EFFECT OF DIFFERENT COMBINATION OF MANURES AND FERTILIZERS ON GROWTH AND YIELD OF CHILLI (*Capsicum frutescence* L.)

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By

EXAMINATION ROLL NO.: MS-120820

In partial Fulfillment of the Requirements for the Degree of

MASTER OF SCIENCE IN HORTICULTURE

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FINAL ORAL EXAMINATION OF THE M. S. Hort. Thesis

The undersigned certify that they have read and recommended to the Agrotechnology Discipline for acceptance, an M. S. Hort. Thesis entitled

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July 2015

Dedicated

To

My Beloved Parents

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June, 2015 **The Author**

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CHAPTER I

INTRODUCTION

Chilli (*Capsicum frutescence* L.) is one of the 5th domesticated species of the genus "Capsicum" which belongs to the family "Solanaceae" (Bosland and Votava, 2000; Seleshi, 2011). It is an important spice and cash crop in many countries of the world and is native to West Indies, Peru, Mexico and America (Erinle, 1989). It was introduced in Bangladesh by Portuguese during 16th century (Raju and Luckrose, 1991). In Bangladesh, chilli is grown round the year in all parts of the country while winter chilli is grown between the months of October to April and accounts for about 70% of total production. At least 32 local varieties are cultivated in Bangladesh (BBS, 2005). In Bangladesh, chilli is cultivated on an area of 1.20 lakh ha and during 2010-2011, the average production of green chilli was about 1.69 t ha^{-1}(BBS, 2011) where as in 2011, the top 20 pepper-producing countries grew 33.3 million tons of hot pepper planted on 3.8 Mha (FAOSTAT, 2011).

In the western countries chilli is mainly used as ingredient of salad while in the tropics it is mainly used as spice in the cooked products (Meoya, 2011). Chilli powder is a world popular spice that is used in many cuisines and recipes of various cultures to add a tangy taste to them. Chilli is an indispensable spice (consumed as fresh, dried or processed in powdered or crushed form) essentially used in every Bangladeshi cuisine due to its pungency, spice, taste, appealing odour and flavour. It also can be processed into sauces or grinded forms (Huq and Arshad, 2010).

For pungency or spicy taste, a high content of the alkaloid "capsaicin ($C_9H_{14}O_2$)" is responsible that is containing in the hot chilli. It is also a very good source of vitamin- A, C as well as good source of protein, carbohydrate and calcium. An edible portion of 100 g

green chilli contains 2.9 g protein, 6.1g carbohydrate and 111mg vitamin C. It also has many medicinal properties (Islam, 2008).

Fertilizer plays a catalytic part in protein synthesis, chlorophyll formation, carbon assimilation, acceleration of enzymatic actions (Hedge, 2001) and be able to increase the production. Manures are gaining importance because of their low cost, no residual toxicity and capacity to enrich soil fertility in addition to high returns under favorable conditions. Besides improving soil properties, manures supply the major nutrients and micronutrients (Nair and Peter, 1990).

Chilli crop responds well to the application of both manures and chemical fertilizers. The application of manures has also been shown to increase ascorbic acid content in chilli (Kodalli, 2006). Cowdung, Farm Yard Manure, vermicompost and *Trichoderma* compost are proved as effective organic manure to increase productivity as well as to maintain soil fertility.

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Cowdung also can be called as life of soil. It plays an important role for sustainable soil fertility by improving the physical, chemical and biological properties of soil and ultimately enhanced the crop productivity (Islam, 2008). Farm Yard Manure is a decomposed mixture of dung and urine of farm animals along with waste feeds, fodder, litter etc. along with bedding materials. The composition of Farm Yard Manure depends on the kind of input use in composting (Hasanuzzaman- web: URL). Vermicompost prepared with the help of earthworms. It is usually a finely-divided peat-like material with a high porosity, aeration, drainage, water-holding capacity and microbial activity (Edwards and Burrows, 1988). It is a rich source of nutrients, vitamins, enzymes, antibiotics, plant growth regulators and other plant growth-influencing materials produced by microorganisms (Shambhavi and Sharma, 2011). With the aid of fungus activator *Trichoderma sp.*, decomposition of cowdung, poultry refuge, water hyacinth or farm

wastes etc. is accelerated to just 3-4 weeks, this is known as *trichoderma* compost (Nahar *et al.*, 2012) which can play a pivotal role in chilli production.

Inorganic fertilizers are one of the major factors of crop production and serves as easy source of nutrient release to plants (Agboola, 1986). Among the inorganic fertilizers, NPK fertilizers increase the ability of plants to resist bacteria and fungi attack (Vanlauwe *et al.*, 2002) and are very much essential for good plant establishment and expected growth (Uddin and Khalequzzaman, 2003). Micro nutrients also played an important role for good production of chilli.

The continuous application of chemical fertilizers alone without use of organic manures has deteriorated soil health in terms of chemical, physical and biological characters resulting in decline in crop yield. Ground and surface water pollution occur for nitrate leaching and surface run off as well as the use of synthetic chemical fertilizers leads to imperfectly synthesized protein in leaves, which is responsible for poor crops and in turn for pathological conditions in humans and animals fed with such deficient food. The excessive application of potassium fertilizers decreased vitamin c and carotene content in vegetables and an excessive application of nitrogenous fertilizers increased the incidence of pests and diseases in crop plants. Moreover, excess use of inorganic fertilizers may create toxicity of crops which is harmful for health. Chemical residues cause depression, insomnia, oral acetomatism, myoclonus and hyper reflexia of man. Accumulation of excess nitrogen in plants causes an infant disease, methaemoglobinemia and amines produced from the nitrogenous fertilizer cause cancer in human beings (Kumari *et al.*, 2014). On the other hand, organic manures are known to have beneficial effect on soil health but their limited nutrient content and their availability in large amount is a limitation for their wider usage which indicates that sole application of organics or inorganic fertilizers are in no way a suitable solution for maintaining soil health and

enhancing crop productivity (Malik *et al.*, 2011). So, it is necessary to reach the proper knowledge about appropriate use of manures and fertilizers level so that it can play a key role in increasing production of chilli with maintaining soil health and fruit quality.

In view of the continued need to increase crop yield unit^{-1} area with proper use of manures and fertilizers, soil health and human health respectively, the present study was therefore undertaken with the following objectives:

- To investigate the effects of different combination of manures and fertilizers on growth and yield of chilli.
- To find out the suitable fertilizer dose for chilli production.

CHAPTER II

REVIEW OF LITERATURE

Review of literature helps to perform the research work successfully by providing various knowledge and information related to the proposed study. As chilli (*Capsicum frutescence L.*) is the most important spice crop in the world especially in Bangladesh, different research works have been done in different category like for the purpose of improving variety using different technology or determination of antioxidant activity of different chilli germplasm etc. But information regarding the previously mentioned four organic fertilizers (cowdung, Farm Yard Manure, vermicompost and *Trichoderma* compost) and their effect in combination with inorganic fertilizers on growth and yield of chilli is insufficient. Therefore, the research findings of different crops so far collected have been reviewed below those were related to the present study:

2.1 Effect of manures on growth and yield of chilli

In a study by Islam (2008), chilli (*Capsicum annum* var. grossum cv. California wonder) was treated with 3 levels (0 g, 750 g and 1500 g) of cowdung and 3 levels of Neem leaves (0 g, 150 g and 300 g) at field condition. In this two factors experiment, 0 g of cowdung and Neem leaf are considered as control and the author observed that the performance of cowdung was greater on plant growth and development than that of Neem leaves. From the sole application of both three levels of cowdung and Neem leaves, he found that cowdung (1500 g) resulted greater plant height (35.07 cm), number of branches /plant (10.80), no. of leaves/plant (53.93) and days to first flowering (50.46 days) followed by Neem leaves (300 g) that resulted 33.52 cm, 10.02/plant, 51.44/plant and 50.49 days respectively where as lowest found in the control. The higher no. of fruits /plant (47.36) was also observed in the treatment 1500 g of cowdung than any other treatments.

However, Haliru *et al.* (2014) also noticed a significant effect of cowdung on growth and yield parameters of sweet potato (*Ipomoea batatas* L.). Two experiments were conducted at two locations simultaneously during 2011-12 taking the same treatments. The treatments were: cowdung @ 3 t/ha or, 2 t/ha or, 1 t/ha and no cowdung rate considered as control. Although no. of leaves/plant at both locations had no significant difference but the vine length was significantly differed among the treatments, highest found at 3 t/ha of cowdung application at both locations (48.43 cm and 53.6 cm, respectively) and lowest found in the control (27.5 cm and 37.6 cm, respectively). This could be due to the quantity difference which is related to the amount of nutrient released into the soil for plant absorption. Also, 3 t/ha application of cowdung gave the best tuber weight (0.83 kg/plant in both place) and tuber yield (14.4 t/ha and 18.73 t/ha, respectively) than control may be due to increase in availability of nutrients and production of growth hormones might have resulted in a higher nutrient uptake by the crops which increased bulking of tubers (Saikia and Borah, 2007).

On another field experiment, Berova *et al.* (2013) observed the efficiency of vermicompost at three levels (1- soil fertilized with 50 cm^3 of the vermicompost Lumbrical per plant before planting; 2- soil fertilized with 50 cm^3 of the vermicompost per plant before planting and 200 cm^3 of Lumbrical extract per plant 30 days after planting; 3- soil fertilized with 100 cm^3 of Lumbrical per plant before planting) on yield and quality parameters of chilli (*Capsicum annum* cv. Gorogled 6). The study was conducted during 2007-2009 and soil without vermicompost considered as control sample. They noticed, highest plant height (45.8 cm), leaf no. $plant^{-1}$ (154) and fruit no. $plant^{-1}$ (18.3) on soil fertilized with vermicompost 100 cm^3/plant before planting than control sample, represented lowest plant height (41.8 cm), leaf no. $plant^{-1}$ (79) and fruit no. $plant^{-1}$ (11.8). However, the other two levels of vermicompost also performed

satisfactorily than control sample. The accelerated vegetative growth of the treated plants may have been achieved due to a considerable quantity of assimilated nitrogen, as well as to the biologically active components of the vermicompost (Canellas *et al.*, 2002).

But on another pot experiment, Venkatasalam *et al.* (2012) observed that FYM improved the plant height, no. of stems plant^{-1}, number of compound leaves plant^{-1}, number of tubers plant^{-1} and tuber yield of some potato varieties as compared to vermicompost. 10 potato varieties (Kufri Ashoka, Kufri Badshah, Kufri Bahar, Kufri Chandramukhi, Kufri Chipsona 1, Kufri Chipsona 2, Kufri Kanchan, Kufri Lalima, Kufri Lauvkar and Kufri Pukhraj) and 2 different rates of FYM (300 g pot^{-1}) and vermicompost (200 g pot^{-1}) were used in this comparative experiment and every variety was treated with each of the manures and recommended fertilizer dose that remained same in all the treatments. However, among the varieties, highest plant height was noticed in Kufri Chipsona-2 (79.6 cm) with FYM, while lowest was observed in Kufri Bahar with vermicompost (23 cm) at 40 DAP. FYM also contributes to the maximum number of stems plant^{-1} in Kufri Lalima (3.8) while Kufri Badshah (1.4) produced least number of stems on vermicompost. The maximum number of tubers plant^{-1} was recorded in Kufri Lalima (18.2) with FYM, whereas they were minimum in Kufri Lauvkar (4.8) with vermicompost and FYM significantly increased per plant tuber yield in almost all the varieties except Kufri Chipsona-2 and the authors recommended that as sterilized potting media FYM can be successfully used than vermicompost. These types of findings may be due to increased availability of humic substances in case of FYM that perform as plant growth regulators and encourage growth (Goenadi and Sudharama, 1995) and due to the type of residue used for the preparation of vermicompost as type of residue influence the quality of vermicompost (Arancon *et al.*, 2004).

On another comparative field study, Ansari (2008) observed that the requirement of vermicompost for tuber crops like potato and turnip was higher (6 t ha^{-1}) and for leafy crops was lower (4 t ha^{-1}) in case of getting higher yield. The experiment was conducted during (1998-2000) on potato, spinach and turnip, each was treated with three different rates of vermicompost (4 or 5 or 6 t ha^{-1}) and untreated crops considered as control. Both the change of soil chemical parameters and yield were observed. The decrease in pH of 1.10 from (9.51+0.03) to (8.41+0.02) and electrical conductivity (0.17) of soil after plant harvest was greater in case of 6 t ha^{-1} of vermicompost treatment than control.

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2.2 Effect of chemical fertilizers on growth and yield of chilli

In a experiment, Osumah and Tijani (2010) found that 100 kg ha^{-1} of NPK (15:15:15) significantly improved the growth and quality attributes of chilli (*Capsicum frutescens* L.). This experiment was conducted in 2005 by taking 7 different treatments: control (No soil additive), 50 kg ha^{-1} NPK, 100 kg ha^{-1} NPK, 150 kg ha^{-1} NPK, 2.5 t ha^{-1} OMF + 50 kg ha^{-1} NPK and 2.5 t ha^{-1} OMF + 100 kg ha^{-1} NPK. Among the treatments, 100 kg ha^{-1} NPK performed best and from 6-10 weeks after planting the highest plant height (29.42 cm-49.64 cm), no. of leaves (60.50-150.25), no. of branches (8.75-17.75) and fruit yield (0.8 kg) was found in case of NPK at 100 kg ha^{-1} that clearly emphasized fertilizer use as a key factor in soil fertility management and yield increase in crop production (Akinrinde, 2006). Also the nutrient composition of the NPK at 150 kg ha^{-1} were available for plant utilization which greatly influence the quality parameters and yield of chilli indicated that rapid supply of nutrient is the main reason for highest growth and yield compared to that of other treatments.

Also on another study, Tesfaw *et al.* (2013) observed the performance of 3 different rates of N (0, 46 and 92 kg ha^{-1}) and P_2O_5 (0, 69 and 138 kg ha^{-1}) on 3 different hot pepper varieties (Marako fana, Melka zala and a local variety) and suggested that N and P_2O_5

fertilizers at the rates of 92 kg ha^{-1} and 138 kg ha^{-1} feasibly be used for obtaining fresh and dry pods. The highest number of primary branches (5.60) in "Melka zala" and fresh fruit yield (10.92 t ha^{-1}) in variety "Mareko fana" received by fertilizer combination of 92 kg N ha^{-1} and 138 kg P_2O_5 ha^{-1}. But the heaviest fruit weight (18.91 g) was recorded in "local variety" with combined use of 46 kg N ha^{-1} and 138 kg P_2O_5 ha^{-1}; the earliest to flower taking 66 days by 'Mareko fana' in plots treated with 0 kg N ha^{-1} and 138 kg P_2O_5 ha^{-1} which indicated that the higher the level of phosphorus used, the earliest and better fruit setting characteristics of the plant with well developed larger sized fruits. The highest no. of fruits $plant^{-1}$ was observed in "local vareity" (23.53) and "Melka zala" (23.50) in the treatment of (0 kg N ha^{-1} + 138 kg P_2O_5 ha^{-1}) and (92 kg N ha^{-1} + 138 kg P_2O_5 ha^{-1}) respectively which might have aroused as a result of the growing environmental factors and associated traits like the no. of primary, secondary and tertiary branches. Also the treatment of (92 kg N ha^{-1} +138 kg P_2O_5 ha^{-1}) maintained a satisfactory level of pod length and breadth in all the varieties.

On another study, Khan *et al.* (2010) also agreed that with the increased level of N, the no. of fruits $plant^{-1}$ increased, observed that highest no. of fruits (9.50) found in the combined treatment of (150 kg N + 30 kg P ha^{-1}). The experiment was conducted during November 2009 to March 2010 for knowing the effect of 4 levels of N (0, 50, 100 & 150 kg ha^{-1} and 3 levels of P (0, 30 & 60 kg ha^{-1}) on chilli (*Capsicum annum.* cv.California Wonder). The highest plant height at first flowering (17.76 cm), first harvesting (25.00 cm) and final harvesting (32.00 cm) was found in treatment of 100 kg N + 60 kg P ha^{-1}. Highest no. of branches/ plant (7.0) at first flowering was found in the treatment of 150 kg N + 30 kg P ha^{-1} and highest no. of branches at first harvest (12.0) and at final harvest (18.50) was found in 150 kg N + 0 kg P ha^{-1} which indicated that higher dose of N and

lower dose of P was influential nutrients for increasing number of branches plant^{-1} at all the stage.

Roy *et al.* (2011) also conducted an experiment by taking the same treatments; comprised of 4 levels of N (0, 50, 100 & 150 kg ha^{-1}) and 3 levels of P (0, 30 & 60 kg ha^{-1}) on same variety of chilli (*Capsicum annum*.L cv.California Wonder) in same time and observed the efficiency of these treatments on fruit size and yield of the respected crop. Among the combined effect of N and P, The highest level of fruit length (8 cm) and breadth (5 cm) was found in 150 kg N + 30 kg P ha^{-1} and lowest found in the control sample (5.05 cm and 2.59 cm respectively). This treatment also performed well in case of making highest number of fruit plant^{-1} (9.50), average fruit weight plant^{-1} (102.50) and fruit yield (8.51 t ha^{-1}) while lowest was found in the control sample (3.50, 83.50 and 4.57 t ha^{-1} respectively) which clearly indicated that increased level of N and medium level of P is highly effective for getting the higher production of fruits.

"Vietnam-2" chilli variety also responsed well at higher level of N:P_2O_5:K_2O @ 150:75:75 kg ha^{-1} and closer spacing, S_4 - 60 cm x 45 cm (Ramakrishna and Palled, 2005). 16 treatment combinations consisting of four spacings (S_1 - 90 cm x 60 cm, S_2 - 90 cm x 45 cm, S_3 - 60 cm x 60 cm and S_4 - 60 cm x 45 cm) and four fertilizer levels (F_1-75:37.5:37.5, F_2 - 100:50:50, F_3-125:62.5:62.5 and F_4 -150:75:75 kg of N:P_2O_5:K_2O ha^{-1}) were used in this experiment which was conducted during kharif 2001. In case of no. of fruits plant^{-1}, F_4 fertilizer level and S_1 spacing gave higher result (90.25 and 90.75 respectively). Although S_1 performed well but closer spacing of S_4 recorded higher number of fruits per unit area. Similarly, although the highest number of fruits plant^{-1} was recorded with S_1 - 90 cm x 60 cm spacing (47.08 g), the maximum fruit weight per sq.m area was in S_4 (122.26 g) over S_1 (87.19 g) spacing which is responsible for getting higher yield. Again, higher fruit weight plant^{-1} was recorded with the application of F_4 fertilizer

level (45.46 g). Significantly, higher fruit yield (1223.8 kg ha^{-1}) was recorded with 60 cm x 45 cm spacing (S_4) over other spacings and in case of fertilizer; F_4 gave higher dry fruit yield (1176.0 kg ha^{-1}). Naturally, the maximum net returns and B:C ratio were obtained in S_4F_4 treatment combination (Rs. 38,759 $ha^{-1}$and 2.56) followed by S_4F_3 (Rs. 36,534 ha^{-1} and 2.51).

Also a significant performance of higher nutrient value of N, P_2O_5 and K_2O was observed by Bharamappa *et al.* (2009) on growth and yield of chili (cv. Byadagi kaddi) during 2007-08. 18 treatment combinations consisting of six planting methods as main plot treatments (M_1 - Drill sowing @ 5.0 kg seed rate per hectare, M_2 - Drill sowing @ 7.5 kg seed rate per hectare, M_3 - Dibbling seeds and later retaining one seedling per hill, M_4 - Dibbling seeds and later retaining two seedlings per hill, M_5 - Transplanting one seedling per hill and M_6 - Transplanting two seedlings per hill) and three nutrient levels as sub-plot treatments (F_1 - 150:75:75, F_2 - 225:112:112 and F_3 - 300:150:150 kg N: P_2O_5: K_2O ha^{-1}) were used in this experiment. Among the nutrient levels, F_3 recorded significantly highest plant height (91.26 cm), number of branches $plant^{-1}$ (25.97) and number of leaves $plant^{-1}$ (251.20) over F_2 and F_1 may be due to increase in the nutrient supply might have enhanced cell division and elongation in chilli resulting in more canopy spread helped the plant in tapping more solar radiation to form more photosynthates. Again, the higher stem girth (1.01 cm), fruit length (10.35 cm) , fruit girth (0.80 cm) and dry fruit weight (85.96 g $plant^{-1}$) was observed in F_3 which was mainly attributed to increased availability of nutrients there by more uptake of nutrients by the crop results in the higher yield attributes.

Jan *et al.* (2000) also agreed with this type of comment conducted experiment on Bottle gourd (*Lageneria siceratia* M) in split plot design having spacing as main plot (S_1 – 50 cm , S_2 – 75 cm and S_3 - 100 cm) and fertilizers - N:P:K as sub-plot (T_1 - control without

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any fertilizer application ,T_2-104:54:104, T_3-124:74:124, T_4- 144:94:144, T_5-164:114:164). Among the effect of fertilizer T_5 - 164:114:164 of NPK/ha took maximum no. of days to germination (20.49 days) while T_3 - 124:74:124 of NPK/ha took minimum no. of days. Also the highest fruit weight (602.89 g), no. of fruits vine^{-1} (5.61), vine length (669.18 cm) and yield (20.40 t ha^{-1}) was observed in the T_5 - 164:114:164 of NPK/ha and lowest was found in control (501.07 g, 3.44/vine, 384.46 cm and 10.91 t ha^{-1}, respectively).

On another study, Leghary *et al.* (2014) concluded that bottle gourd (*Lagenaria siceraria*) vines fertilized with N at the rate of 150 kg ha^{-1} resulted in superior performance for all the traits examined as compared to other N levels. Two different varieties (Long green and Anmol) were treated with six levels of N (0, 50, 75, 100, 125, 150 kg ha^{-1}) with a constant dose of phosphorus (P) 100 kg ha^{-1} and potassium (K) 75 kg ha^{-1}. The maximum vine length (272.67 cm) was found in the interactive effect of 150 kg ha^{-1} N × variety "Long Green". But other attributes were not significantly affected by the interaction between nitrogen levels × varieties. However, the levels of different N and varieties were significantly affected separately on making better performance. Among different nitrogen levels, maximum branches (4.49) were obtained from plots given N at the rate of 150 kg ha^{-1}, followed by 125 kg (4.21 branches vine^{-1}) and 100 kg (4.06 branches vine^{-1}) N ha^{-1} while lowest found in the control (3.10 branches vine^{-1}). Similarly, the highest fruits vine^{-1}(7.75), single fruit weight (729.17 g) and weight of fruits vine^{-1} (3630 g) were observed in the 150 kg ha^{-1} rate of N and 125 kg and 100 kg of N also performed in satisfied level (7.41 and 7.03 fruits vine^{-1}; 588.00 and 477.33 g single fruit weight). In all case lowest found in the control sample.

Vishwakarma (2013) also conducted an experiment during Kharif season of 2007 to know the impact of different levels of nitrogen and phosphorus on performance of spine gourd (*Momordica dioica* Roxb.). The treatments were combination of 4 levels of nitrogen (0,

40, 80 and 120 kg N ha^{-1}) and 4 levels of phosphorous (0, 40, 60 and 80 kg ha^{-1}). However, among the treatments, N_2 (nitrogen @ 80 kg ha^{-1}), P_2 (phosphorus @ 60 kg ha^{-1}) and N_2P_2 (80 kg N ha^{-1} + 60 kg P_2O_5 ha^{-1}) recorded minimum no. of days to sprouting of tubers (13.33, 14.92 and 9.33 days, respectively), first female anthesis (43.25, 43.83 and 42.33 days, respectively) and first harvest (60.00, 62.25 and 61.00 days, respectively). This same treatment also responsible for maximum number of nodes to first female flower (6.50, 6.75 and 7.00 respectively), number of fruits $plant^{-1}$ (42.50, 40.00 and 46.00 respectively), vine length (255.08, 246.25 and 269.00 cm, respectively), fresh weight of fruit (15.25, 14.75 and 17.00 g, respectively), fruit yield $plant^{-1}$ (650.08, 595.33 and 782.33 g, respectively), maximum yield (104.27 q. ha-1), gross return (Rs 417066.67 ha-1) and cost:benefit ratio (1:3.44).

So, the application of appropriate level of inorganic fertilizer significantly performed well in case of all crop plants while excess dose may create toxicity.

2.3 Effect of manures and chemical fertilizers on growth and yield of chilli

Kodally (2006) conducted an experiment by taking 7 different combinations of fertilizers on two varieties of chilli (*Capsicum annuum* L.) considered treatments namely, T_1 – Control (Recommended fertilizer dose - 100:50:50 kg NPK/ha), T_2 – RDF + FYM (25 t/ha), T_3 – RDF + Vermicompost (5 t/ha), T_4 – RDF + VAM (2 kg/ha), T_5 – RDF + *Azospirillum* (500 g/ha), T_6 – RDF + NAA (40 ppm), T_7 – RDF + Ethrel (250 ppm) and 2 varieties namely, V_1 – Byadagi kaddi and V_2 – Byadagi dabbi. Among the treatments, RDF + FYM 25 t ha^{-1} recorded significantly higher plant height (92.8 cm) and higher number of branches (31.1) over all other treatments at all the stages followed by RDF + vermicompost 5 t/ha (85.3 cm and 28 respectively) while lower was recorded in control (75.1 cm and 23.5). However, the days to 50% flowering, number of fruits $plant^{-1}$, fruit length, fruit diameter and fruit yield $plant^{-1}$ was differed significantly due to treatments

and varieties but not with interaction of these two factors. The maximum number of days to attain 50% flowering was noticed in control (32.2) and the minimum was in RDF + FYM (25 t/ha) (27.6) in both genotypes. Higher number of fruits plant^{-1} (105.3), fruit length (11.2 cm), fruit diameter(2.53 cm) and fruit yield plant^{-1} (104.8 g) was observed in T_2 – RDF + FYM (25 t/ha) followed by T_3 – RDF + Vermicompost (5 t/ha)- 97.7, 10.2 cm, 2.36 cm, 98.8 g respectively which may be attributed to the increased solubilization effect and availability of nutrients by the addition of FYM and increased physiological activity leading to the build up of sufficient food reserves for the developing sinks and better portioning towards the developing fruits. While lowest was found in the control (only RDF).

The combined effect of Farm Yard Manure and inorganic fertilizers on chilli (*Capsicum annuum* L.) was also found on another experiment by Dorji *et al.* (2009). This study was conducted over four consecutive years (2001 - 2004) by taking four different levels of FYM (0, 2, 4 and 8 t/ha) and N:P:K (0:0:0, 8:6:6, 16:8:8 and 24:18:18 kg/acre). This experiment revealed that when quantity of fruits increases the quality of fruit tended to decrease with increasing NPK and FYM applications. The highest crop yield of 5.17 t ac^{-1} and 4.78 t ac^{-1}, highest yield per plant 256 g and 229 g, highest number of fruits per plant 22 and 19 as well as highest number of rejected fruits per acre (664 and 529) was observed with highest rate of NPK (24:18:18 kg/acre) and FYM (8 t/ha) and the author stated that the integrated use of these organic and inorganic fertilizers is benefitted than with the use of either of these separately, although their combination effect on the quantity and quality of the fruits was not statistically significant.

But on another experiment, Malik *et al.* (2011) observed that the various combinations of inorganic fertilizers and FYM rate significantly affected on growth and yield attributing traits of sweet pepper (*Capsicum annuum* L. var. *grossum*). This experiment was

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conducted on two different locations by 9 different combinations of FYM and inorganic fertilizers treatments, e.g.: T_1 (N = 90 kg ha^{-1}; P_2O_5 = 60 kg ha^{-1}; K_2O = 60 kg ha^{-1}; FYM = 20 t ha^{-1}), T_2 (N = 90 kg ha^{-1}; P_2O_5 = 60 kg ha^{-1}; K_2O = 60 kg ha^{-1}; FYM = 30 t ha^{-1}), T_3 (N = 90 kg ha^{-1}; P_2O_5 = 60kg ha^{-1}; K_2O = 60 kg ha^{-1}; FYM = 40 t ha^{-1}), T_4 (N= 120 kg ha^{-1}; P_2O_5 = 90 kg ha^{-1}; K_2O = 60 kg ha^{-1}; FYM = 20 t ha^{-1}), T_5 (N = 120 kg ha^{-1}; P_2O_5 = 90 kg ha^{-1}; K_2O = 60 kg ha^{-1}; FYM = 30 t ha^{-1}), T_6 (N = 120 kg ha^{-1}; P_2O_5 = 90 kg ha^{-1}; K_2O = 60 kg ha^{-1}; FYM = 40 t ha^{-1}), T_7 (N = 150 kg ha^{-1}; P_2O_5 = 120 kg ha^{-1}; K_2O = 60 kg ha^{-1}; FYM = 20 t ha^{-1}), T_8 (N = 150 kg ha^{-1}; P_2O_5 = 120 kg ha^{-1}; K_2O = 60 kg ha^{-1}; FYM = 30 t ha^{-1}), T_9 (N = 150 kg ha^{-1}; P_2O_5 = 120 kg ha^{-1}; K_2O = 60 kg ha^{-1}; FYM = 40 t ha^{-1}), T_{10} (control = no chemical fertilizers or FYM). However, Treatment 9 recorded a maximum of plant height (57.14 cm and 54.16 cm), number of branches (6.70 and 6.53), plant spread (46.00 and 43.00 cm), number of fruits $plant^{-1}$ (20.45 and 19.00), fruit length (8.40 and 8.20 cm), fruit diameter (8.09 and 7.70 cm), average fruit weight (94.85 and 93 g), average fruit yield/plot (38.79 and 35.34 kg) and average fruit yield ha^{-1} (718.47 and 686.39 kg) at Wadura and Shalimar respectively where as lowest found in the control. The increase in growth in this treatment might be due to increase in fertilizer and FYM application may be ascertained to increase amount of nutrients such as nitrogen, phosphorus and potassium in plants, leading to increase formation of plant metabolites that helped to build the plant tissue and the increase in yield and yield contributing characters may be due to balanced C/N ratio, decomposition, mineralization, availability of native and applied macro and micro-nutrients.

Ghimire *et al.* (2013) also conducted an experiment to know the effectiveness of different nitrogen sources on growth and yield of sweet pepper cv. California Wonder. The treatments were : FYM 100%- (33 t FYM), FYM 50%+urea 50%- (16.5 t FYM + 163 kg urea), GM 100%- (26.8 t goat manure), GM 50% + urea 50%- (13.4 t goat manure + 163

kg urea), VC 100% - (28.8 t vermicompost), VC 50% + urea 50% - (14.4 t vermicompost + 163 kg urea) and NPK chemicals - (262.3 kg urea + 163 kg DAP + 83.3 kg MOP). However, application of FYM 50% + urea 50% significantly increased the plant height (33.02 cm), number of leaves plant^{-1} (61.20). Number of primary branches (4.267), fresh shoot weight (193.5 g) at 60 days after planting where application of only chemicals represented lower vegetative growth. On the other hand, days to first flowering did not differed significantly among the treatments but numerically the highest number of days to first flowering (48.75 days) was seen with only chemicals. Fruit set (45.85%), fruit length (8.80 cm), fruit weight (96.54 g) and fruit yield was the highest (13.524 MT/ ha) with application of FYM 50% + urea 50%. While, lower percent of fruit set was observed with the application of vermicompost 50% + urea 50% and goat manure 50% + urea 50% may have been due to more availability of nitrogen at the time of flowering.

On the other experiment, Shashidhara and Shivamurthy (2008) studied the impact of integrated nutrient management on growth, yield and yield parameters of 3 chilli Genotypes (Vietnam-2, byadagi kaddi and byadagi dabbi). The integrated fertilizers are : RDF 100%, FYM@ 10 t ha^{-1} + RDF 100%, chilli Stalk (crop residue of previous crop) @ 10 t ha^{-1} + RDF 100%, FYM@ 5 t ha^{-1}+ Chilli Stalk(CS) @ 5 t ha^{-1} + Biofertilizer(BF) +Secondary & Micronutrients(MN) + RDF100% and FYM@ 5 t ha^{-1}+ CS@ 5 t ha^{-1}+BF+S&MN+RDF 50%). Among the combined nutrient level, application of FYM @ 10 t/ha along with 100 percent RDF resulted in significantly higher plant height (89.77 cm), number of branches per hill (40.52), number of fruits per hill (54.8), fruit length (14.2 cm) and fruit yield (919) and also FYM@ 10 t/ha with 100% RDF and 100% RDF recorded to significantly higher B:C ratio (2.81 & 2.83) as compared to other treatments. The authors also conclude that among the interaction between genotypes and combination of organic and inorganic fertilizer, Vietnam-2 along with application of FYM @ 10 t /ha

+ 100% FYM demonstrated higher plant height (99.10 cm), number of branches (45.87), fruit yield (1039 kg/ha) and B:C ratio (3.19) as compared to other treatment combinations that may be attributed to increasing in availability of nutrients for longer period and continuous supply of nutrients.

The combination of Farm Yard Manure and inorganic fertilizers were also proved to be effective in case of improving the growth and yield of Cucumber (*Cucumis sativus* L.cv. Ashley) (Eifediyi and Remison, 2010). Three different rates of farmyard manure (0, 5 and 10 t/ha) and 5 rates of inorganic fertilizers (0, 100, 200, 300 and 400 kg/ha) were used in this trial. Although the vine length and no. of leaves were not significantly differ among the treatments but numerically at 8 weeks after planting (WAP), the highest vine length (276.93 cm) and no. of leaves (61.73) were observed in the combined rates of Farm Yard Manure at 10 t/ha x 400 kg/ha fertilizer. However, the yield attributing characters of cucumber significantly differed among the treatments except fruit length (highest was found 15.71 cm in highest rate of Farm Yard Manure and inorganic fertilizers). The highest fruit weight plant^{-1} (2.43 kg) and fruit weight per hectare (43,259.24 kg/ha) was observed in the treatment 10 t/ha x 400 kg/ha fertilizer. Also this treatment fertilizer gave a yield of 166.42% over the control which indicated that response to FYM was more at higher rates of NPK application and nutrients were more readily available when organic and inorganic fertilizer were combined.

On other study, Prativa and Bhattarai (2011) also noticed the impact of integrated use of vermicompost, Farm Yard Manure and NPK on tomato (*Lycopersicon lycopersicum* L. cv. Yash). 9 different treatments were considered in this study : T_1= 20 MT/ha, T_2 = Half of the recommended NPK + 30 MT/ha FYM, T_3 = Three fourths of the recommended NPK + 25 MT/ha, T_4 = 10 MT/ha vermicompost, T_5 = Half of the recommended NPK + 15 MT/ha vermicompost, T_6 = Three fourths of the recommended NPK +12.5 MT/ha

vermicompost, T_7 = 16.66 MT/ha FYM + 8.33 MT/ha vermicompost + NPK, T_8 = Recommended NPK (100:80:60 kg/ha), T_9 = Control (no organic manures and inorganic fertilizers). Although the earliness in days to 50% flowering (26.33) was recorded in treatment 20 MT/ha FYM (may be due to the faster enhancement of vegetative growth and storing sufficient reserved food materials for differentiation of flower buds) but the overall good performance in case of highest plant height (116.16 cm), number of leaves per plant (105.50), number of fruit clusters/plant (6.90), fruit weight (52.8 g) and fruit yield (25.74 MT/ha) was observed in T_7 (16.66 MT/ha FYM + 8.33 MT/ha vermicompost + NPK) might be due to the fact that the application of NPK, FYM and vermicompost provided adequate N which is associated with high photosynthetic activity, vigorous vegetative growth and solubilization effect of plant nutrients.

But on another study, Solaiman and Rabbani (2006) suggested that a lower rate of cowdung and half dose of recommended inorganic fertilizers for tomato is most effective for this crop production which provided most benefit to the cultivator. Five treatments consisting of T_1- control, T_2- Recommended dose- (200 kg N+ 35 kg P+ 80 kg K+ 15 kg S/ha), T_3- (5 t/ha+ ½ of T_2), T_4 - (10 t/ha+ 1/3 of T_2) and T_5 - 15 t cowdung/ha. Although the highest no. of plant height at 50% flowering stage and final harvesting stage was observed in both treatments T_2 (72.02 cm and 75.03 cm) and T_3 (68.02 cm and 72 cm), the integrated use of cowdung and ½ of T_2 found to be more beneficial as they provide more benefit cost ratio (4.38). Highest number of clusters/plant (23.48 -T_2, 21.10 - T_3), no. of flowers/plant (44.13 - T_2, 43.47 - T_3), no. of fruits/plant (33.32 - T_2, 33.30 - T_3), fruit length (4.72 cm - T_2, 4.69 cm - T_3), fruit breadth (4.75 cm -T_2, 4.73 cm-T_3), fruit yield plant^{-1} (1159 g -T_2, 1114 g - T_3) and fruit yield ha^{-1} (44.11 t -T_2 , 43.81 t - T_3) were also maintained the same pattern.

On another experiment, Chanda *et al.* (2011) observed that vermicompost along with chemical fertilizers showed 73% better yield of fruits than control. 6 different types of treatments were used in this trial (T_1 - control, T_2 - chemical fertilizers, T_3 - Farm Yard Manure (FYM), T_4 - vermicompost, T_5 and T_6 - FYM supplemented with chemical fertilizers and vermicompost supplemented with chemical fertilizer, respectively). However, the authors found that organic fertilizer add with chemical fertilizer treated plants (T_5 and T_6) exhibited better results than the plants treated separately with different fertilizers treated plants (T_2 - inorganic, T_3 - FYM and T_4 - vermicompost) might be due to N, P, K of organic manure require more time for their utilization by plants because of slow releasing of N, P, K.

In a study Haque *et al.* (2012) proposed that *Trichoderma*-enriched biofertilizer could save at least 50% N fertilizer uses for mustard and tomato and could reduce excessive uses of NPK for crop cultivation. Treatments were T_1 - control (without biofertilizer and chemical fertilizers), T_2 – NPK fertilizer, T_3 – BioF/compost (618 g/plot), T_4 – BioF/pellets (5 g/plant for tomato and 25 g/row for mustard), T_5 – BioF/suspension (5 ml/plant for tomato and 25 ml/row for mustard), T_6 - 50% N-fertilizer + 50% BioF/compost, T_7 - 50% N fertilizer + 50% BioF/pellets and T_8 – 50% N fertilizer + 50% BioF/suspension. The authors observed that combined application (supplemented with N) of *Trichoderma*-enriched biofertilizer such as the treatments T_6, T_7 and T_8 significantly increased the growth and yield attributes of Mustard (*Brassica rapa* L. cv. BARI mustard) and Tomato (*Lycopersicon esculentum* Mill. cv. Ratan). In case of Mustard, highest plant height, no. of branches/ plant, no. of leaves/plant , Flower (per cluster), Siliqua (no/plant), Siliqua length (cm) and yield were observed in the treatment of only inorganic fertilizers and the other three combined treatments. In case of tomato although plant height and branch no. were not significantly differed among the treatments, highest

leaf no. plant^{-1} (T_6 - 69.73, T_8 - 73.77), Flower cluster plant^{-1} (T_7 - 21.00, T_8 - 18.73, T_6 - 16.42), Flower no. cluster^{-1} (T_7 - 7.75, T_6 - 6.45), Fruit no. plant^{-1} (T_7 - 41.03, T_8 - 39.43, T_6 - 35.97) and Fruit yield plant^{-1} (T_8 - 1.67, T_7 - 1.41, T_6 - 1.24) were observed in the combined treatments.

On another pot study, conducted by Agarwal *et al.* (2010) it was observed that live earthworms which is applied along with cowdung gave the best results in case of growth and yield of lady's finger (*Abelmoschus esculentus*) followed by vermicompost application. Treatments those were used in this experiment were: P_1- Live earthworm (50 number) + Cattle dung (250 g), P_2 - Only cattle dung (250 g), P_3 – vermicompost (300 g), P_4 - Urea, SSP and MOP (1.40, 2.50 and 2.04 g) and control (no input given). However, lowest (bud initiation time – 30 days and flower formation time – 36 days) and highest (number of buds and flowers – 50 and 47, number of fruits – 225, maximum weight of fruit – 70 g and maximum length of fruit – 23.87 cm) were observed in case of P_1 treatment followed by P_3 treatments may be due to more growth and flowering hormones (auxins and gibberlins) available in soil and around the plant roots secreted by live earthworms (Sinha *et al.*, 2009).

So, the combined use of organic and inorganic nutrients result in solubilization of plant nutrients which lead to increased uptake of NPK. Mixing of organic and inorganic nutrients reduce the nutrient losses, improving the fertilizer use efficiency thus increasing the soil nutrient availability that is more beneficial for the production of crops.

From the above findings, it is seen that different works have been done by taking organic and inorganic fertilizers but in case of hot chilli it is meager especially in Khulna region. That's why I have done this work to know the effect of different manures and fertilizers on the performance of hot chilli and so that it can be beneficial for the farmers of hot chilli producing.

CHAPTER III

MATERIALS AND METHODS

This chapter includes the details of different materials used and methodology followed during the experimental period; is presented under the following heads:

3.1 Experimental site

The field experiment was conducted at Prof. Purnendu Gain Field Laboratory of Agrotechnology Discipline, Khulna University (KU), Khulna during the period from December, 2013 to May, 2014.

3.2 Climate of the experimental site

The climate of the experimental area was subtropical in nature that was characterized high temperature, heavy rainfall with occasional gusty winds, high humidity and relatively long day during kharif season and low temperature and humidity, low rainfall and short day during Rabi season.

3.3 Characteristics of soil of the experimental plot

The trial was carried out on a medium high land, fairly leveled, well drained silty loam. The chemical properties of soil were analyzed in case of before fertilizer application, after fertilizer application and after harvesting of crop at the "Soil Resource Development Institute" (SRDI), Daulatpur, Khulna. According to the analysis, before fertilizer application, the pH of the soil was counted 6.8 while the amount of organic matter, total N, available P and available K were found 2.03%, 0.117%, 26.37 µg/g soil and 0.73 meq/100g of soil, respectively.

3.4 Materials used for the experiment

Chilli (*Capsicum frutescence* L.) var. Chandrapuri, which was a local variety. The seed from the Samrat seed company was collected from the commercial seed market in Gollamari, Khulna.

3.5 Raising of Seedlings

Seedlings were raised in one seedbed of 3m×1m×30 cm. The soil was nicely prepared and converted into loose friable and dried mass by spading. All weeds and unwanted materials were removed. The upper soil portion was mixed with 1:1:1 proportion of sand, soil and dry cowdung compost. Single seed was sown in 2-3 cm deep on 5 cm apart. Sevin dust was applied for protection of ants. Seedlings were germinated on 7 days after seed sown. Weeding, mulching and irrigation were done when required. Seedlings were raised at Germplasm centre, Agrotechnology Discipline of Khulna University.

3.6 Treatments of the experiment

The single factor experiment included 10 treatments as follows:

T_0= Control (without manures and fertilizers)

T_1= Vermicompost (10 ton/ha)

T_2= *Trichoderma* compost (12 ton/ha)

T_3= Farm Yard Manure (FYM) (30 ton/ha)

T_4= Cowdung (30 ton/ha)

T_5= Recommended fertilizer dose of NPKS and Cowdung (N- 97 kg/ha, P- 144 kg/ha, K- 120 kg/ha, S- 20 kg/ha, Cowdung- 10 t/ha) [Source: Chilli, 2010, Mashala fashaler utpadan poddhoty, Spice Research Centre, BARI, Shibgonj, Bogra]

T_6= 50% Vermicompost + 50% Recommended fertilizers

T_7= 50% *Trichoderma* compost + 50% Recommended fertilizers

T_8= 50% Farm Yard Manure (FYM) + 50% Recommended fertilizers

T_9= 50% Cowdung + 50% Recommended fertilizers

3.7 Design and layout of the experiment

The experiment was laid out in the Randomized Complete Block Design (RCBD) with three replications. The entire experimental plot was divided into 3 blocks each containing 10 unit plots. Totally there were 30 unit plots. The treatment combinations were randomly assigned to each unit plot so as to alloted one treatment combination once in each block. The unit plot was 2m×2m in size with 1m distance between the blocks and 75 cm between the unit plots. Each plot was contained 16 plants.

3.8 Preparation of the land for chilli cultivation

The field for the experiment was first opened 12 December, 2013 with a power tiller and was exposed to the sun for 7 days. Then it was gradually prepared to obtain good tilth by several ploughing, cross ploughing and laddering. The laddering was done after each ploughing to break the clods and to break soil. Further works were done with harrow, spade and hammer. Weeds and other stubbles of the previous crops were collected and removed from the land. The plot was divided into the unit plots according to the experimental design. Then according to the treatments, each separate fertilizers and/or manures were applied to the respective plot. Proper irrigation and drainage channel were also prepared around the plots. The bed soil was made friable and the surface of the beds was leveled.

3.9 Application of manures and fertilizers

The whole amount of cowdung, Farm Yard Manure, vermicompost and *Trichoderma* compost was applied during the final land preparation (1 week before transplanting of

seedling) to the respective plot according to the treatment. The amount of organic manures was selected according to the basis of required N% that is suggested by Mashala fashaler utpadan poddhoty, Spice Research Centre, BARI, Shibgonj, Bogra.

Cowdung and Farm Yard Manure was collected from the nearest farm of Khulna University, Gollamari. Vermicompost was collected from "Plant breeding and Biotechnology lab'', Agrotechnology Discipline, Khulna University. *Trichoderma* compost was collected from Gabtoli, Bogra and Synthetic fertilizers were collected from the nearest market of Khulna University.

From the recommended dose, entire amount of cowdung (10 t/ha), TSP (300 kg/ha), gypsum (110 kg/ha) and 1/3rd MOP (65 kg/ha) were applied during final land preparation. Urea (210 kg/ha) and rest 2/3rd MOP (135 kg/ha) were applied in 3 equal installments 25, 50 and 70 days after transplanting on 10-15 cm apart from the root of seedling (Chilli, 2010, Mashala fashaler utpadan poddhoty, Spice research centre, BARI, Shibgonj, Bogra). In case of 50% recommended dose the same procedure was followed applied in half amount of the full dose of recommended fertilizers.

3.10 Transplanting of Chili seedlings

Thirty days old healthy seedlings were transplanted on 12 January, 2014 at 2 cm depth maintaining a spacing of 50 cm between the rows and 50 cm between the plants. Thus 16 plants would plant in each plot. One seedling was planted in each hole. Planting was done in the afternoon. After planting, the base of seedlings were covered with soil and then pressed firmly by hand and immediately after planting, the seedlings were watered.

3.11 Intercultural operations

The transplanted seedlings were always kept under careful observations. Various intercultural operations were accomplished for better growth and development of the plants that were transplanted. The intercultural operations are as follows:

3.11.1 Irrigation

Immediately after transplanting, the experimental plot was semi-flooded by irrigation. The plant was irrigated when needed depending on the moisture status of the soil and requirement of plants.

3.11.2 Gap filling

Transplanted seedlings were regularly observed to find out any damage and dead seedlings for its replacement. Gap filling was done as and when necessary by using healthy disease free seedling. Uniform seedling of the same variety previously planted in the border of the experimental area.

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3.11.3 Weeding

Weeding was accomplished to keep the plots free from weeds, easy aeration and for conserving soil moisture. When the plants were well established, the soil around the base of plants was pulverized.

3.12 Shading

Shading was done on first 4 days after transplanting to protect from excess sunshine.

3. 13 Staking

To protect the plants from breaking by strong wind staking by bamboo sticks were done so that the plant remain erect.

3.14 Plant protection

a. Insect pests

Cutworm is a notorious pest of chilli. It was controlled by spraying sevin-85 sp. @ 3 kg/ha. The grown up plant were affected by aphids and during fruiting stage affected by chilli fruit borer. Ricon 60 EC was applied @ 1.5 ml/L against aphid and chilli fruit borer at 15 days interval. White fly was affected the plants that was controlled by insecticide of Emitachloropid group.

3.16.5 Days to 50% flowering

Days to 50% flowering per plot was recorded. This date was counted when half of the plants from a plot showed flowering.

3.16.6 Days to fruit setting

The first date to fruit setting was recorded per plant and counted on the whole plant.

3.16.7 Number of fruits plant^{-1}

Fruits were collected in different dates from the selected plants and their average was taken as the number of fruits per plant. Then the sequential average amount of fruits were added finally which was considered as total no. of fruits per plant.

3.16.8 Fruit size

i. **Fruit length**: It was measured with a slide calipers in centimeter from the neck of the fruit to the bottom of the fruit. Five selected fruits from the selected plants were measured and their average was taken as length of fruit.

ii. **Fruit diameter:** Diameter of the fruits at the middle portion of 5 selected fruits from the selected plants was also measured with a slide calipers in centimeter and their average was counted as the diameter of the fruits.

3.16.9 Fruit yield per plant

Total weight of all fruits (g) per plant that was selected for data collection was recorded by a electric balance. Then the average yield of 5 selected plants was considered as fruit yield per plant. The sum of the entire average yield on different dates considered as fruit yield per plant as a whole.

3.16.10 Single fruit weight (g)

Single fruit weight was also recorded in electric balance. It was measured by fruits those were considered to measure fruit length and breadth.

3.16.11 Yield per plot (kg)

Fruits collected from all plants within a plot were counted at each harvest. Then yield of every harvest was added considered as yield per plot.

3.16.12 Yield /ha

Yield (t/ha) was calculated from the per plot yield.

3.16.13 Root and shoot fresh weight (g)

After uprooting root and shoot of the selected plant was divided and their fresh weight was taken by a balance.

3.16.14 Root and shoot dry weight (g)

After air drying, root and shoot were placed in a woven for 3 days. After removing from the woven the dry weight was taken in electric balance.

3.16. 15 Cost of production

The production cost was recorded and all accumulates in case of individual treatment that was spent during production time.

3.16.16 Gross return

The total sell price was counted which termed as gross return.

3.16.17 Benefit from the product

It was counted by the following formula: The price of the total yield- cost of production. It also termed as net return.

3.16.18. Benefit cost Ratio (BCR)

It was calculated by the following formula:

$$\text{B:C ratio} = \frac{\text{Net profit (Tk. ha}^{-1}\text{)}}{\text{Cost of cultivation (Tk. ha}^{-1}\text{)}}$$

3.17 Data analysis

The data obtained from different yield components were statistically analyzed to find out the significance of the difference among the treatments. The analysis of variance (ANOVA) was performed by F-test and means of the parameters were compared using DMRT- Duncan's new Multiple Range Test (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

Results on the effect of different types and levels of manures and fertilizers on growth and yield parameters of chilli are illustrated in this chapter.

Effect of different manures and fertilizers on growth parameters

The data on growth components such as plant height, leaves number plant^{-1}, branches plant^{-1}, days to anthesis, days to 50% flowering, days to fruit setting of the crop as affected by different treatments have been discussed below:

4.1 Plant height

A significant variation was observed in the height of chilli with deviation of different treatments (Appendix 4). In the height of chilli, the tallest plant was observed in T_6 (50% vermicompost + 50% recommended fertilizer dose) treatment at all the stage of data collection and continued at 105 DAT (61.45 cm) followed by T_5 treatment (60.21cm) and lowest found in control (46.77 cm) and T_4 treatment (48.29 cm). However, Treatment T_7 (57.95 cm), T_8 (58.37 cm) and T_9 (56.5 cm) showed statistically almost similar growth pattern at all the stage of data collection (Fig 1 and Appendix-1).

Plant height is a genetically control character, but several studies have indicated that it can be modified by the application of chemical fertilizers and organic manures.

Kodally (2006), Malik *et al.* (2011), Ghimire *et al.* (2013) and Shashidhara and Shivamurthy (2008) have also reported the highest plant growth due to combined application of manures and fertilizers on *Capsicum annum* L.

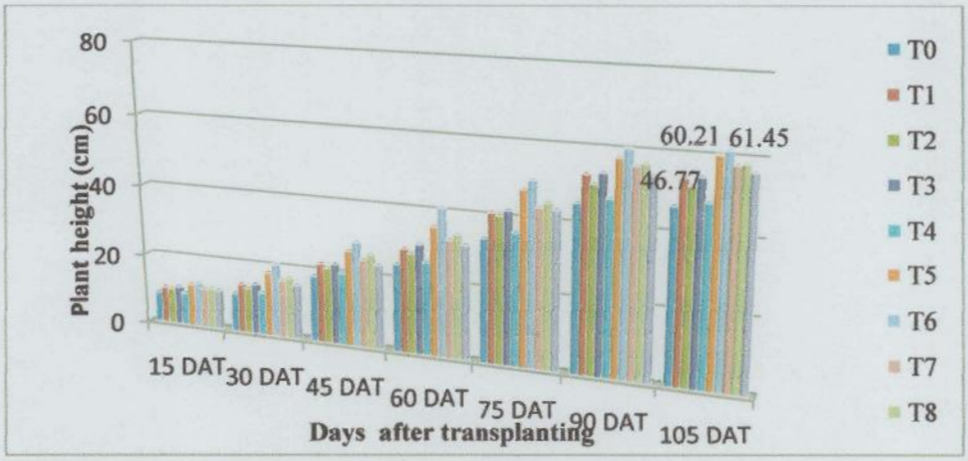

Fig 1. Plant height of chilli at 15 days intervals from 15 - 105 DAT

4.2 Number of leaves plant^{-1}

Number of leaves plant^{-1} significantly differed among the treatments at all the date of data collection (Appendix 4). At 105 DAT, the highest no. of leaves (205.8) was observed in the treatment T_7 followed by T_6 (168.1) and T_5 (161.3) treatments (Fig 2 and Appendix 2), while the lowest no. of leaves plant^{-1} was found in the control (109.5) preceded by T_3 (117.9) and T_4 treatment (122.5). Higher number of leaves might help to elaborate more photosynthates and induces flowering stimulates, thus affecting early initiation of flower bud.

Haque *et al.* (2012) also observed the same results in case of tomato and mustard but Ghimire *et al.* (2013) found that application of only chemicals represented lower vegetative growth in case of sweet pepper which is slightly differ in the present study where a good performance was observed both in case of combined application of (Tricho-compost + Recommended doses of Fertilizers), (vermicompost + Recommended doses of Fertilizers) and also in only Recommended doses of Fertilizers.

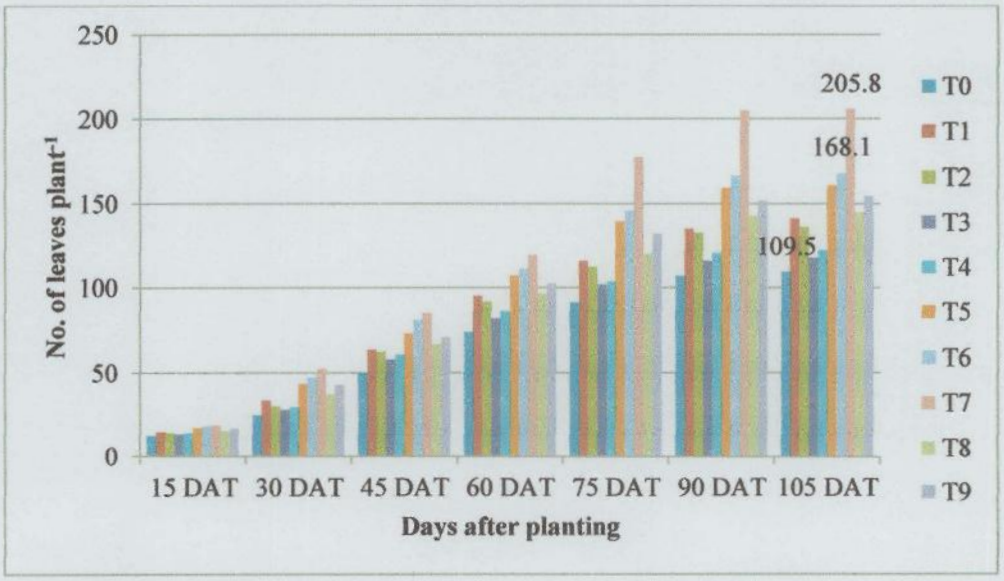

Fig 2. Number of leaves per plant at 15 days intervals from 15 - 105 DAT

4.3 Number of branches plant^{-1}

Number of branches plant^{-1} differed significantly due to application of different levels of organic and inorganic fertilizers and their combinations (Appendix 4). Among all the treatments, T_7 performed well at all the stage of data compilation gave the highest value at 105 DAT (28.73) while on the same date treatment T_6 and T_5 gave the second highest value of number of branches plant^{-1} (22.4 and 21.13, respectively). However, the lowest number of branches was found in control and all the sole application of manures (Fig. 3 and Appendix 3) which indicated that probably for the lowest availability of essential nutrient elements, the sole application of different manures and control did not perform well. On the other hand, treatment T_7, T_6 and T_5 might be provide a good level of essential nutrient for branching which was a good indicator for improving yield potential in chilli.

Renuka and Ravisankar (2001) reported that integrated application of manures with nitrogen resulted into significantly higher number of branches on tomato.

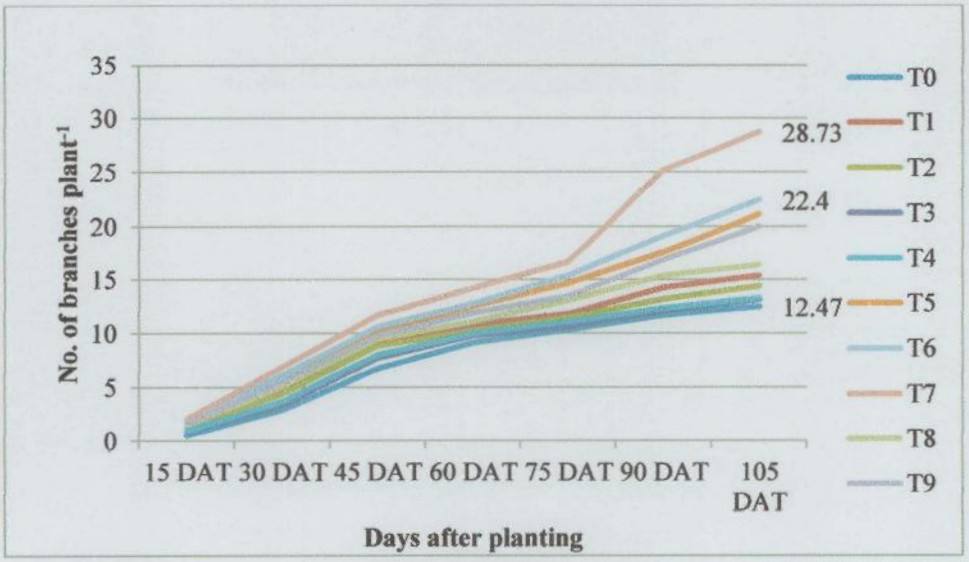

Fig 3. Number of branches plant^{-1} at 15 days intervals from 15 - 105 DAT

4.4 Days to Anthesis

Maximum period of 58.5 days and 57.79 days were required for anthesis in chilli on control (T_0) and sole application of cowdung (T_4). On the other hand, the shortest period of 49.44 days was required in the treatment T_6 (50% RDF + 50% vermicompost) followed by treatment T_7 (50.35) and T_8 (50.81) (Table 1). The results indicated that combined application of vermicompost, Trichocompost and Farm Yard Manure with recommended fertilizer dose could enhance anthesis of the chilli and in turn, maturity would expect to be earlier. Naik (2005) reported that delayed flowering was recorded in the treatment supplying 100% nitrogen through urea which was a different observation from the present study.

4.5 Days to 50% flowering

Days to 50% flowering also influenced by the application of different manures and fertilizers (Table 1). The maximum period of 63.07 days was required for 50% flowering of chilli without any chemical fertilizers and manure. On the other side, the minimum period (52 days) was required in the treatment T_6 (50% vermicompost+ 50% Recommended Fertilizers). However, Treatment T_1 (only vermicompost), T_5 (only Recommended fertilizers dose), T_7 (50% Tricho-compost + 50% Recommended Fertilizers), T_8 (50% FYM + 50% Recommended Fertilizers) and T_9 (50% Cowdung + 50% Recommended Fertilizers) did not statistically differ in case of 50% flowering initiation. The earliness in flowering may be due to the faster enhancement of vegetative growth and storing sufficient reserved food materials for differentiation of buds into flower buds.

4.6 Days to fruit setting

Days to fruit setting did not differ statistically due to application of different levels and types of organic manures and fertilizers (Table 1 and Appendix 4). Numerically, the maximum period (76.55 days) was required in chilli in the control, while minimum period was required from T_6 (50% Recommended Fertilizers + 50% vermicompost) and T_5 (100% Recommended Fertilizer dose) treatment 63.77 days and 68.15 days, respectively.

Table 1. Effect of different treatment combination on anthesis, 50% flowering and fruit setting of chilli

Treatment	Days to Anthesis	Days to 50% flowering	Days to fruit setting
T_0	58.5a	63.07a	76.55
T_1	52.9a-c	55.5bc	74.15
T_2	54.9a-c	57.33a-c	74.46
T_3	56.58ab	58.33a-c	75
T_4	57.79a	59.5ab	75.48
T_5	52.52a-c	55bc	68.15
T_6	49.44c	52c	63.77
T_7	50.35bc	53.4bc	69.92
T_8	50.81bc	53.8bc	72
T_9	53.93a-c	56bc	73.06
Level of significance	*	*	ns
CV (%)	6.64	5.85	9.34

T_0= control, T_1 = vermicompost, T_2 = *Trichoderma* compost, T_3 = Farm Yard Manure, T_4 = cowdung, T_5 = Recommended fertilizers, T_6 = 50% vermicompost + 50% recommended fertilizers, T_7 = 50% *Trichoderma* compost + 50% recommended fertilizers, T_8 = 50% Farm Yard Manure + 50% recommended fertilizers and T_9 = 50% cowdung + 50% recommended fertilizers.

*= Significant at 5% level and ns = non significant. Means followed by common letter(s) in a column do not differ significantly by DMRT.

Effect of different manures and fertilizers on yield and yield contributing characters

4.7 Number of fruits plant^{-1}

Among the fruit yield attributes, total number of fruits plant^{-1} seemed to be the most important character closely related with fruit yield per plant, per plot and in turn yield per hectare. Number of fruits per plant found significantly highest (182.53) in the treatment T_6 (50% vermicompost + 50% recommended fertilizers) while the lowest was found in the control (T_0) and sole application of cowdung (T_4); 82.23 and 100.77, respectively.

Increased number of fruits per plant was due to production of more number of flowers, higher percentage of fruit set and reduces shedding of flowers and fruits; resulted in increased fruit yield. However, the other combined application of either tricho-compost or farmyard or cowdung with recommended fertilizer dose or only recommended fertilizers showed good performance in case of total number of fruits per plant but it was not statistically differ among the indicated treatments (Table 2 and Appendix 4).

4.8 Fruit size

The data on fruit size as influenced by the application of different manures and fertilizers are shown in Table 2. A significant variation was observed in terms of fruit length and breadth of chilli. The maximum fruit length (5.91 cm) was obtained from T_9 followed by T_6 (5.60 cm) and T_7 (5.33 cm) and the highest fruit breadth was found in the treatment T_6 (1.06 cm) followed by T_5 (0.93 cm), T_8 (0.9 cm) and T_7 (0.89 cm) while the lowest was found in the control both in case of fruit length (3.79 cm) and fruit breadth (0.7 cm). This parameter indicated that adequate fertilization helps to produce the largest sized chilli fruit. Probably combined application of manures and fertilizers or only inorganic fertilizers was able to release adequate fertilizer that helps to make the fruit largest.

Hassan *et al.* (1993) also found that improved N availability during early stage of growth increased pepper fruit size.

4.9 Single fruit weight

Single fruit weight responded significantly to the application of different doses of manures and fertilizers (Table 2). It ranged from 1.30 g-1.90 g. The highest single fruit weight was observed from treatment T_6 (1.9 g) followed by T_7 (1.78 g) while lowest was noticed in control (1.30g). Also the sole application of vermicompost, *Trichoderma* compost, Farm Yard or cowdung did not perform well in terms of single fruit weight while application of only recommended fertilizers (T_5) or the combined application of

(recommended fertilizers + farmyard) T_8 or (recommended fertilizers + cowdung) T_9 showed moderately good result in terms of single fruit weight. The reason behind that the nitrogen provided from the combined treatment of recommended fertilizer dose was used for initial growth of plant and the slow release nitrogen and other nutrient component of manures was used for making the plant heaviest.

Wiedenfeld (1986) reported that fruit weight of bell pepper was heavier with basal application of total nitrogen than split application when slow releasing N fertilizers were applied.

4.10 Fruit yield plant^{-1}

Fruit yield plant^{-1} differed significantly due to application of organic and chemical fertilizers (Table 2 and Appendix 4). Among all the treatments, T_6 (336.6 g) and T_7 (305.3 g) recorded maximum fruit yield per plant followed by treatment T_8 (268.6 g) on the other hand minimum yield was observed in control (105.2 g). Moreover, Treatment T_9 (245.8 g) and T_5 (232.9 g) gave a satisfied level of fruit yield than the sole application of other four manures which indicated that only organic manure could not perform well in increasing yield probably because of too slow release of nutrient component that could not fulfill the timely demand of plant but when they incorporated with chemical fertilizers then that was beneficial for plant. Another probable reason for highest fruit yield per plant was highest percentage of fruit set and highest fruit weight with the application of same treatment.

Table 2. Effect of different organic manures and fertilizers on yield and yield contributing parameters

Treatment	No. of fruits plant^{-1}	Fruit size		Single fruit weight(g)	Fruit yield plant^{-1} (g)	Fruit yield plot^{-1} (kg)	Yield (t/ha)
		Fruit length (cm)	Fruit breadth (cm)				
T_0	82.23f	3.79e	0.70e	1.30f	105.2f	1.63e	4.09e
T_1	124.53de	4.95a-d	0.77de	1.46d-f	169.9de	2.72cd	6.8cd
T_2	130.5cd	4.58b-e	0.82b-d	1.54c-e	190.8d	3.05c	7.63c
T_3	112.07de	4.31c-e	0.81cd	1.46d-f	161.1de	2.58cd	6.45cd
T_4	100.77ef	4.19de	0.79c-e	1.40ef	143.1e	2.29d	5.72d
T_5	151.33bc	4.64b-e	0.93b	1.59b-e	232.9c	3.72b	9.31b
T_6	182.53a	5.60ab	1.06a	1.90a	336.6a	5.38a	13.46a
T_7	174.87ab	5.33a-c	0.89bc	1.78ab	305.3a	4.94a	12.34a
T_8	158.63ab	5.14a-d	0.9bc	1.70a-c	268.6b	4.25b	10.63b
T_9	153.13bc	5.91a	0.85b-d	1.66b-d	245.8bc	3.93b	9.83b
Level of significance	**	**	**	**	**	**	**
CV (%)	7.5	8.49	4.87	5.73	6.99	6.59	6.60

T_0= control, T_1 = vermicompost, T_2 = *Trichoderma* compost, T_3 = Farm Yard Manure, T_4 = cowdung, T_5 = Recommended fertilizers, T_6 = 50% vermicompost + 50% recommended fertilizers, T_7 = 50% *Trichoderma* compost + 50% recommended fertilizers, T_8 = 50% Farm Yard Manure + 50% recommended fertilizers and T_9 = 50% cowdung + 50% recommended fertilizers.

**= Significant at 1% level. Means followed by common letter(s) in a column do not differ significantly by DMRT.

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4.11 Fruit yield plot^{-1}

In case of fruit yield plot^{-1} significant variation also found among all the treatments (Table 2 and Appendix 4). The highest fruit yield per plot was recorded both in the treatment T_6 (5.38 kg) and T_7 (4.94 kg) and the second highest was recorded in the treatment T_8 (4.25 kg), T_9 (3.93 kg) and T_5 (3.72 kg) while control (1.63 kg) gave the

lowest yield per plot. The lowest yield in control might be due to lack of essential nutrient.

4.12 Fruit yield hectare^{-1}

Data in terms of fruit yield per hectare showed in table 2. Treatment T_6 (50% vermicompost + 50% RDF) and T_7 (50% *Tricho*-compost+ 50% RDF) gave the maximum fruit yield per hectare (13.46 t ha^{-1} and 12.34 t ha^{-1}, respectively) might be for getting optimum level of essential nutrient element that was found after soil test (Appendix 6). Also the treatment T_8 (50% RDF + 50% Farm Yard Manure), T_9 (50% RDF+ 50% cowdung) and T_5 (100% RDF) gave the second maximum yield per hectare 10.63 t ha^{-1}, 9.83 t ha^{-1} and 9.31 t ha^{-1}, respectively than the sole application of organic manures or control. One more interesting thing was that the performance of only cowdung was very negligible but if it combined with chemical fertilizers then performed well. This indicated that combined application of organic manures and chemical fertilizers play a pivotal role in case of yield of chilli.

The results are in agreement with the findings of Kumaran *et al.* (1995) who recorded an increase in fruit yield by the application of NPK with FYM and vermicompost in tomato.

Effect of different manures and fertilizers on Shoot and Root fresh weight and dry weight

4.13 Shoot fresh weight

Shoot fresh weight of chilli responded significantly due to the application of different manures and fertilizers (Table 3 and Appendix 4). It ranged from 114 g - 685.3g. The maximum shoot fresh weight (685.3 g) was recorded in the treatment T_7 and T_6 (652.9 g) followed by treatment T_5, T_8 and T_9 and lowest weight found in control, T_3 (100% Farm Yard) and T_4 (100% cowdung). Increased level of shoot fresh weight probably due to

increased level of organic matter and nitrogen (%) and optimum amount of P (Appendix 6).

4.14 Root fresh weight

A statistical variation also recorded in the root fresh weight for different treatments. In terms of root fresh weight, treatment T_1 (120.7 g) and T_2 (115.8 g) recorded highest value followed by T_5, T_6, T_8, T_9 and T_7 while the lowest recorded in the control, T_3 and T_4 treatment (Table 3) which indicated that a satisfied level of root fresh weight play an important role in case of nutrient uptake from the soil.

4.15 Shoot dry weight

Shoot dry weight showed a significant variation among all the treatments (Table 3 and Appendix 4). The highest shoot dry weight observed in treatment T_7 (483.1 g) and T_6 (473.5 g) and lowest observed in the control (84.43 g) while all the other treatments did not differ statistically but their value is higher than the control (T_0).

Table 3. Fresh weight and dry weight of root and shoot.

Treatment	Shoot fresh weight(g)	Root fresh weight (g)	Shoot dry weight (g)	Root dry weight (g)
T_0	114c	26.92d	83.43c	18.66d
T_1	426.4b	120.7a	238.5b	77.13a
T_2	421b	115.8a	234.5b	75.21ab
T_3	180.6c	29.79d	121.9bc	20.43d
T_4	183.6c	28.67d	125.4bc	19.87d
T_5	589.4ab	92.63b	262.4b	61.27a-c
T_6	652.9a	90.32bc	473.5a	61.87a-c
T_7	685.3a	79.89c	483.1a	52.16c
T_8	579.9ab	85.95bc	261.2b	58.02a-c
T_9	574.6ab	82.39bc	252.7b	56.87bc
Level of significance	**	**	*	**
CV (%)	19.27	6.23	18.8	15.08

T_0= control, T_1 = vermicompost, T_2 = *Trichoderma* compost, T_3 = Farm Yard Manure, T_4 = cowdung, T_5 = Recommended fertilizers, T_6 = 50% vermicompost + 50% recommended fertilizers, T_7 = 50% *Trichoderma* compost + 50% recommended fertilizers, T_8 = 50%

Farm Yard Manure + 50% recommended fertilizers and T_9 = 50% cowdung + 50% recommended fertilizers.

**= Significant at 1% level and *= Significant at 5% level. Means followed by common letter(s) in a column do not differ significantly by DMRT.

4.16 Root dry weight

Root dry weight also showed a significant difference among the treatments. The maximum weight was recorded in treatment T_1 and T_2 and minimum weight recorded in control, T_3 and T_4 treatment. While other treatments maintain a optimumlevel of root dry weight.

This findings agree with the results of Masson *et al.*(1999) found that nitrogenous fertilization increased tomato shoot dry weight and root dry weight.

4.17 Economic analysis

According to the procedure of Ramakrishna and Palled (2005), cost and return analysis in details was done and has been shown in Table 4. Material, Non-material and overhead cast were recorded for all treatments on unit plot basis and calculated per hectare. The total cost of production range between Tk. 143925 to Tk. 293925 /ha. The highest cost of production (293925 Tk/ha) was found in the treatment T_2 (100% *Tricho*-compost) followed by treatment T_1- 100% vermicompost (263925 Tk/ha) and the lowest found in T_0 (143925 Tk/ha). The range between the gross return was 163466.67 Tk to 538400 Tk/ha. The treatment T_6 (50% vermicompost + 50% recommended fertilizer dose) gave the highest net return of Tk. 326558.59 followed by treatment T_7 (50% *Tricho*-compost + 50% recommended fertilizer dose) of Tk. 266758.59 and the lowest was found in the treatment T_4 (100% cowdung) of Tk (-11125/ha). Maximum benefit cost ratio was found 2.54 in the treatment T_6 (50% vermicompost+ 50% recommended fertilizer dose) followed by T_5 (100% recommended fertilizer dose), T_8 (50% Farm Yard Manure + 50%

recommended fertilizer dose) and T_7 (50% *Tricho*-compost+ 50% recommended fertilizer dose) – 2.33, 2.18 and 2.17; respectively.

Considering the economic return per hectare, this experiment demonstrated that application of 50% vermicompost and 50% recommended fertilizer dose (T_6) was found more appropriate for chilli production under soil and climatic conditions of Khulna region. Although 100% fertilizer dose (T_5) gave the second highest benefit cost ratio, but considering the health condition of soil, human and environment, the other two combined treatment of manure and fertilizers that is T_8 (50% Farm Yard Manure + 50% recommended fertilizer dose) and T_7 (50% *Tricho*-compost+ 50% recommended fertilizer dose) would be more preferable for production of chilli.

Table 4. Cost and return analysis of chilli production

Treatments	Yield (t/ha)	Gross return (Tk/ha)	Total cost of production (Tk/ha)	Net return (Tk/ha)	Benefit cost ratio(BCR)
T_0	4.09e	163466.67i	143925	19541.67fg	1.14d
T_1	6.8cd	271866.67g	263925	7941.67g	1.02d
T_2	7.63c	305200f	293925	11275fg	1.04d
T_3	6.45cd	257866.67g	230325	27541.67f	1.12d
T_4	5.72d	228800h	239925	-11125h	0.95d
T_5	9.31b	372400e	159757.8	212642.20d	2.33ab
T_6	13.46a	538400a	211841.41	326558.59a	2.54a
T_7	12.34a	493600b	226841.41	266758.59b	2.17bc
T_8	10.63b	425333.33c	195041.41	230291.93c	2.18bc
T_9	9.83b	393066.67d	199841.41	193225.26e	1.97c
Level of significance	**	**		**	**
CV (%)	6.60	6.60		17.72	7.47

T_0= control, T_1 = vermicompost, T_2 = *Trichoderma* compost, T_3 = Farm Yard Manure, T_4 = cowdung, T_5 = Recommended fertilizers, T_6 = 50% vermicompost + 50% recommended fertilizers, T_7 = 50% *Trichoderma* compost + 50% recommended fertilizers, T_8 = 50% Farm Yard Manure + 50% recommended fertilizers and T_9 = 50% cowdung + 50% recommended fertilizers.

**= Significant at 1% level. Means followed by common letter(s) in a column do not differ significantly by DMRT.

Cost of vermicompost @ Tk.12/kg

Cost of *Tricho*-compost @ Tk.15/kg

Farm Yard manure @ Tk. 2.88/kg

Cost of cowdung@ Tk. 3.2/kg

Sale of chilli @ Tk.40000/t

Gross return =Total yield (t/ha) ×Tk.40000

BCR = Gross return ÷ Total cost of production

Net return= Gross return - total cost of production

CHAPTER V

SUMMARY AND CONCLUSION

The present study was conducted through field experiment to investigate the efficacy of chemical fertilizers and four different organic manures either applied solely or in combinations. The experiment received 10 treatments where an untreated plot consider as control. "Chandrapuri" a local variety of chilli was used as the test crop in this experiment.

Summary

The height of plant was maximum at 105 DAT but the rate of increase was higher at early and middle stages of growth that means with upcoming of reproductive phase the vegetative growth decreases gradually. Significant variation in plant height was found among the treatments. The best result was found in treatment of using 50% vermicompost and 50% recommended fertilizer dose.

Application of manures and fertilizers caused a variation in number of leaves per plant of this local chilli variety "Chandrapuri" and the effect was significant. The obtained number of leaves 168.1 and 161.3 from the treatment (50% vermicompost + 50% recommended fertilizer dose) and 100% recommended fertilizer dose were the nearest second value from the highest value (205.8) resulted from the treatment (50% *Tricho*-compost + 50% recommended fertilizer dose).

Branches per plant of chilli varied significantly due to various treatments. The highest number of branches was obtained in the treatment T_7 (50% *Tricho*-compost + 50% recommended fertilizers) and the second highest recorded in the T_6 and T_5 treatments those were statistically similar in case of this parameter.

Days to anthesis of chilli was significantly affected by different treatments ranging from 49.44 days to 58.5 days. Though the lowest days for anthesis required in the treatment T_6 (50% vermicompost + 50% recommended fertilizer dose) but treatment T_7 and T_8 also performed well in case of early anthesis of chilli.

The lowest time (52 days) for 50% flowering was also found in the treatment T_6 (50% vermicompost + 50% recommended fertilizer dose) and treatment T_1, T_5, T_7, T_8 and T_9 took second lowest time for 50% flowering while control took highest time for 50% flowering initiation.

Days to fruit setting did not differ statistically among the treatments but numerically highest time required in T_0, T_3 and T_4 treatment and lowest found in T_6 treatment.

Data on yield components revealed that fertilization by different types and levels of manures and fertilizers influenced markedly the number of total fruits plant^{-1}. The highest number of total fruits plant^{-1} was obtained in the treatment T_6 (182.53) and the second highest observed in the treatments T_7 and T_8.

Fruit size also significantly affected by the application of different manures and fertilizers. The maximum fruit length (5.91 cm) and breadth (1.06 cm) observed from treatment T_9 and treatment T_6; respectively. However, treatment T_6, T_7, T_8 and T_5 gave a satisfied level of length and breadth.

Application of different types and levels of fertilizers and manures significantly affected the single fruit weight which found maximum in the treatment T_6 (1.9 g) and T_7 (1.78 g) while the performance of control was lowest (1.3 g).

It was also observed that among the treatments T_6 (50% vermicompost + 50% recommended fertilizer dose) and T_7 (50% *Tricho*-compost + 50% recommended

fertilizer dose) provided highest fruit yield per plant (336.6 g and 305.3 g) and the performance of T_0 was poorest.

Fruit yield per plot also maintain the same variation, the highest found in the T_6 (5.38 kg) and T_7 (4.94 kg) treatment and the second highest was observed in other combined application of manures and fertilizers or only inorganic fertilizers.

Yield (t/ha) responded significantly to various treatments. The highest yield (13.46 t/ha and 12.34 t/ha) found in the treatments (T_6 - 50% vermicompost + 50% RDF and T_7- 50% *Trichoderma* + 50% RDF) and the second highest observed in T_8, T_9 and T_5 treatments while performance of control was very poor.

The impact of different manures and fertilizers was also significant in case of shoot and root fresh weight and dry weight of chilli. The highest shoot fresh weight and dry weight was observed in the treatment T_7 and T_6 on the other hand highest root fresh weight and dry weight was found in T_1 and T_2 but Other combined treatments T_6, T_8, T_9, T_7 and only inorganic fertilizers T_5 maintained a satisfied level of root fresh weight and dry weight.

Economic analysis shows the highest gross return, net return and benefit cost ratio (BCR) in the treatment T_6 (50% vermicompost + 50% recommended fertilizer dose). Although, the second highest gross return and net return was observed in the treatment T_7 (50% *Tricho*-compost + 50% recommended fertilizer dose) but the second highest BCR was observed in the treatment T_5 (100% recommended fertilizers) for the high cost of *Trichoderma* compost. BCR of T_7 and T_8 was statistically similar and might be more benefitable than T_5 in the sense of sustainable agriculture.

Conclusion

From the present study it was found that highest plant height, number of fruits per plant, fruit breadth, single fruit weight and a short period of days to anthesis and 50% flowering initiation was obtained using treatment T_6 (50% vermicompost and 50% recommended fertilizer dose).

Number of leaves and number of branches per plant counted maximum on T_7 (50% *Trichoderma* compost and 50% recommended fertilizer dose) followed by T_6 (50% vermicompost and 50% recommended fertilizer dose).

Although the statistical value of fruit yield per plant, fruit yield per plot, yield (t/ha) and shoot fresh and dry weight were similar between T_6 and T_7 but numerically highest value except shoot fresh and dry weight was observed in the treatment T_6.

A highest value of shoot fresh and dry weight and medium level of root fresh and dry weight was observed in T_7.

A maximum level of gross return, net return and benefit cost ratio (BCR) was recorded in the treatment T_6.

In case of yield the better performance observed in T_6 and T_7 but in case of BCR the highest observed in T_6 followed by T_5 and then T_8 and T_7 due to highest cost of *Trichoderma* compost in the treatment T_7.

Although from T_5 (only recommended fertilizers) second highest BCR was found but in the sense of sustainable agriculture combined application of manures and fertilizers could be benefitable than other treatments.

In a word the performance of T_6 (50% vermicompost and 50% recommended fertilizer) was found to be the best in this local variety of chilli.

As it was a first trial, the investigation needs further study. If the same result is found it may enable farmers to replace/reduce the use of chemical fertilizers and use of vermicompost as a source of organic manure as an alternative of chemical fertilizers.

CHAPTER VI

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APPENDICES

Appendix 1. Plant height (cm) over time as affected by manures and fertilizers

Treatment	Plant height (cm)						
	15 DAT	30 DAT	45 DAT	60 DAT	75 DAT	90 DAT	105 DAT
T_0	8.65c	10.70g	18.46g	24.39f	33.97d	45.37e	46.77e
T_1	10.29a-c	13.70de	22.26d-f	28.90d-f	40.97b-d	52.88b-d	53.89b-d
T_2	10.05a-c	12.73ef	21.24e-g	27.76ef	40.30b-d	50.51c-e	52.04c-e
T_3	10.73a-c	14.12de	22.53d-f	30.63c-e	41.81bc	53.52a-d	54.45a-d
T_4	9.12bc	11.80fg	20.05fg	25.75f	36.20cd	47.13de	48.29de
T_5	12.03a	18.02b	26.76ab	35.71b	47.63ab	57.71ab	60.21ab
T_6	12.45a	20.57a	29.37a	40.93a	50.25a	60.16a	61.45a
T_7	11.09a-c	16.11c	24.59b-d	32.59b-d	43.35a-c	55.87a-c	57.95a-c
T_8	11.47ab	17.00bc	26.30bc	34.23bc	44.71ab	56.71a-c	58.37a-c
T_9	11.06a-c	15.23cd	23.55c-e	31.62b-e	43.09a-c	53.76a-d	56.5a-c
Level of significance	*	**	**	**	**	**	**
CV (%)	12.47	5.36	5.20	5.89	7.17	5.20	5.10

**= Significant at 1% level and *= Significant at 5% level. Means followed by common letter(s) in a column do not differ significantly by DMRT.

Appendix 2. Leaves number plant^{-1} over time as affected by manures and fertilizers

Treatment	No.of leaves plant^{-1}						
	15 DAT	30 DAT	45 DAT	60 DAT	75 DAT	90 DAT	105 DAT
T_0	12.53e	25.13e	49.80f	74.07f	91.20e	107.20h	109.50f
T_1	15.07b-e	33.93c-e	63.80c-e	95.13cd	116.00cd	135.30d-f	141.30d
T_2	14.40c-e	30.53de	62.53c-e	91.80c-e	112.60d	132.90e-g	136.20de
T_3	13.53de	28.33de	57.87ef	81.87ef	101.90de	116.20gh	117.90f
T_4	14.27c-e	29.93de	60.67de	86.07de	103.60de	120.80f-h	122.50ef
T_5	17.60ab	43.53a-c	73.2bc	107.30b	139.70b	159.70bc	161.30bc
T_6	18.60a	47.13ab	81.13ab	111.30ab	145.80b	166.80b	168.10b
T_7	19.20a	52.47a	85.13a	119.70a	177.70a	204.90a	205.80a
T_8	15.67b-d	37.47b-d	67.07c-e	96.53cd	120.40cd	142.80c-e	145.00cd
T_9	17.00a-c	42.80a-c	71.00b-d	102.40bc	132.30bc	151.90b-d	154.70b-d
Level of significance	**	**	**	**	**	**	**
CV (%)	7.46	12.9	6.55	4.73	6.40	5.02	5.30

**= Significant at 1% level. Means followed by common letter(s) in a column do not differ significantly by DMRT.

Appendix 3. Branches number plant^{-1} over time as affected by manures and fertilizers

Treatment	No. of Branches plant^{-1}						
	15 DAT	30 DAT	45 DAT	60 DAT	75 DAT	90 DAT	105 DAT
T_0	0.53d	2.93f	6.73e	9.13e	10.33f	11.67e	12.47e
T_1	1.47b	4.73d	9.20b-d	10.80cd	11.80d-f	14.27c-e	15.40de
T_2	1.27bc	4.40de	8.86b-e	10.27de	11.47d-f	13.20de	14.40e
T_3	0.86cd	3.40f	7.73de	9.80de	10.67f	12.07e	13.13e
T_4	0.93cd	3.73ef	8.00c-e	10.00de	11.07ef	12.33e	13.27e
T_5	1.67ab	5.80bc	10.13a-c	12.53b	14.67a-c	17.60bc	21.13bc
T_6	1.80ab	6.13ab	10.60ab	12.73b	15.40ab	19.13b	22.40b
T_7	2.07a	6.87a	11.67a	14.20a	16.67a	25.20a	28.73a
T_8	1.53ab	5.07cd	9.47a-d	11.07cd	13.07c-e	15.4b-e	16.40c-e
T_9	1.60ab	5.57bc	9.80a-d	11.87bc	13.47b-d	16.87b-d	20.00b-d
Level of significance	**	**	**	**	**	**	**
CV%	15.83	7.28	9.81	5.33	6.87	10.13	11.84

**= Significant at 1% level. Means followed by common letter(s) in a column do not differ significantly by DMRT.

Appendix 4. Analysis of variance (Plant height)

Source of variation	Degrees of Freedom	Mean square						
		15 DAT	30 DAT	45 DAT	60 DAT	75 DAT	90 DAT	105 DAT
Replication	2	1.79	13.36	14.55	79.29	91.56	312.35	325.79
Treatment	9	4.33*	27.24**	32.99**	73.33**	70.58**	64.59**	71.39**
Error	18	1.78	0.64	1.49	3.39	9.17	7.05	7.29
Total	29	-	-	-	-	-	-	-

Appendix 4. Continued.(Leaf number plant^{-1})

Source of variation	Degrees of Freedom	Mean square						
		15 DAT	30 DAT	45 DAT	60 DAT	75 DAT	90 DAT	105 DAT
Replication	2	14.82	145.03	71.73	356.42	217.54	1003.97	1279.29
Treatment	9	14.92**	245.12**	344.03**	585.19**	1952.68**	2468.90**	2389.55**
Error	18	1.39	22.92	19.38	20.86	63.11	52.06	1082.09
Total	29	-	-	-	-	-	-	-

Appendix 4. Continued.(Branch number plant^{-1})

Source of variation	Degrees of Freedom	Mean square						
		15 DAT	30 DAT	45 DAT	60 DAT	75 DAT	90 DAT	105 DAT
Replication	2	1.24	4.74	20.52	7.56	2.64	15.69	12.36
Treatment	9	0.67**	4.80**	6.38**	7.43**	14.03**	52.05**	82.22**
Error	18	0.05	0.12	0.82	0.36	0.78	2.55	4.41
Total	29	-	-	-	-	-	-	-

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Appendix 4. Continued. (Days to anthesis, days to 50% flowering, days to fruit setting, no. of fruits plant^{-1}, fruit length and fruit breadth)

Source of variation	Degrees of Freedom	Mean square					
		Days to anthesis	Days to 50% flowering	Days to fruit setting	No. of fruits plant^{-1}	Fruit length	Fruit breadth
Replication	2	78.09	290.70	1041.59	286.73	4.09	0.009
Treatment	9	29.75*	32.24*	46.61	3190.81**	1.33**	0.03**
Error	18	12.76	10.89	45.55	105.59	0.17	0.002
Total	29	-	-	-	-	-	-

Appendix 4. Continued. (single fruit weight, fruit yield plant^{-1}, fruit yield plot^{-1}, yield t ha^{-1}, shoot fresh weight, root fresh weight, shoot dry weight and root dry weight)

Source of variation	Degrees of Freedom	Mean square							
		Single fruit weight	Fruit yield plant^{-1}	Fruit yield plot^{-1}	Yield t ha^{-1}	Shoot fresh weight	Root fresh weight	Shoot dry weight	Root dry weight
Replication	2	0.07	935.09	0.15	0.93	235214.39	433.85	135840.39	3537.98
Treatment	9	0.10**	16610.45**	4.39**	27.08**	135126.43**	3665.97**	54825.34*	1506.58**
Error	18	0.008	227.95	0.05	0.32	7212.03	22.04	6105.75	57.16
Total	29	-	-	-	-	-	-	-	-

Appendix 4. Continued. (Gross return, total cost of production, net return and bcr)

Source of variation	Degrees of Freedom	Mean square			
		Gross return	Total cost	Net return	BCR
Replication	2	1490992000	0	1490992000	0.03
Treatment	9	43327220740.74**	6112348590.37	49936385241.53**	1.23**
Error	18	517954962.96	0	517954962.96	0.01
Total	29	-	-	-	-

Appendix 5. Chemical analysis of soil sample before manure and fertilizers application

P^H	EC (dS/m)	Organic matter (%)	Potassium (mg/100g soil)	Total Nitrogen (%)	Phosphorus (µg/ g soil)	Sulphur (µg/g soil)	Zinc (µg/g soil)	Boron (µg/g soil)
6.8	6.0	2.03	0.73	0.117	26.37	205.69	1.89	0.71

Source: SRDI office; Daulatpur, Khulna

Appendix 6. Chemical analysis of soil sample after manure and fertilizers application

Treatment	P^H	EC (dS/m)	Organic matter (%)	Potassium (mg/100g soil)	Total Nitrogen (%)	Phosphorus (µg/ g soil)	Sulphur (µg/g soil)	Zinc (µg/g soil)	Boro (µg/ soil)
T_0	6.8	6.0	2.03	0.73	0.117	26.37	205.69	1.89	0.71
T_1	7.1	7.4	3.25	1.02	0.185	65.26	269.51	7.5	0.83
T_2	7.3	7.0	3.87	1.08	0.187	52.39	239.12	5.09	0.90
T_3	7.5	7.5	2.73	0.90	0.158	55.58	228.20	2.74	1.19
T_4	7.4	7.0	2.20	0.87	0.127	61.48	219.20	2.28	0.94
T_5	7.4	7.2	2.43	0.94	0.2	85.00	246.63	2.98	1.14
T_6	7.2	6.2	3.20	0.95	0.188	123.40	259.11	4.09	1.41
T_7	7.1	7.0	3.46	0.98	0.224	129.50	267.5	3.59	1.11
T_8	7.4	7.9	2.68	0.87	0.155	98.31	282.43	2.72	0.90
T_9	7.3	8.2	2.33	0.81	0.135	88.92	252.41	2.09	1.5
Range(min-max)	6.8-7.5	6.0-8.2	2.03-3.87	0.73-1.08	0.117-0.224	26.37-129.50	205.69-282.43	1.89-7.5	0.71-1.41

Source: SRDI office; Daulatpur, Khulna

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Appendix 7. Chemical analysis of soil sample after harvesting of chilli

Treatment	P^H	EC (dS/m)	Organic matter (%)	Potassium (mg/100g soil)	Total Nitrogen (%)	Phosphorus (µg/ g soil)	Sulphur (µg/g soil)	Zinc (µg/g soil)	Bo (µ soi
T_0	6.7	1.1	3.13	0.52	0.181	16.27	111.68	1.65	0.6
T_1	7.2	2.1	3.03	0.87	0.120	57.31	161.60	4.25	0.7
T_2	7.4	2.6	3.00	0.67	0.154	86.61	169.55	4.37	0.8
T_3	7.5	0.7	2.99	0.81	0.173	25.10	154.3	2.24	0.9
T_4	7.3	1.3	2.74	0.73	0.158	31.40	39.11	1.66	0.6
T_5	7.5	1.3	2.95	0.91	0.159	40.40	85.05	1.5	0.7
T_6	7.3	0.7	2.07	0.81	0.175	42.41	39.89	3.2	0.8
T_7	7.0	2.0	2.74	0.71	0.174	100.4	58.77	1.74	0.9
T_8	7.3	2.0	3.02	0.73	0.175	35.67	140.13	1.72	0.6
T_9	7.5	1.8	2.94	0.59	0.170	32.39	114.5	1.9	0.7
Range (min to max)	6.7-7.5	0.7-2.6	2.07-3.13	0.52-0.91	0.120-0.181	16.27-100.4	39.11-169.55	1.5-4.37	0.6 0.9

Source: SRDI office; Daulatpur, Khulna

Appendix 8. Some pictorial presentation of chilli variety 'Chandramukhi' as influenced by different manures and fertilizers

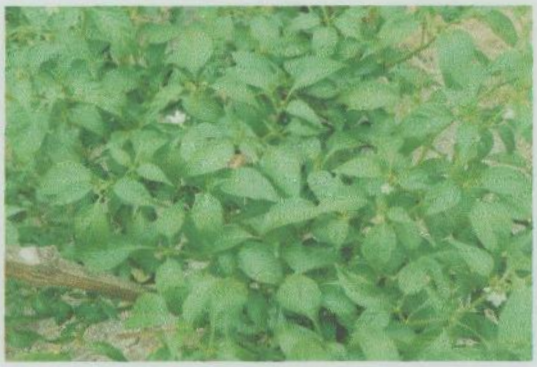

Plate 1. Flowering intiation of T_6 treatment

Plate 2. Fruiting stage of T_6 treated plant

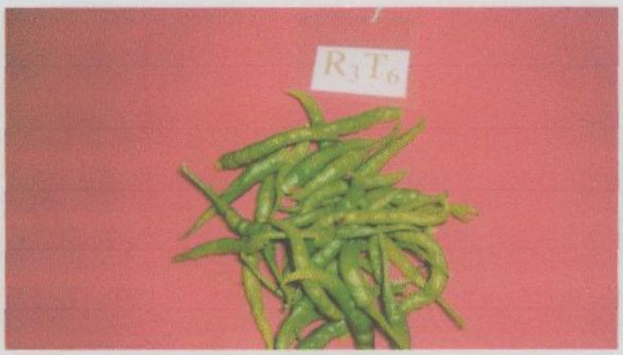

Plate 3. Fruit of T6 treatment

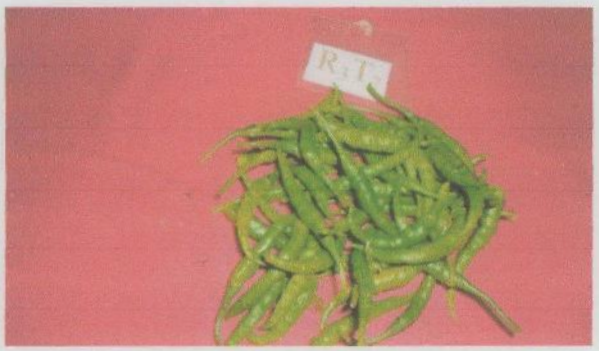

Plate 4. Fruit of T7 treatment

Plate 5. Taking breadth of fruit T_6 treatment

Plate 6. Length of fruit of T_6 treatment