth-related parameters, except for yield parameters. In case of yield parameters F_3 (½ vermicompost + ½ $N_{110}P_{170}K_{100}$) and S_2 (60cm × 45cm) combination were given the better performance of chilli cultivation.

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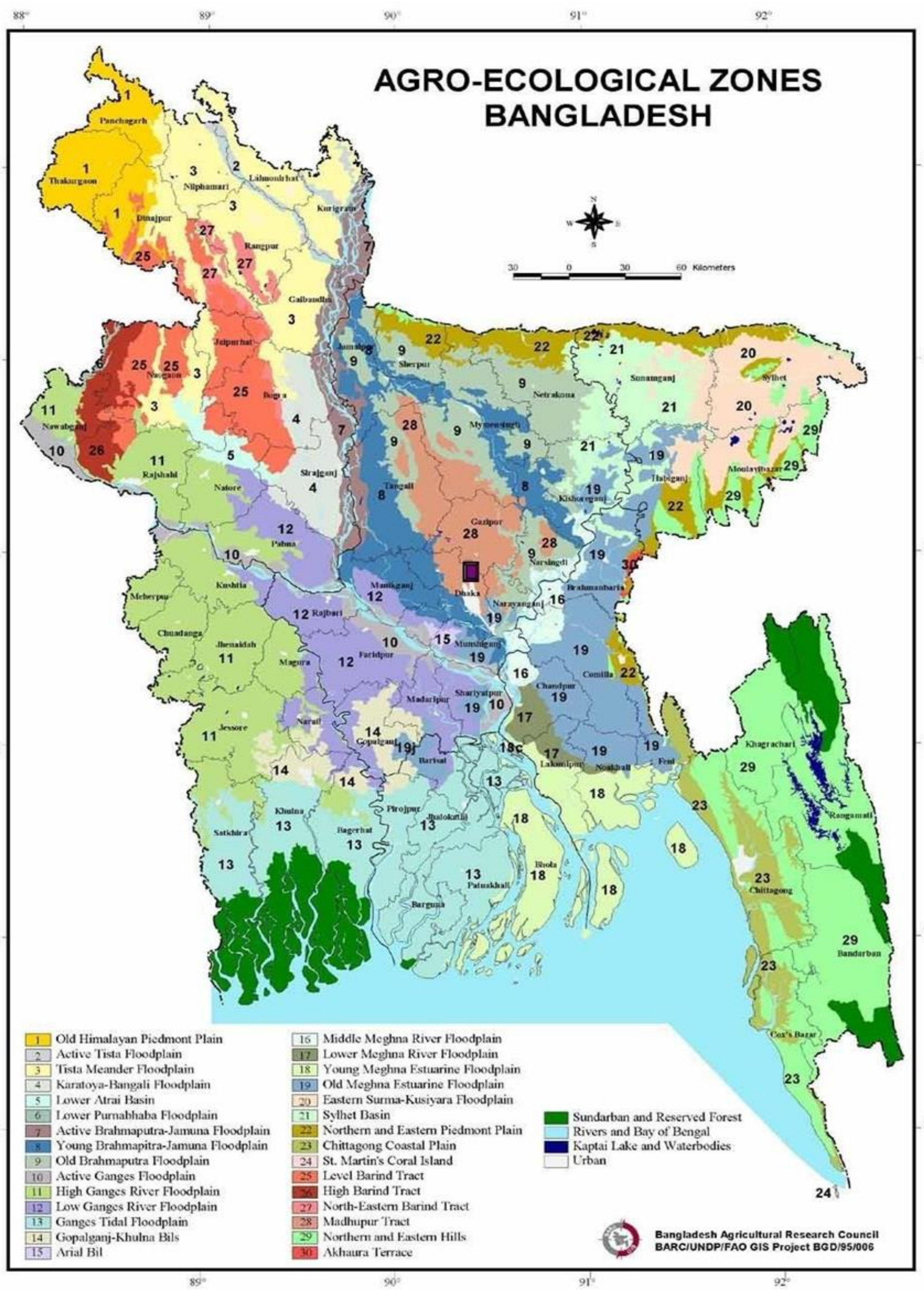
APPENDICES

Appendix I: Map showing the experimental sites under study



■ The experimental site under study

Appendix II: Characteristics of soil of experimental site is analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

A. Morphological characteristics of the experimental field

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

B. Physical and chemical properties of the initial soil

Characteristics	Value
%Sand	27
%Silt	43
%clay	30
Textural class	Silty-clay
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.077
Available P (ppm)	20.00
Exchangeable K (mel 1.00 g soil)	0.10
Available S (ppm)	45

Source: SRDI, 2014

Appendix III. Monthly records of air temperature, relative humidity, rainfall and sunshine hours during the period from October 2018 to April 2019

Month and year	RH (%)	Air temperature (C)			Rainfall (mm)
		Max.	*Min.*	*Mean*	
October, 2018	56.25	28.70	8.62	18.66	14.5
November, 2018	51.10	26.00	10.50	18.25	10.2
December, 2018	46.20	23.70	11.55	17.62	0.0
January, 2019	37.95	22.85	14.15	18.50	0.0
February, 2019	52.50	35.30	21.10	28.20	21.7
March, 2019	65.20	34.75	24.70	29.72	160.0
April, 2019	68.40	32.60	23.85	28.22	187.2

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

Appendix IV. Analysis of variance (mean square) of plant height at different days after transplanting (DAT)

Source of Variation	**Df**	**Mean Square of plant height at**		
		30 DAT	**60 DAT**	**90 DAT**
Fertilizer	3	126.38***	155.104***	242.34***
Spacing	2	169.434***	192.028***	433.249***
Fertilizer*Spacing	11	72.322***	84.686***	144.879***
Replication	2	0.107	7.601	1.763
Error	17	1.507	2.658	2.270
Total	35			

***indicates significant at <1% level of probability

Appendix V. Analysis of variance (mean square) of number of branch per plant and number of leaves per plant at different days after transplanting (DAT)

Source of Variation	Df	Mean Square of number of branch per plant at		Mean Square of number of leaves per plant at	
		30 DAT	60 DAT	30 DAT	60 DAT
Fertilizer	3	58.852***	58.868***	134.255***	133.388***
Spacing	2	89.583***	92.397***	142.66***	139.083***
Fertilizer*Spacing	11	33.971***	34.171***	64.842***	64.139***
Replication	2	3.938	5.257	0.342	0.541
Error	17	0.912	1.035	0.988	1.09
Total	35				

***indicates significant at <1% level of probability

Appendix VI. Analysis of variance (mean square) of number of green fruits per plant, number of dry fruits per plant and weight of green fruit of chilli

Source of Variation	Df	Mean Square of		
		Fruit length	Weight of dry fruit	Number of dry fruits per plant
Fertilizer	3	9.232***	0.116***	0.870***
Spacing	2	2.495*	0.60*	3319.083***
Fertilizer*Spacing	11	3.020***	0.044***	1686.407***
Replication	2	315.250	42.333	0.206
Error	17	0.087	0.005	42.333
Total	35			

*indicates significant at 5% level of probability
***indicates significant at <1% level of probability

Appendix VII. Analysis of variance (mean square) of weight of dry fruits, yield per plant green fruits, yield per plant dry fruits of chilli

Source of Variation	**Df**	**Mean Square of**		
		Yield per plant dry fruits	**Yield per plot dry fruits**	**Yield per hectare dry fruits**
Fertilizer	3	0.116***	3098.519***	252.094***
Spacing	2	4129.333***	0.241***	3.193***
Fertilizer*Spacing	11	1731.030***	0.102***	1.358***
Replication	2	7.000	0.003	0.002
Error	17	12.194	0.001	0.007
Total	35			

***indicates significant at <1% level of probability

Appendix VIII. Analysis of variance (mean square) of yield per plot green fruits, yield per hectare green fruits and yield per plot dry fruits of chilli

Source of Variation	**Df**	**Mean Square of**		
		Number of seeds per fruit	**1000 seed weight**	**Seed yield per plant**
Fertilizer	3	238.769*	3.472***	26.399***
Spacing	2	90.861***	4.053*	74.346*
Fertilizer*Spacing	11	88.755***	1.766***	21.113***
Replication	2	10.194	0.004	0.127
Error	17	9.111	.021	0.253
Total	35			

*indicates significant at 5% level of probability

***indicates significant at <1% level of probability

Appendix IX. Analysis of variance (mean square) of yield per hectare dry fruits, seed yield per plant and seed yield per plot of chilli

Source of Variation	**Df**	**Mean Square of**		
		Seed yield per plot	**Seed yield per hectare**	**Germination percentage**
Fertilizer	3	2551.42***	34928.933***	268.886***
Spacing	2	1700.264***	23276.609**	347.241***
Fertilizer*Spacing	11	1117.854***	15303.416***	142.971***
Replication	2	30.837	422.158	1.34
Error	17	26.712	365.687	2.007
Total	35			

**indicates significant at 1% level of probability
***indicates significant at <1% level of probability

Appendix X. Analysis of variance (mean square) of seed yield per hectare, seed fruit length and root length of chilli

Source of Variation	**Df**	**Mean Square of**		
		Root length	**Shoot length**	**Seedling length**
Fertilizer	3	9.991***	9.362***	37.199***
Spacing	2	3.312*	3.02*	13.124*
Fertilizer*Spacing	11	3.595***	3.212***	12.883***
Replication	2	0.03	0.041	0.338
Error	17	0.282	0.148	0.601
Total	35			

*indicates significant at 5% level of probability
***indicates significant at <1% level of probability