EFFECT OF ORGANIC AND INORGANIC FERTILIZERS ON THE GROWTH AND YIELD OF BROCCOLI (*Brassica oleracea* var. *italica* L)

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CERTIFICATE

This is to certify that thesis entitled ***"EFFECT OF ORGANIC AND INORGANIC FERTILIZERS ON THE GROWTH AND YIELD OF BROCCOLI (Brassica oleracea var. italica L)*** *submitted to the* ***Faculty of Agriculture,*** *Sher-e-Bangla Agricultural University (SAU), Dhaka in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE (MS) in HORTICULTURE,*** *embodies the result of a piece of bona fide research work carried out by* ***TASLIMA AKTER*** *Registration No. 19-10264 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

I further certify that any help or source of information, received during the course of this investigation has been duly acknowledged and style of this thesis have been approved and recommended for submission.

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DEDICATED
TO
MY BELOVED
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ABSTRACT

A field experiment was conducted at the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka 1207, Bangladesh, during November 2021 to March 2022 to find out the effect of organic and inorganic fertilizer managements for the growth and yield of broccoli (*Brassica oleracea* var. *italica*). The experiment comprised 9 different treatments of organic and inorganic fertilizer and their combination viz., T_0: Control (without fertilizer); T_1: Cow dung (CD) @ 15 ton/ha; T_2: Recommend fertilizer dose @ CD_{10}t N_{150}kg P_{150}kg K_{120}kg/ha; T_3: Vermicompost @ 10 ton/ha and Trichoderma @ 22 kg/ha; T_4: Vermicompost @ 10 ton/ha and biochar 150 kg/ha; T_5: Kitchen compost @ 8 ton/ha; T_6: Mushroom compost @ 5 ton/ha; T_7: Vermicompost (50%) + Cowdung (50%) and T_8: Mushroom Spent compost @ 5 ton/ha (60%) + Vermicompost (20%) + Trichoderma (20%) and experiment was setup in Randomized Complete Block Design (RCBD) with three replications. A positive impact of each fertilizer was observed on vegetative growth and yield of the crop. Early curd initiation (44.33 days after transplanting), maximum curd diameter (13.58 cm), maximum weight of primary curd (344.2 g), maximum number of secondary curd (6.67), maximum weight of secondary curd (210 g), maximum dry matter content (9.86%) of curd, highest yield plant^{-1} (550 g), yield plot^{-1} (4.95 kg) and yield ha^{-1} (26.76 t) were found from T_2 treatment, while the control treatment gave the lowest. The highest benefit cost ratio (3.40) was noted from T_2 and the lowest (1.21) from T_4. Considering the differences between different organic fertilizers with the recommended dose, the lowest differences of plant height (1.57 cm) at 60 DAT, diameter (0.33 cm) of primary curd, weight (26.1 g) of primary curd, per plant yield (21.9 g) and yield (1.07 t/ha) of broccoli over the recommended dose was observed in T_8 treatment. Considering the sustainable yield, application of recommend fertilizer dose @ CD_{10}t N_{150}kg P_{150}kg K_{120}kg/ha seemed to be more promising for broccoli cultivation and among the organic fertilizers, the combination Mushroom Spent compost @ 5 ton/ha (60%) + Vermicompost (20%) + Trichoderma (20%) was best in respect of plant growth and yield.

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LIST OF ABBREVIATIONS AND ACRONYMS

Abbreviation	Full meaning
AEZ	Agro-Ecological Zone
Agric.	Agriculture
Agril.	Agricultural
BBS	Bangladesh Bureau of Statistics
cm	Centi-meter
CV	Coefficient of variation
^{0}C	Degree Celsius
df	Degrees of freedom
DAT	Days After Transplanting
et al.	And others
FAO	Food and Agriculture Organization
g	Gram
ha	Hectare
J.	Journal
kg	Kilogram
RCBD	Randomized Complete Block Design
mg	Milligram
MoP	Muriate of Potash
No.	Number
SAU	Sher-e-Bangla Agricultural University
TSP	Triple Super Phosphate

CHAPTER I

INTRODUCTION

Broccoli (*Brassica oleracea* L.), belongs to the family Brassicaceae or Cruciferae (mustard family) is an important cole vegetable crops; which includes cabbage, cauliflower, Chinese cabbage, brussels sprouts and kohlrabi and becoming popular day by day in Bangladesh (Rabbee *et al.*, 2020). It is a member of the Cole group that originally comes from the Mediterranean region and it has about 130 times more Vitamin-A contents than cauliflower and 22 times more than cabbage, Broccoli is rich source of vitamins, minerals and essential amino acids, also contains the compound glucoraphanin which have anticancerous properties (Thamburaj and Singh, 2014). It contains more nutrients among cole crops and rich in vitamins, minerals, antioxidants also fat and cholesterol free (Zhang, 2004). It has a high nutritional value where every 100 g of head contains 89.1 g water, 32 calories, 3.6 g protein, 0.3 g fat, 5.9 g carbohydrate, iron, potassium, sodium and vitamin A (Hanza and Al-Taey, 2020). It well known that, broccoli has enormous nutritional and medicinal values due to its high contents of vitamins (A, B_1, B_2, B_5, B_6 and E), minerals (Ca, Mg, Zn and Fe) and antioxidant substances which prevent the formation of cancer-causing agents (El-Magd *et al.,* 2006). It is either consumed raw as salad or cooked to prepare curries, soup and pickles. In the world market broccoli sold about 60 percent as frozen and remaining 40 percent as fresh. Now days, broccoli emerges as an important crop under protected cultivation during off season around metropolitans and tourist places (Swarup, 2012).

China leads the world in production with 43% (FAO, 2014). The growth and productivity of broccoli in the production area is influenced by many factors, which ultimately lead to improved quality of food product and increased yields of cultivated

areas. To increase the yield, plenty of chemical fertilizers along with a small quantity of organic one were being used by different workers which ultimately affects the health of soil as well as human (Meena *et al.,* 2017). Environmental impacts of excessive applications of chemical fertilizers in Bangladesh have been reported (Muhibbullah *et al.,* 2005). Excessive use of chemical fertilizers causes unforeseen environmental impacts and sensitivity to pests and diseases through the oversupply of nitrogen (Chen, 2006). Organic farming practices are a potential way to decrease the negative environmental impact of excessive amounts of chemical fertilizers (Chowdhurey, 2004). Organic fertilizers are environmentally friendly and improve soil health, water-holding capacity, high cation exchange capacity and low bulk density and they foster diverse population of beneficial soil microorganisms (Mohammed *et al.,* 2013). Organic fertilizers contain macro- and micro-nutrients, vitamins, growth-promoting factors indole 3-acetic acid (IAA), gibberellic acid (GA), and beneficial microorganisms and they increase production in ways similar to inorganic fertilizers (Maske, 2015).

Alternatively, there are mixed fertilizers or integrated plant nutrient systems (IPNS) where organic fertilizer is combined with inorganic fertilizer for soil improvement and higher yield. Due to excess use of chemical fertilizers a decline pattern is observed in soil fertility therefore integrated nutrient management is an important demand of present era (Attigah *et al.,* 2013). However, the process of chemical fertilization with N-P-K compound fertilizer and organic fertilizers is one of the most important processes and agricultural factors important for improving plant growth (Al-Taey *et al.,* 2018). Organic fertilizers and chemical fertilizers of various kinds and sources are being used, is considered one of the production inputs that contribute effectively in agricultural development and food security (Al-Taey *et al.,* 2019). This

also reduces the gap between the produced quantities and imported food. The main aim of integrated nutrient management is to cultivate a land in such a way that the soil should remain sustainable with maximum quality production of crop (Mishra *et al.*, 2014). Hence, being a newly introduced crop in Bangladesh, there is an urgent need for standardization of integrated nutrient management practices with locally available organic manures integrated with inorganic fertilizers. Keeping this in view, a field experiment was carried out with the objectives to study the effect of integrated application of inorganic fertilizers and organic manures on growth and yield attributes.

Keeping all the points in mind mentioned above, the present piece of research work was under taken with the following objectives:

- To find out the yield difference among organic treatments comparing with recommended dose,
- To find out the effects of different inorganic and organic fertilizers on growth performances of broccoli, and
- To optimize the effects of different inorganic and organic fertilizers on yield attributes of broccoli.

CHAPTER II

REVIEW OF LITERATURE

Broccoli is one of the most widely grown vegetables in the temperate zones and is a biennial and herbaceous “Cole” crops in Bangladesh. It is a thermo sensitive crop and grown in Bangladesh and grown as an annual crop in winter crop. Growth and curd development of broccoli are greatly influenced by growing environment. As a minor vegetable and newly introduced crop it has less attention by the researchers on various production aspects especially the use of organic and inorganic fertilizers on the growth and yield of broccoli have been carried out in Bangladesh. Therefore, the research work so far done in Bangladesh is not adequate and conclusive. Nevertheless, some of the important informative works and research findings related to the effect of organic and inorganic fertilizers on broccoli so far been done at home and abroad have been reviewed in this chapter under the following headings: -

2.1 Effect of organic and inorganic fertilizer on broccoli

Sadanand and Fatmi (2022) carried out an experiment to find out the effects of different combinations of organic and inorganic fertilizers on growth, quality and yield of red cabbage (*Brassica oleracea* var. *capitata* f. *rubra*). The results shown that the highest growth parameters were obtained by application of nitrogen through inorganic fertilizer at plant height 33.6 cm, number of leaves 36 and plant spread 55.7 cm, whereas treatment T_5 (50% Nutrient through inorganic fertilizer + 50% through Vermi-compost) was found best in respect to yield and quality parameters via, (maximum head diameter (26.32 cm), head size (32.86 cm), gross head weight (1470.2 g), net head weight (988.7 g), highest head yield/plot (6.72 kg/ha), highest head yield (25.1 kg t/ha), highest Vitamin C (58.8 mg/100g) and TSS (5.49 ^{o}Brix)). Treatment T_4 also gave best net return (₹ 3, 03,779/ha) with B: C ratio (4.07:2). The

study revealed that, treatment T_5 and T_4 provides high benefits in respect to yield and quality parameters to the farmers through easy cultivation.

Biswas *et al.* (2021) conducted an experiment with ten combinations of inorganic fertilizers and organic manures with one control to investigate the effects of inorganic and organic fertilizers on broccoli and found that the application of 50% RDF + PM @ 6 t/ha (T_2) responded better with respect to the plant height, number of leaves per plant, head initiation, days to first harvest. head weight, number of secondary head per plant, lateral head weight, head diameter, head yield per plant, head yield per plot, head yield. The stalk length and stalk diameter were observed to be the maximum in treatment in 100% RDF [NPK through chemical Fertilizer] (T_{10}).

Al-Bayati et al. (2021) carried out an experiment to investigate the effects of organic fertilizers and chemical fertilizers in the vegetative growth and yield of broccoli and found that combination of 100 kg chemical fertilization ha^{-1} + 7 mlL^{-1} of organic extract (Tecamine Max) showed the best values in both of head weight and the heads yield (459.72 g $plant^{-1}$ and 28,732 t ha^{-1}) respectively.

Kori and Singh (2021) conducted an experiment to find out the effect of organic manures and inorganic fertilizers on growth, yield quality and economics of broccoli and found that increase in nitrogen and Bioinoculant level had significant response on vegetative growth yield and quality of Broccoli. The treatment (T_{10}) with 100% NPK + 50% FYM + 50% VC + Bioinoculant was found to be the best treatment among the different treatments with growth, yield and quality as well as maximum gross return for broccoli under satna condition.

Rabbee *et al.* (2020) carried out an experiment with two organic manures (vermicompost and farmyard manure) to investigate the effects of organic fertilizers on the growth and yield of broccoli and observing that using of vermicompost treated

plants gave better growth and yield contributing characters of Broccoli in contemporary with other treatments.

Singh *et al.* (2020) carried out an experiment with ten treatments having different combination of organic manures and inorganic fertilizers to find out the effect of integrated nutrient management (INM) on growth and yield of broccoli and found that the application of integrated nutrient management significantly increased the growth and yield of broccoli. The use of 10 t/ha vermicompost + 50% RDF recorded the earliest days to head initiation (57.13 days) and first harvesting (80.07 days), maximum head weight (190 g), head diameter (110.33 mm), yield/plot (4.50 kg) and yield/ha (50.29 q).

Kandil and Gad (2020) conducted an experiment to investigate the effect of different solution fertilizers formula and organic manure on vegetative growth, heads yield quantity and quality as well as nutrient composition of broccoli (*Brassica oleracea* var. *italica*). They found that all mineral solution fertilizers gave a significant synergistic effect for broccoli growth, yield quantity and quality as well as nutrients composition compared the control (mineral N, P, K recommended fertilizers). The mineral formula 19: 19: 19 recorded the highest growth heads, yield and quality along with mineral content in broccoli. Using farmyard manure plus inorganic fertilizers enhanced all growth and yield parameters. Applying farmyard manure plus the mineral solution fertilizer formula 19: 19: 19 caused the superior and optimum figures of broccoli growth, mineral composition as well as heads yield quantity and quality.

Hussain *et al.* (2020) conducted an experiment with a view to assess the combined effect of inorganic and organic sources of nitrogen on yield of broccoli and to develop a combined dose under integrated plant nutrition system (IPNS) for broccoli production. The treatment PU-N_{180}+PM_3 showed better performance regarding yield

(13.7 t ha_{-1}), harvest index (27.1%) and benefit cost ratio (BCR) (3.84). Therefore, USG @160 kg N ha^{-1}+ 3 t ha^{-1} poultry manure as adjusted $N_{126}P_{22}K_{62}S_{14}Zn_2B_1Mo_{0.8}$ kg/ ha+3 t/ha PM or PU @180 kg N/ ha + 3 t/ ha poultry manure can be recommended for broccoli production in Grey Terrace Soil.

Yoldas *et al.* (2020) conducted an experiment with sheep and cattle manure and organic commercial fertilizer to determine the animal manures on yield, quality, and nutrient content of broccoli heads and found that manure rates significantly increased yield, average weight of main and secondary heads, and the diameter in broccoli compared to control. The highest total yield (27.74 t ha^{-1}) was obtained using sheep manure (30 t ha^{-1}). At harvest, the highest amount of the total N in broccoli heads was measured at organic commercial fertilizer application. Potassium (K), sodium (Na), iron (Fe) and manganese (Mn) content increased with higher doses but, phosphorus (P), calcium (Ca), copper (Cu) and zinc (Zn) contents were not influenced. Additionally, the highest nutrient removal for broccoli heads was obtained at 30 t ha^{-1} sheep manure application rate.

Al-Hussainy and Manea (2019) conducted an experiment with eight organic fertilizers to find out the effect of planting distance and organic fertilization on growth and yield of Broccoli. It is noted that the results of organic fertilization with rice waste and poultry manure did not differ significantly from the results of chemical fertilization in the plant height and percentage of chlorophyll. The planting distance in all the traits of the studied quantitative yield and the organic fertilization did not differ from the chemical fertilization in the traits of the quantitative yield except for the trait of diameter and perimeter of the curd, where the superiority was significant for chemical fertilization compared to rice waste, which recorded the lowest diameter and perimeter.

Mauriya *et al.* (2018) carried out an experiment to find out the influence of organic, inorganic fertilizers and micronutrient on growth of broccoli. Twelve treatments including control were used and each treatment was replicated thrice. Growth and yield component was highest under the treatment T_{10} Recommended Dose of Fertilizer (RDF) in which second top-dressing dose of N in urea was replaced by UVM-1, as compared to other treatments. The maximum plant height (31.82 cm and 44.30 cm) and minimum (24.43 cm and 4035 cm) 30 and 60 days receptively. The maximum number of leaves per plant (8.21 and 15.80) and minimum (7.25 and 13.11) 30 and 60 days receptively, The minimum day of curd initiation 63.65 and maximum 66.29, maximum weight of curd with guard leaf 418.33 gram and minimum 289.74 gram, maximum weight of curd without guard leaf 553.21 gram and minimum 338.37 gram, maximum curd diameter, 15.63 and minimum 13.46, maximum yield kg/plot 3.18 and minimum 2.14 and maximum yield q/ha 224.33 and minimum 151.40 under treatment T_{10} and minimum yield quality of broccoli days 30 and 60 DAT under treatment T_0. Whereas, which second top dress dose of N in urea from replaced through UVM-1 followed by under treatment T_{11} which total dose of N in urea form replaced through UVM-1 which total dose of N in urea form replaced through UVM-1 and maximum curd initiation days 30 and 60 DAT (66.29 days) under treatment T_0.

Mohanta *et al.* (2018) conducted an experiment to investigate the effect of integrated nutrient management on growth, yield, quality and economics of sprouting broccoli and found that the application of 50% recommended dose of NPK/ha with 2.5 tonnes of vermicompost in sprouting broccoli was found to be the best for obtaining better growth, optimum yield, better quality produce, highest net returns as well as cost benefit ratio and is recommended for Odisha condition.

Lodhi *et al.* (2017) conducted an experiment to find out the effect of inorganic and organic fertilizers on yield and economics of broccoli. They used different doses of recommended dose of nitrogen (RDN), Farm yard manure (FYM), Poultry manure, Vermicompost and their combinations and found that the use of 50% recommended dose of nitrogen (RDN) + 16.6 % farm yard manure (FYM) + 16.6 % Vermicompost + 16.6 % Poultry Manure gave the maximum curd diameter (15.37cm), weight of trimmed curd (413.33g), curd yield per plot (7.44 kg) and curd yield (14.16 t/ha) in broccoli.

Mebrahtu and Solomun (2018) carried out an experiment to find out the combined effect of organic and inorganic fertilizer on yield and yield component of cabbage and found that the use of organic fertilizer as an alternative to inorganic fertilizer increased among subsistence farmers in rural areas in meremieti. Despite the fact that, no clear recommendation exist for the application of rate of organic fertilizer on vegetable. Field experiment was conducted to evaluate the different combination of organic and inorganic fertilizer on yield and yield component of cabbage. The result indicates application of organic and inorganic fertilizer increases the yield and yield component of cabbage. The highest cabbage weight, plant height, root length and yield of cabbage was obtained when the plot was received 1.75ton/ha of FYM and 75kg/ha of Urea; and 112.5kg Urea+0.875 ton FYM followed by150 kg Urea and plots received 37.5kg Urea+2.625 ton FYM and 3.5ton FYM shown intermediate yield. The lowest yield was recorded in control. Thus, yield and yield component of cabbage was positively influenced by the different combination of organic and inorganic fertilizer. Application of fertilizer in the combination of 1.75ton/ha of FYM and 75kg/ha of Urea; and 112.5kg Urea+0.875 ton FYM leads in better yield and

yield component of cabbage and hence farmers within that area should apply these appropriate combination.

Doklega and El-Hady (2017) conducted a Two field experiments at the Experimental Station Farm, Faculty of Agriculture, Mansoura University, Egypt, during 2014/2015 and 2015/2016 seasons to estimate the effect of organic (compost and compost tea), mineral (100%, 75% and 50% from recommended dose of NPK) and bio-fertilization (without, mixture of bacteria with fungi and EM) as well as their interactions on growth, yield and quality of broccoli plants. Data which obtained in this experiment indicated that organic treatments gave the highest means of vegetative growth parameters, total yield and quality of broccoli heads were recorded from plants which fertilized with compost compare to compost tea except total carbohydrates and regarding to mineral fertilization, broccoli plants which fertilized with 75% NPK from recommended dose gave the maximum means of all studied characters in both seasons. Moreover bio-fertilizers, the highest values of all parameters were resulted from plants treated with EM followed by bio-fertilizer mixture treatment in both seasons. It could be recommended that fertilization of broccoli plants with compost (4 ton/fed.), 75% NPK from recommended dose and inoculation with EM (10 ml/plant) in would improve broccoli plants productivity and quality.

Singh *et al.* (2016) carried out an experiment to study the growth and yield potential of broccoli influenced by combined effect of organic manures and bio-fertilizer. The results showed that the combined use of organic and bio-fertilizer significantly effective on growth and yield characters.

Acharya *et al.* (2015) conducted an experiment with FYM @ 20 ton/ha (T_1), Compost @ 6.66 ton/ha (T_2), Vermicompost @ 4 ton/ha (T_3), Poultry manure@ 2 ton/ha (T_4), FYM+PM @ (10 ton FYM + 1 ton PM)/ha (T_5), FYM+VC @ (10 ton FYM + 2 ton

VC)/ha (T_6) and control (T_7) to find out the growth, yield and soil nutrient status of broccoli under organic nutrient management and found tallest plant height (46.83 cm) and highest canopy area (47.62cm), the highest yield per plant (803.33 g/plant), yield per plot (9.64 kg/plot) and yield per ha (24.1 ton/ha) when treated with poultry manure.

Srichandan et al. (2015) conducted an experiment entitled "Growth, yield and economics of broccoli (*Brassica oleracea*) as influenced byorganic and inorganic nutrients" and found that T_{10} i.e. 75% NP+ 100% K+bio inoculants+ VC (5t/ha) proved to be the best on account of growth factor such as plant height, leaf area and curd diameter. The plant height, leaf area and curd diameter in T_{10} was 41.58 cm, 363.32 cm^2 and 46.91 cm respectively. The yield was also highest in T_{10} i.e. 149.43 q/ha. Similarly, the highest net return was also obtained from T_{10} i.e. 95,455 with benefit cost ratio of 3.45.

Jigme *et al.* (2015) investigated the effects of application of different rate of organic fertilizers on broccoli. Three levels of chicken manure tea (CMT) i.e. (0 ml/week, 100 ml/week and 200 ml/week), one inorganic and one control were compared. In all the vegetative parameters measured, the inorganic fertilizer treatment gave the highest mean value which was statistically significantly different from other treatments except for leaf diameter which was statistically similar to CMT 200 ml and compost treatment. The highest yield was obtained from inorganic fertilizer with the yield of 12.12 t/ha and the least from control with yield of 9.29 t/ha respectively. The positive dose-response pattern of the CMT applications suggests that there is good potential to further optimize this soil amendment.

Ryan (2011) conducted a field experiment to assess the release of plant-available N to broccoli plants from five N-rich soil amendments approve for organic production.

Data shows that fish meal supplied an optimal pattern of N for high broccoli yield in both years. Soil analysis in 2010 showed N availability from fish meal differed from other fertility sources, with greater initial NH_4^+ availability and consistently high NO3 levels from early to mid-June.

Boari *et al.* (2010) investigated the effects of fertilization and cultivar on yield and quality of broccoli in organic farming. Three levels of organic manure 0, 40 and 80 kg/ha of amino sprint, respectively indicated with F_1, F_2 and F_3 on 4 cultivars of broccoli, were compared. Any effects of fertilization levels were observed on broccoli yield and quality, because of low quantity of main nutritional elements contained in the amino sprint. The most productive cultivar was 'Chevalier'. The nitrate content was low mainly in 'Lord', 'Marathon' and 'Chevalier', and good ascorbic acid content was observed in 'Chevalier' and 'Switch'.

Maurya *et al.* (2008) conducted a field experiment in Pantnagar, Uttaranchal, India to study the effects of the following treatments on broccoli (cv. Fiesta): recommended fertilizers (RF; 120:60:60 kg NPK/ha), farmyard manure (FYM) at 20 t/ha, FYM at 10 t/ha + 50% FR, neem cake at 5 quintal/ha, neem cake at 2.5 quintal/ha + 50% RF, vermicompost at 5 t/ha, vermicompost at 2.5 t/ha + 50% RF, poultry manure at 5 t/ha, and poultry manure at 2.5 t/ha + 50% RF. In 2005-06, poultry manure + 50% RF and FYM + 50% RF resulted in the greatest plant height. In 2006-07, poultry manure + 50% RF, vermicompost + 50% RF, RF and poultry manure gave the tallest plants. The number of fully opened leaves in both years was highest for poultry manure + 50% RF. Leaf length was greatest for poultry manure + 50% RF and vermicompost + 50% RF. The greatest leaf weight per plant was recorded for poultry manure + 50% RF, FYM + 50% RF and vermicompost + 50% RF in 2005-06, and for poultry manure + 50% RF, RF, FYM + 50% RF and vermicompost + 50% RF in 2006-07.

Poultry manure + 50% RF, FYM + 50% RF and vermicompost + 50% RF registered the greatest head weight in 2005-06, whereas poultry manure + 50% RF was superior for this trait in 2006-07. The highest yields were obtained with poultry manure + 50% RF.

Wang *et al.* (2007) conducted a pot experiment to determine the effects of N, P and K on yield and quality of broccoli and reported that K was the most important element for yield. Additive effects were observed on yield and source-sink vitamin C [ascorbic acid] content when K was applied together with N or N + P. Application of N + P gave 110.8% higher yields than N alone. N application advanced the harvest. Significant positive correlations were found between yield and dry weight of leaves and plant size. They suggested that to obtain high yields and quality, N, P and K applications should be balanced.

Ahlawat *et al.* (2006) conducted a field experiment to study the effects of spent mushroom substrate (SMS) recomposed by different methods and mixed with arable soil on the vegetative growth, yield and quality attributes of cauliflower (*Brassica oleracea* var. *botrytis* cv. *Pusa Snowball*-1) were studied. Mixing of anaerobically recomposed SMS at 2.5 kg/m + chemical fertilizers (N, P and K at 12.5, 7.5 and 6.5 g/m^2, respectively) significantly enhanced vegetative growth during curd harvesting, gross and net yields, and quality attributes, and reduced the incidence of black rot disease and larval infestation. The mortality of plants during seedling transplanting was also lower under anaerobic SMS treatments. Thus, the use of anaerobically recomposed SMS with chemical fertilizers for cauliflower cultivation was found to be a better option of SMS disposal and raising high quality vegetable crops.

Yang *et al.* (2006) conducted a field experiment for two years to study the effect of nitrogen, phosphorus and potassium on growth and yield of broccoli. Treatments

comprised: 60:40:30, 120:80:50, 150:80:70 and 200:100:80 kg NPK/ha. They observed that plant height was increased through stem length, leaf length and breadth with increasing NPK and the highest plant height and number of leaves were obtained with 200:120:80 kg NPK/ha, respectively. The highest yield per plot was also obtained from the same treatment.

El-Magd *et al*. (2006) conducted two field experiments during the two successive seasons of 2003/2004 and 2004/2005 to study the response of vegetative growth and yield of some broccoli varieties to apply organic manures (cattle and poultry manures) compared with mineral fertilization. From the experiment it was found that use of 100% cattle manure produce the highest vegetative growth of broccoli plants whereas the use of poultry manure produce highest total yield and quality of broccoli.

Choudhary (2006) carried out a field experiment to investigate the effect of organic and inorganic source of nutrients on growth, yield and quality of sprouting broccoli cv.C.B.H-1 during rabi season of 2005-06 at Horticulture Farm, S.K.N. College of Agriculture, Jobner and found that application of inorganic fertilizers and organic manures under the treatment combination 100% recommended dose of NPK (100 : 80 : 60 kg ha^{-1}) + 5.0 t ha^{-1} vermicompost remaining at par with 125 % RDF, exhibited maximum plant height, number of leaves, leaf area, volume of head, diameter of head, average head yield (weight of central head and secondary head) $plant^{-1}$, total head yield (yield of central head and secondary head) $plot^{-1}$, total head yield (yield of central head and secondary head) ha^{-1}, biological yield $plant^{-1}$, crude protein content in head and chlorophyll content in leaves but days taken to central head initiation and vitamin-C content in head affected non-significantly with increasing inorganic and organic sources. Post-harvest analysis of soil indicates that both organic and inorganic

sources of nutrients brought significantly increase in available NPK and organic carbon of the soil.

Reddy *et al.* (2005) investigated the effect of P (0, 50, 100 and 200 kg/ha) and Zn (0, 10, 20 and 40 kg/ha) fertilizers, alone and in combination, on the yield and quality of cauliflower cv. Snowball 16. Curd yield significantly increased with increasing P and Zn rates up to 100 kg P/ha (238 q/ha) and 20 kg Zn/ha (210 q/ha). However, an increase in Zn rate up to 40 kg Zn/ha decreased curd yield (198 q/ha). Curd yield was also the highest (249 q/ha) with 100 kg P + 10 kg Zn/ha. The ascorbic acid content significantly increased up to 100 kg P/ha (83 mg/100 g) and 10 kg Zn/ha (82 mg/100 g), while it decreased significantly (80 mg/100 g) with 40 kg Zn/ha. Protein content significantly increased with 200 kg P/ha (30.84%), 10 kg Zn/ha (27.05%) and 100 kg P + 10 kg Zn/ha (31.28%).

Chaterjee *et al.* (2005) carried out an experiment to find out the effect of organic nutrition in sprouting broccoli (*Brassica oleracea* var. *italica*) and found that application of recommended dose of inorganic fertilizers had produced early vegetative growth, earliness in curd initiation and maturity, curd weight and in turn curd yield (124.07 q/ha) as well as highest cost benefit ratio (1:6.49) than organic sources of nutrition significantly. However, among the organic sources, application of Mustard oil cake + Bio-fertilizer-II (Azotobacter +VAM + Potash Mobilizer) had produced significantly higher yield (103.70 q/ha) and cost benefit ratio (1:4.46). On the other hand, organic sources of nutrition had produced significantly better quality of curd parameters than inorganic sources. Poultry manure + Bio-fertilizer-I (Azotobacter + Phosphate Solubilizer + Potash Mobilizer) had produced curds having significantly highest chlorophyll (32.80 mg/100g), ascorbic acid (80.30 mg/100g) and reducing sugar (2.20%).

Feller *et al.* (2005) reported on the nitrogen requirement of broccoli (*Brassica oleracea* var. *italica*) ranges from 300 to 465 kg/ha. Recommendations for N fertilizer application are accordingly high. High fertilizer rates applied at planting result in a high soil mineral N content that remains high for weeks because the N requirement of the crop is low at early growth stages. Therefore, the risk of leaching is high for several weeks until the available N is finally taken up by the crop. Their study had two objectives: (1) to quantify yield responses to preplant fertilizer application, and (2) to test our hypothesis that the preplant fertilizer rate could be reduced without yield losses by increasing the N content in the transplants and improving crop establishment. Field experiments (on a sandy soil, an Arenic Luvisol, in Germany, during 2000 and 2001) were carried out on transplants with four levels of N content in dry matter (0.018 to 0.038 g g-1 dry weight), which were tested in all combinations with four fertilizer application timings. All treatments received the same amount of N fertilizer (270 and 272 kg/ha in 2001 and 2002, respectively), but with different rates of supply at the time of planting (0 to 90 kg N fertilizer per ha plus 30 and 28 kg soil mineral N/ha in 2001 and 2002, respectively). Total and marketable yields increased significantly with an increasing N supply at time of planting. In our experiments, in which topdressing was applied 25 days after planting, N supply at planting of 80 to 118 kg/ha was required to obtain maximum marketable yields. The N content in transplants had little effect on growth and yield, and there were no significant interactions between the N content in the transplant and fertilizer timing.

Mahamud (2005) conducted an experiment to study the effect of different sources of nutrients on the growth and yield of Broccoli and Cauliflower. The experiment consists of five different sources of nutrient; fertilizer; C_0 (control), C_1 (cowdung 20 t/ha), C_2 (inorganic fertilizer urea 250 kg/ha, TSP 150 kg/ha and MP 200 kg/ha) and

C_3 (cowdung 10 t/ha, urea 250 kg/ha, TSP 150 kg/ha MP 200 kg/ha, agro growgranular 20 kg/ha) and C_4 (vermicompost 205 kg/ha) and two different cultivars Broccoli cv. 'Premium crop' (Br) and cauliflower cv. 'BARI 1' (Ca) were used in the experiment. The C_3 treatment gave the maximum gross yield (16.22 and 22.70 t/ha) and the minimum marketable yield (15.59 and 20.04 t/ha) in Br and Ca, respectively. While, the C_0 treatment gave the minimum gross yield (6.82 and 7.89 t/ha) and marketable yield (5.82 and 6.85 t/ha) in Br and Ca, respectively. Among the five different sources of nutrient treatments, the C_3 treatment performed the best.

Reddy *et al.* (2005) conducted a field experiment to study the effect of P (0, 50,100 and 200kg /ha) and Zn (0, 10, 20 and 40kg/ha) fertilizers, alone and in combination, on the yield and quality of cauliflower cv. snowball 16. Curd yield significantly increased with the increasing P and Zn rates up to 100kg P/ha and 20kg Zn/ha. However, an increase in Zn rate up to 40kg Zn/ha decrease curd yield. Curd yield was also highest with 100kg P +10kg Zn/ha. The ascorbic acid content significantly increased up to 100kg P/ha (83mg /l00g) and 10 kg Zn/ha (82mg/100g) while it decreased significantly (80mg/100g) with 40 kg Zn/ha. Protein content significantly increased with 200kg P/ha (30.84%), 10kg Zn/ha (27.05%) and 100kg P/ha+l0kg Zn/ha (31.28%).

Singh (2004) conducted a field experiment during 2001 and 2002 to evaluate the growth and yield of cauliflower c.v. Snowball-16 under different N (0, 60, 100 and 140kg/ha) and P levels (0, 60, 80 and 100 kg/ha). Increasing N and P levels advanced curd initiation and maturity and increased plant height, leaf length, lead width, curd diameter, curd depth, net curd weight and marketable curd yield. There were no significant differences between 100 and 140kgN/ha and between 80 and 100kg P/ha. Application of 140kg N/ha and 80kg p/ha recorded the highest values for number of

leaves per plant (19.44), Curd diameter (16.42cm), Curd depth (10cm), net curd weight (740.38g), Curd solidity (66.84g/cm) and marketable curd yield (236.92 q/ha) as well as the highest net returns (Rs. 101060/ha) and benefit cost ratio (6.81).

Magnani *et al.* (2003) conducted an experiment on the growth rate and qualitative characteristics of 3 vegetable (broccoli, cabbage and cauliflower) seedlings, grown with an organic method, were evaluated. The organic method consisted of using cocopeat as the growth medium and organic fertilizer for fertigation. This method was compared with a traditional one based on a peat growth medium and synthetic fertilizers for fertigation. The results showed different responses among the vegetables, regarding growth rate and quality. Broccoli grown with organic method presented an increase of growth rate, fresh weight, leaf number and area, height, root/shoot ratio and nutrient content compared to the traditional method. On the contrary, cabbage and cauliflower, grown with organic method, showed a reduction of growth rate, dry weight, leaf number and area, chlorophyll content, height and nutrient content. The different responses among these species could be related to the length of the nursery cycle, which is longer for cabbage (higher production of dry matter). Moreover, the leaf uptake of nutrients in cabbage was easier than cauliflower broccoli because of different characteristics of leaves.

Waltert and Theiler (2003) an experiment was conducted on the effects of growth of different cultivars of Cauliflower and Broccoli were analyzed by the diameter of curd, stem and weight of curd and showed that there was a strong correlation between the diameter of stem and plant biomass and diameter of stem and curd. Growth of stem and curd diameter is dependent on days after transplantation in the field, but dependence is even stronger if related to the sum of maximum daily temperature. Growth of curd showed higher cultivar variation and was more sensitive to

environmental factors than growth of stem. In consequence there is a higher variation between curds of one crop, which differs between cultivars. Depending on the correlations and the variation of harvesting period for cultivars can be predicted.

Brahma *et al.* (2002) conducted an experiment at Assam Agricultural University in India during rabi season of 1998-99 and 1999-2000 to study the effect of nitrogen, phosphorus and potassium on growth and yield of broccoli cv. Pusa Broccoli KTS-1. Treatments comprised: 0:0:0, 50:30:20, 100:60:40, 150:90:60 and 200:120:80 kg NPK/ha. The growth and yield of broccoli showed marked improvement with the application of 200:120:80 kg NPK/ha.

Sharma *et al.* (2002) a field experiment was conducted to evaluate the effects of N (60, 120, 180 and 240 kg/ha) and P (60, 120 and 18 kg/ha) on the growth and seed yield of Broccoli cv. Green Curd and observed that plant height, number of branches per plant, number of seeds per siliqua, seed yield, 1000-seed weight, germination percentage, seedling length and vigor index. In general, all parameters significantly improved with increasing concentrations of N and P.

Pardeep *et al.* (2001) conducted an experiment on performance of different broccoli cultivars (Green Head, Palam Samridhi, DPGB 12 and American Selection) under different N. P and K rates (0. 0 and 0; 60. 45 and 15 kg/ha; 90. 60 and 30 kg/ha; 120, 75 and 45 kg/ha and 150. 90 and 60 kg/ha, respectively) in India during 1998-99. Crop yield per plant (392.04 g/plant) and yield per hectare (13.05 t/ha), as well as vitamin C content (73.13 mg per 100 g), were highest in DPGB 12 compared to the other cultivars. The maximum values for growth, yield and quality characteristics were obtained at the highest N, P and K levels (150, 90 and 60 kg/ha, respectively). Treatment with these fertilizer levels combined with treatment with DPGB 12 resulted in the highest yield and benefit: cost ratio (2.71:1).

Guan and Chen (2001) reported that there was a significant effect of N and K on growth and yield of cauliflower and broccoli especially N on growth and K on yield. Higher amount of nitrogen increases plant height, leaf length and stem diameter at least at a certain range. On the other hand, higher amount of potassium contribute higher curd weight, curd diameter and secondary curd number per plant at least at a certain range of K application.

Sharma (2000) studied and observed that integration of organic and inorganic fertilizer application on Broccoli production (variety Green curd) significantly increased the curd yield over inorganic fertilizer alone and also over control. The treatment N 175 kg/ha, P 75 kg/ha, K 60 kg/hand FYM 12.60 ton/ha gave the maximum yield (63.12 q/ac) which was at far with N 160 kg/ha, P 75 kg/ha, K 60 kg/ha and FYM 12.60 ton/ha (57.59q/ac) but significantly superior to rest of the treatments in terms of yield and net profit.

CHAPTER III

MATERIALS AND METHODS

This chapter deals with the materials and methods that were used in carrying out the experiment. It includes a short description of location of the experimental plot, characteristics of soil, climate and materials used for the experiment. The details of the experiment were described below:

3.1 Location and site of the experiment field

The field experiment was conducted at the Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh from November 2020 to March 2021 to evaluate the effect of organic and inorganic fertilizer managements for the growth and yield of broccoli. It is located at $90^0$22′ E longitude and 23°4l′ N latitude at an altitude of 8.6 meters above the sea level. The land belongs to Agro-ecological zone of Modhupur Tract, AEZ-28 which is shown in Appendix I.

3.2 Climate

The climate of the experimental area is characterized by high temperature, high humidity and medium rainfall with occasional gusty winds during the kharif season (March- September) and a scanty rainfall associated with moderately low temperature in the Rabi season (October-March). The weather information regarding temperature, rainfall, relative humidity and sunshine hours prevailed at the experimental site during the cropping season November 2020 to March 2021 has been presented in Appendix II-III.

3.3. Characteristics of the soil

The soil of the experimental field belongs to the General soil type, Shallow Red Brown Terrace Soils under Tejgaon Series. The land was above flood level and sufficient sunshine was available during the experimental period. Soil samples from

0-15 cm depths were collected from the experimental field. The soil analyses were done at Soil Resource and Development Institute (SRDI), Dhaka. The physicochemical properties of the soil are presented in Appendix IV-V.

3.4 Planting Material

Broccoli *Brassica oleracea* var. *italica* sub var. *cymosa* cv. 'Premium crop' (by Takki company of Japan) was used in the experiment. The seeds were collected from Siddik Bazar, Gulistan, Dhaka.

3.5 Treatment of the experiment

The experiment comprised with the following nine treatments including control.

T_0: Control (without fertilizer)
T_1: Cow dung @ 15 ton/ha
T_2: Recommend fertilizer dose[1] @ $CD_{10\ t/ha}$ $N_{150\ kg/ha}$ $P_{150\ kg/ha}$ $K_{120\ kg/ha}$
T_3: Vermicompost @ 10 ton/ha and Trichoderma @ 22 kg/ha
T_4: Vermicompost @ 10 ton/ha and biochar 150 kg/ha
T_5: Kitchen compost @ 8 ton/ha
T_6: Mushroom compost @ 5 ton/ha
T_7: Vermicompost (50%) + Cowdung (50%)
T_8: Mushroom Spent compost @ 3 ton/ha (60%) + Vermicompost (20%) + Trichoderma (20%)

3.5.1 Nutrient composition of the organic fertilizers

The nutrient composition of different organic fertilizers used in the experiment is presented below:

Table 1: Nutrient composition of the organic fertilizes

Name of the organic fertilizer	Major nutrient content (%)			Source
	N	P	K	
Cow dung	0.85	0.12	1.49	Adebayo *et al.*, 2017
Vermicompost	1.61	1.02	0.73	Nagavallemma *et al.*, 2004
Kitchen compost	0.8	0.35	0.48	Nagavallemma *et al.*, 2004
Mushroom compost	2.33	0.77	1.62	Ji and Kim, 2008

[1] Recommend fertilizer dose by BARI

3.6 Seedbed preparation

Seedbed was prepared on 10 November 2020 for raising seedlings of broccoli and the size of the seedbed was 3 m×1 m. For making seedbed, the soil was well ploughed and converted into loose friable and dried masses to obtained good tilth. Weeds, stubbles and dead roots were removed from the seedbed. The soil was treated by Seven 50WP @ 5 kg/ha and Furadan 5G @ 40 kg/ha to protect the young plants from the attack of mole crickets, ants and cutworm.

3.7 Seed treatment

Seeds were treated by Provax 200WP @ 3g/1kg seeds to protect some seed borne diseases such as leaf spot, blight, anthracnose, etc.

3.8 Seed sowing

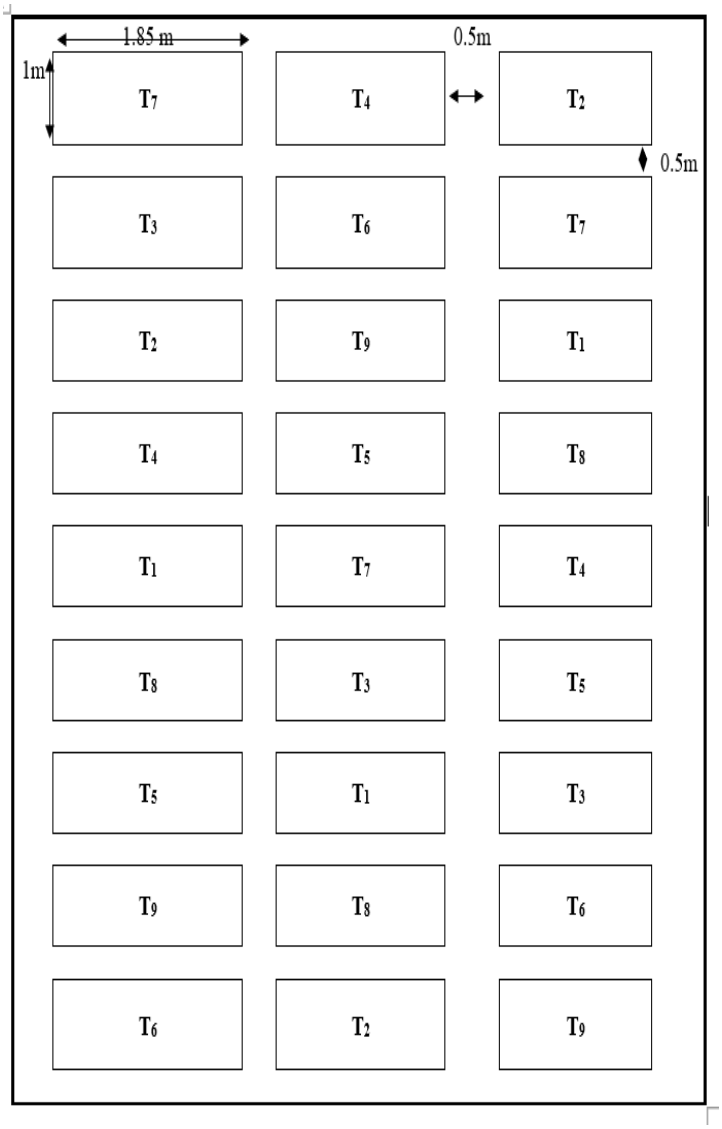
Seeds were sown on 13 November 2020 in the seedbed. Sowing was done thinly in lines spaced at 5 cm distance. Seeds were sown at a depth of 2 cm and covered with a fine layer of soil followed by light irrigation by water can. Thereafter the beds were covered with dry straw to maintain required temperature and moisture. The cover of dry straw was removed immediately after emergence of seed sprout. When the seeds were germinated, shade by bamboo mat (*Chatai*) was provided to protect the young seedlings from scorching sunshine and rain. The seeds in the seedbed were germinated at 17 November 2020 and the germination rate of the seed was around 85%.

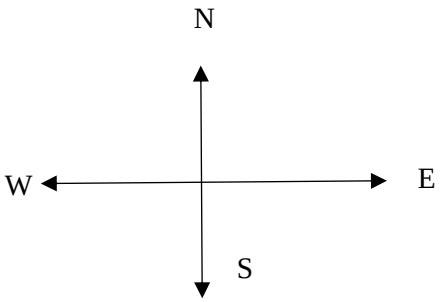
3.9 Raising of seedlings

Light watering and weeding were done several times. No chemical fertilizers were applied for rising of seedlings. Seedlings were not attacked by any kind of insect or disease. Healthy and 23 days old seedlings were transplanted into the experimental field on 10 December 2020.

3.10 Layout and design

The field experiment was conducted by Randomized Complete Block Design (RCBD) with three replications. The experimental plot was first divided into three blocks. Each block consisted of 9 plots. Thus, the total number of plots were 27. The size of a unit plot was 1.85 m × 1 m. A distance of 0.5 m between the plots and 0.5 m between the blocks were kept. Thus, the total area of the experiment was 19.0 m × 8.5 m. Plant to plant distance was 0.45 m.





Plot size: 1.85 m x 1 m

Spacing between plot: 0.5 m

Spacing between row: 0.5 m

Treatments were as follows:

T_0: Control (without fertilizer)
T_1: Cow dung @ 15 ton/ha
T_2: Recommend fertilizer dose @ $CD_{10\ t/ha}$ $N_{150\ kg/ha}$ $P_{150\ kg/ha}$ $K_{120\ kg/ha}$
T_3: Vermicompost @ 10 ton/ha and Trichoderma @ 22 kg/ha
T_4: Vermicompost @ 10 ton/ha and biochar 150 kg/ha
T_5: Kitchen compost @ 8 ton/ha
T_6: Mushroom compost @ 5 ton/ha
T_7: Vermicompost (50%) + Cowdung (50%)
T_8: Mushroom Spent compost @ 5 ton/ha (60%) + Vermicompost (20%) + Trichoderma (20%)

Figure 1: Layout of the field experiment

3.11 Cultivation procedure

3.11.1 Land preparation

The experimental area was first opened on 7 December 2020 with a disc plough to open direct sunshine to kill soil born pathogens and soil inhabitant insects. It was prepared by several ploughing and cross ploughing with a power tiller followed by laddering to bring about a good tilth. The land was leveled, corners were shaped and the clods were broken into pieces. The weeds, crop residues and stables were removed from the field. The doses of manure were applied and finally leveled. The soil of the plot was treated by Seven 50wp @ 5kg/ha to protect the young plants from the attack of mole cricket, ants and cutworm.

3.11.2 Fertilization

All the fertilizers according to treatment for different plots were applied during final land preparation except urea and potash fertilizer, which was applied in two equal split doses, at 15 DAT and 35 DAT. Fertilization was done at 04 January 2021 according to treatment for different plots.

3.11.3 Transplanting

The seedbed was watered before uprooting the seedlings to minimize the damage of roots. At the time of uprooting, care was taken so that root damage became minimum and some soil remained with the roots. Twenty-one days old healthy seedlings were transplanted at the spacing of 45 cm × 45 cm in the experimental plots on 10 December 2020. Thus the 9 plants were accommodated in each unit plot. Planting was done in the afternoon. Light irrigation was given immediately after transplanting around each seedling for their better establishment. The transplanted seedlings were shaded for five days with the help of transparent polythene to protect them from scorching sunlight, watering was done up to five days until they became capable of establishing on their own root system.

3.12 Intercultural operations

3.12.1 Gap filling

Very few seedlings were damaged after transplanting and gap filling was carried out with new seedlings from the same stock at 14 December 2020. Replacement was done with healthy seedlings having a boll of earth which were also planted on the same date by the side of the unit plot. Transplants were given shading and irrigation for 7 days for their proper establishment.

3.12.2 Weeding

The plants were kept under careful observation. Two times weeding were done during cropping period, viz. 3rd January 2021, 18th January 2021 and 03rd February 2021, for proper growth and development.

3.12.3 Irrigation

Irrigation was given by observing the soil moisture condition. Three times irrigation as done during crop period, viz. 25th December 2020, 3rd January 2021, 18th January 2021 and 03rd February 2021 for proper growth and development of plants.

3.12.4 Spading

After each irrigation soils of each plot were pulverized by spade for easy aeration.

3.12.5 Earthing up

Earthing up was done by taking the soil from the space between the rows on 24th December 2020.

3.12.6 Insects and disease control

Insect infestation was a serious problem during the period of establishment of seedling in the field. In spite of Furadan 5G applications during final land preparation few young plants were damaged due to the attack of mole cricket and cut worm. Cut worms were controlled both mechanically and spraying Darsban 29 EC @ 3%. To

prevent the spread of insect, Neem oil and Ripcord 10 EC @ 1 ml/L was applied in all the plot at 9 January 2021. Some of plants were infected by Alternaria leaf spot disease caused by *Alternaria brassicae.* To prevent the spread of the disease Sulcox 50WP @ 2 g per liter of water was sprayed in the field. The diseased leaves were also collected from the infested plant and removed from the field. The nightingale visited the fields in the morning and afternoon. The birds were found to puncture the soft leaves and newly initiated curd and were controlled by striking attach with cassette tapes.

3.13 Harvesting

Harvesting of the broccoli var. Premium crop was not possible on a certain or particular date because curd initiation as well as curd maturation period in different plants were not uniform or similar probably due to different management practices and genetic or other factors. Only the compact mature curds were harvested with 2-4 cm stalk by using a sharp knife. According to Thompson and Kelly (1997) the curds were harvested in compact condition before the flower buds opened. Before harvesting of the broccoli head, compactness of the head was tested by pressing with thumbs. After harvesting the main curd, secondary shoots were developed from the leaf axils, which also developed into small secondary curds and were harvested over a period of time. The crop under investigation was harvested for the first time on February 7th, 2021 and the last harvesting was done on March 25th, 2021.

3.14 Data collection

The data pertaining to following characters were recorded from four plants randomly selected from each plot, except yield of curds, which was recorded plot wise.

3.14.1 Growth parameters

3.14.1.1 Plant height

Plant height was measured from base to the tip of the longest leaf at 20, 40 and 60 days after transplanting (DAT). A meter scale was used to measure plant height of the plant and expressed in centimeter (cm).

3.14.1.2 Number of leaves per plant

Number of leaves were counted from four randomly selected plants at 20, 40, 60 DAT. All the leaves of each plant were counted separately. Only the smallest young leaves at the growing point of the plant were excluded from counting. The average number of leaves of ten plants gave number of leaves per plant.

3.14.1.3 Leaf length

The length of the leaf was measured from the base of the petiole to the tip at 20, 40 and 60 DAT. A meter scale was used to measure the length of the leaves and expressed in centimeter (cm).

3.14.1.4 Leaf breadth

The large leaf breadth was measured on 20, 40 and 60 DAT. A meter scale was used to measure the large breadth of the leaves and expressed in centimeter (cm).

3.14.1.5 Diameter of stem

Diameter of the stem was measured at the point where the central curd was cut off. Diameter of the stem was recorded in three dimensions with scale and the average of three values was taken into account and was expressed in centimeter (cm).

3.14.1.6 % of dry matter content of leaf

Sample of 100 g leaf was taken, cut into pieces and dried under direct sunshine for 3 days and then dried in an oven at 70°C for 72 hours. The dry weight was recorded in

gram (g) with an electric balance and converted into percentages. The percentage of dry matter content of leaves was calculated by using the following formula:

$$\text{Percent dry matter content of leaf} = \frac{\text{Dry weight of leaf}}{\text{Fresh weight of leaf}} \times 100$$

3.14.2 Yield contributing parameter

3.14.2.1 Days required for curd initiation

Each plant of the experiment plot was kept under close observation from 40 DAT to count days required for initiation. Total number of days from the date of transplanting to the visible curd initiation was recorded.

3.14.2.2 Diameter of primary curd

Curd diameter was measured by using a meter scale at the final harvest. Diameter of the curd was measured at different directions and finally the average of all directions was recorded and expressed in centimeter (cm).

3.14.2.3 Weight of primary curd per plant (g)

Weight of the central curd was recorded excluding the weight of all secondary marketable curds.

3.14.2.4 Number of secondary curds per plant

When the secondary curds reached marketable size, they were counted. The small shoots were not taken into consideration.

3.14.2.5 Weight of secondary curd per plant (g)

Weight of secondary curd was recorded by weighing the total marketable auxiliary curds of an individual plant.

3.14.2.6 % of dry matter content of curd

Sample of 100 g curd was taken, cut into pieces and dried under direct sunshine for 3 days and then dried in an oven at 70°C for 72 hours. The dry weight was recorded in

gram (g) with an electric balance and converted into percentage. The percentage of dry matter content of curd was calculated by using the following formula:

$$\text{Percent dry matter content of curd} = \frac{\text{Dry weight of curd}}{\text{Fresh weight of curd}} \times 100$$

3.14.3 Performance of yield

3.14.3.1 Yield/plant

Yield per plant was calculated by adding the weight of central curd and the weight of all secondary curds harvested and it was measured in gram (g).

3.14.3.2 Yield/plot

Yield per unit plot was calculated by adding the weight of all the central curds and secondary curds produced in the respective plot. Yield of all plants in each unit plot was recorded and was expressed in kilogram (kg).

3.14.3.3 Yield/hectare

Yield per hectare was calculated out by converting per plot yield data to per hectare and was measured in ton (t).

3.14.3.4 Economic analysis

The cost of production was analyzed in order to find out the most economic treatment for cultivation of broccoli. All input cost including the cost for lease of land and interests on running capital was computed for the cost of production. The interests were calculated @ 13% in simple interest rate. The market price of broccoli was considered for estimating the cost and return. Analyses were done according to the procedure determining by Alam *et al.,* (1989). The benefit cost ratio (BCR) was calculated as follows:

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

3.15 Statistical analysis

Data were collected from the experimental plot in respect of various characteristics were compiled and tabulated in proper form for statistical analysis. Collected data on different parameters were statistically analyzed using the MSTAT computer package program. The treatment means were separated by Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1983) at 5% level of significance for interpretation of the results.

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to study the influences of different combination of inorganic and organic fertilizers in broccoli. Data of the different parameters were analyzed statistically and the results were presented in the Tables and Figures. The results of the present study were presented and discussed in this chapter under the following headings.

4.1. Plant height (cm)

Plant height is an important morphological character that acts as a potent indicator of availability of growth resources in its vicinity. Plant height of broccoli varied significantly at 20, 40 and 60 DAT for different inorganic and organic fertilizer and their combinations under the present trial (Table 2 and Appendix VI). At 20 DAT, the plant height ranged from 10.08 cm to 13.42 cm. The tallest plant (13.42 cm) was recorded from T_2 (Recommend fertilizer dose @ CD_{10}t N_{150}kg P_{150}kg K_{120}kg/ha) and the shortest plant (10.08 cm) was recorded from T_0 (control). At 40 DAT, plant height ranged from 33.17 cm to 43.08 cm. The tallest plant (43.08 cm) was obtained from T_2 treatment which was statistically similar with T_8 (Mushroom Spent compost @ 5 ton/ha (60%) + Vermicompost (20%) + Trichoderma (20%)). On the other hand, the shortest plant was recorded from T_0 (33.17 cm) which was statistically identical with T_1 (Cow dung @ 15 ton/ha) and T_5 (Kitchen compost @ 8 ton/ha). Similarly, at 60 DAT plant height ranged from 44.50 cm to 53.92 cm. The tallest plant (53.92 cm) was obtained from T_2 treatment which was statistically identical with T_8 (52.33 cm) and similar to T_3, T_4, T_7, T_6 and T_5, respectively. On the other hand, the shortest plant was recorded from T_0 (44.50 cm) which was statistically similar with T_1 (45.58 cm).

Considering the difference of plant height (cm) over the recommended dose at 60 DAT, the lowest difference of plant height (cm) over the recommended dose at 60 DAT was observed (1.57 cm) in T_8, followed by T_3 (4.57 cm), T_4 (5.40 cm) and T_7 (5.65 cm). Whereas the highest difference of plant height (cm) over the recommended dose at 60 DAT was observed in T_0 (9.40 cm), followed by T_1 (8.32 cm), T_6 (5.90 cm), and T_5 (5.98 cm) (Table 2).

It was revealed that the plant height increased with the advance of DAT and the application of organic and inorganic fertilizers as well. The observation confirms the findings of Myint *et al.* (2009), Patil and Udmale (2016) and Bacchav (1996). Myint *et al.* (2009) added that chemical fertilizer application provided better plant growth due to its higher nutrient availability and rapid nitrogen mineralization power. Patil and Udmale (2016) and Bacchav (1996) also reported that, the increase in plant height due to inorganic inputs might be attributed to increase in the availability of cytokinine to shoot which in turn play a role in cell elongation process either through cell division or cell elongation. Similar results due to effect of integrated nutrient management were reported by Mohapatra *et al.* (2013), Meena *et al.* (2017) and Singh *et al.* (2018).

Table 2. Effect of organic and inorganic fertilizers on plant height of broccoli at different days after transplanting (DAT)

Treatments	Plant height (cm) at			Difference of plant height (cm) over the recommended dose at 60 DAT
	20 DAT	40 DAT	60 DAT	
T_0	10.08 c	33.17 b	44.50 b	9.40
T_1	10.83 bc	33.92 b	45.58 b	8.32
T_2	13.42 a	43.08 a	53.92 a	0
T_3	12.75 ab	39.58 ab	49.33 ab	4.57
T_4	12.00 abc	38.75 ab	48.50 ab	5.40
T_5	11.17 bc	34.50 b	47.92 ab	5.98
T_6	11.25 abc	37.17 ab	48.00 ab	5.90
T_7	11.58 abc	38.50 ab	48.25 ab	5.65
T_8	12.92 ab	42.50 a	52.33 a	1.57
LSD(0.05)	1.975	6.406	5.861	
CV (%)	9.69	9.76	6.95	

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

[T_0: Control (without fertilizer); T_1: Cow dung @ 15 ton/ha; T_2: Recommend fertilizer dose @ CD_{10}t N_{150}kg P_{150}kg K_{120}kg/ha; T_3: Vermicompost @ 10 ton/ha and Trichoderma @ 22 kg/ha; T_4: Vermicompost @ 10 ton/ha and biochar 150 kg/ha; T_5: Kitchen compost @ 8 ton/ha; T_6: Mushroom compost @ 5 ton/ha; T_7: Vermicompost (50%) + Cowdung (50%) and T_8: Mushroom Spent compost @ 5 ton/ha (60%) + Vermicompost (20%) + Trichoderma (20%)]

4.2 Number of leaves plant^{-1}

Statistically significant variation was recorded for number of leaves plant^{-1} of broccoli at 20, 40 and 60 DAT for the application of different combinations of inorganic and organic fertilizers (Table 3 and Appendix VII). During the period of plant growth, the highest number of leaves plant^{-1} (8.42, 11.33 and 19.83 at 20, 40 and 60 DAT, respectively) was observed in T_2 (Recommend fertilizer dose @ CD_{10}t N_{150}kg P_{150}kg K_{120}kg/ha) treatment. On the other hand, the minimum number of leaves^{-1} (5.25, 8.33

and 10.67 at 20, 40 and 60 DAT, respectively) was found T_0 (control). From the finding it was revealed that number of leaves per plant was increased due to the application of organic and inorganic fertilizer as well as with the advanced of DAT. Increase in number of leaves might be due to application of recommend fertilizer dose, that ultimately helped in increasing the uptake of nitrogen and other nutrients and produced a greater number of leaves per plant. These findings are in accordance with the results of Mohaptra *et al.* (2013) and Jasim *et al.* (2014).

Table 3. Effect of organic and inorganic fertilizers on number of leaves plant^{-1} of broccoli at different days after transplanting (DAT)

Treatments	Number of leaves per plant at		
	20 DAT	40 DAT	60 DAT
T_0	5.25 b	8.33 c	10.67 c
T_1	5.42 b	9.58 b	16.50 b
T_2	8.42 a	11.33 a	19.83 a
T_3	6.08 b	10.33 ab	19.75 a
T_4	5.92 b	10.33 ab	19.75 a
T_5	5.83 b	9.75 b	17.25 ab
T_6	5.83 b	10.17 ab	18.83 ab
T_7	5.92 b	10.17 ab	19.00 ab
T_8	6.58 b	11.17 a	19.83 a
$LSD_{(0.05)}$	1.789	1.115	2.685
CV (%)	16.83	7.74	8.65

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

[T_0: Control (without fertilizer); T_1: Cow dung @ 15 ton/ha; T_2: Recommend fertilizer dose @ CD_{10}t N_{150}kg P_{150}kg K_{120}kg/ha; T_3: Vermicompost @ 10 ton/ha and Trichoderma @ 22 kg/ha; T_4: Vermicompost @ 10 ton/ha and biochar 150 kg/ha; T_5: Kitchen compost @ 8 ton/ha; T_6: Mushroom compost @ 5 ton/ha; T_7: Vermicompost (50%) + Cowdung (50%) and T_8: Mushroom Spent compost @ 5 ton/ha (60%) + Vermicompost (20%) + Trichoderma (20%)]

4.3 Leaf length (cm)

Application of organic and inorganic fertilizers had a significant effect on the length of leaves of broccoli plants at 20, 40 and 60 DAT (Table 4 and Appendix VIII). At 20 DAT, the leaf length ranged from 16.33 cm to 11.92 cm. The largest leaf (16.33 cm) was recorded from T_2 (Recommend fertilizer dose @ CD_{10}t N_{150}kg P_{150}kg K_{120}kg/ha) and the smallest leaf (11.92 cm) was recorded from T_0 (control). At 40 DAT, leaf length ranged from 40.83 cm to 28.83 cm. The largest leaf was recorded from T_2 (40.83 cm) and the smallest leaf was recorded from T_0 (28.83 cm). At 60 DAT, leaf length ranged from 45.33 cm to 38.42 cm. The largest leaf was recorded from T_2 (45.33 cm) and the smallest leaf was recorded from T_0 (38.42 cm). Mohaptra *et al.* (2013), Meena *et al.* (2017) and Singh *et al.* (2018) were also reported the similar findings due to effect of integrated nutrient management.

Table 4. Effect of organic and inorganic fertilizers on length of leaves of broccoli at different days after transplanting (DAT)

Treatments	Length of leaves (cm) at		
	20 DAT	**40 DAT**	**60 DAT**
T_0	11.92 b	28.83 b	38.42 b
T_1	12.67 ab	32.33 ab	40.75 ab
T_2	16.33 a	40.83 a	45.33 a
T_3	15.50 ab	37.25 ab	43.42 ab
T_4	15.42 ab	37.00 ab	43.00 ab
T_5	12.75 ab	34.17 ab	41.08 ab
T_6	13.17 ab	35.08 ab	41.58 ab
T_7	14.00 ab	36.58 ab	41.83 ab
T_8	15.83 ab	37.25 ab	44.83 ab
$LSD_{(0.05)}$	3.539	7.595	5.799
CV (%)	14.42	12.37	7.93

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

[T_0: Control (without fertilizer); T_1: Cow dung @ 15 ton/ha; T_2: Recommend fertilizer dose @ CD_{10}t N_{150}kg P_{150}kg K_{120}kg/ha; T_3: Vermicompost @ 10 ton/ha and Trichoderma @ 22 kg/ha; T_4: Vermicompost @ 10 ton/ha and biochar 150 kg/ha; T_5: Kitchen compost @ 8 ton/ha; T_6: Mushroom compost @ 5 ton/ha; T_7: Vermicompost (50%) + Cowdung (50%) and T_8: Mushroom Spent compost @ 5 ton/ha (60%) + Vermicompost (20%) + Trichoderma (20%)]

4.4 Leaf breadth (cm)

Application of organic and inorganic fertilizers had a significant effect on the leaf breadth of broccoli plants at 20, 40 and 60 DAT (Table 5 and Appendix IX). At 20 DAT, the leaf breadth ranged from 6.08 cm to 8.33 cm. The maximum leaf breadth (8.33 cm) was recorded from T_2 (Recommend fertilizer dose @ CD_{10}t N_{150}kg P_{150}kg K_{120}kg/ha) and the minimum leaf breadth (6.08 cm) was recorded from T_0 (control). At 40 DAT, leaf breadth ranged from 14.25 cm to 20.17 cm. The highest leaf breadth was recorded from T_2 (20.17 cm) which was statistically at par with T_8 (19.17 cm) and statistically identical with T_3, T_4, T_7, T_6 and T_5, respectively. On the other hand the lowest leaf breadth was recorded from T_0 (14.25 cm) which was statistically at par with T_1 (14.71 cm). Similarly, at 60 DAT, leaf breadth ranged from 17.00 cm to 21.83 cm. The highest leaf breadth was recorded from T_2 (21.83 cm) and the lowest leaf breadth was recorded from T_0 (17.00 cm).

Table 5. Effect of organic and inorganic fertilizers on breadth of leaves of broccoli at different days after transplanting (DAT)

Treatments	Breadth of leaves (cm) at		
	20 DAT	**40 DAT**	**60 DAT**
T_0	6.08 c	14.25 b	17.00 c
T_1	6.42 bc	14.71 b	17.17 bc
T_2	8.33 a	20.17 a	21.83 a
T_3	7.92 abc	17.42 ab	20.83 ab
T_4	7.25 abc	17.42 ab	20.42 abc
T_5	6.42 bc	16.17 ab	17.50 bc
T_6	6.75 abc	16.50 ab	17.75 bc
T_7	6.92 abc	16.58 ab	18.33 abc
T_8	8.09 ab	19.17 a	20.83 ab
$LSD_{(0.05)}$	1.629	3.583	3.284
CV (%)	13.20	12.23	9.95

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

[T_0: Control (without fertilizer); T_1: Cow dung @ 15 ton/ha; T_2: Recommend fertilizer dose @ CD_{10}t N_{150}kg P_{150}kg K_{120}kg/ha; T_3: Vermicompost @ 10 ton/ha and Trichoderma @ 22 kg/ha; T_4: Vermicompost @ 10 ton/ha and biochar 150 kg/ha; T_5: Kitchen compost @ 8 ton/ha; T_6: Mushroom compost @ 5 ton/ha; T_7: Vermicompost (50%) + Cowdung (50%) and T_8: Mushroom Spent compost @ 5 ton/ha (60%) + Vermicompost (20%) + Trichoderma (20%)]

4.5 Stem diameter (cm)

The stem diameter of broccoli was significantly influenced by the application of different organic and inorganic fertilizers at different days after transplanting (DAT) (Table 6 and Appendix X). At 20 DAT, stem diameter ranged from 0.33 cm to 0.57 cm. The maximum diameter (0.57 cm) was found in T_2, which was statistically similar to T_8 (0.51 cm) and the minimum (0.33 cm) was found in T_0, which was statistically identical with T_1, T_5, T_6, T_7, and, respectively. At 40 DAT, the stem diameter was statistically insignificant due to the application of different levels of organic and inorganic fertilizers. The stem diameter ranged from 1.10 cm to 1.80 cm.

Numerically, the highest stem diameter (1.80 cm) was recorded from T_2 and the lowest stem diameter (1.10 cm) was found in T_0 treatment. At 60 DAT, the maximum stem diameter (3.23 cm) was found in T_2 treatment which was statistically similar to T_8, T_3, T_4, and T_7, respectively, whereas the minimum (1.99 cm) was found in T_0.

Table 6. Effect of organic and inorganic fertilizers on stem diameter of broccoli at different days after transplanting (DAT)

Treatments	Stem diameter (cm) at		
	20 DAT	40 DAT	60 DAT
T_0	0.33 c	1.10 a	1.99 d
T_1	0.36 c	1.29 a	2.35 cd
T_2	0.57 a	1.80 a	3.23 a
T_3	0.43 bc	1.52 a	2.91 abc
T_4	0.40 c	1.41 a	2.70 abc
T_5	0.36 c	1.35 a	2.46 bcd
T_6	0.38 c	1.38 a	2.55 bc
T_7	0.38 c	1.41 a	2.67 abc
T_8	0.51 ab	1.55 a	3.02 ab
$LSD_{(0.05)}$	0.10	0.64	0.51
CV (%)	13.99	26.02	11.14

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

[T_0: Control (without fertilizer); T_1: Cow dung @ 15 ton/ha; T_2: Recommend fertilizer dose @ CD_{10}t N_{150}kg P_{150}kg K_{120}kg/ha; T_3: Vermicompost @ 10 ton/ha and Trichoderma @ 22 kg/ha; T_4: Vermicompost @ 10 ton/ha and biochar 150 kg/ha; T_5: Kitchen compost @ 8 ton/ha; T_6: Mushroom compost @ 5 ton/ha; T_7: Vermicompost (50%) + Cowdung (50%) and T_8: Mushroom Spent compost @ 5 ton/ha (60%) + Vermicompost (20%) + Trichoderma (20%)]

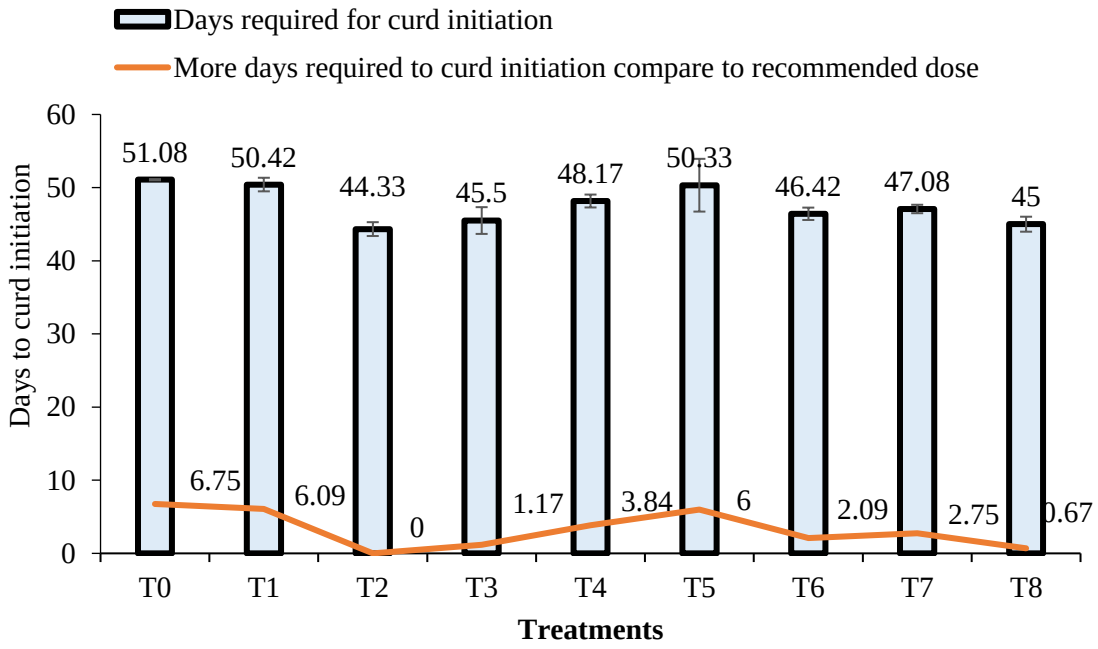
4.6 Days required for curd initiation

Earliness is a desirable trait for any crops; thus, the significant early curd initiation (44.33 days) was recorded in T_2 treatment followed by T_8 (45.00 days), T_3 (45.50 days), T_6 (46.42 days) and T_7 (47.08 days). Whereas, control took maximum days for

curd initiations (51.08 days) followed by T_1 (50.42 days), T_5 (50.33 days) and T_4 (48.17 days).

Considering the difference of days required to curd initiation over the recommended dose, in T_8 treatment, more 0.67 days required to curd initiation over the recommended dose followed by T_3 (1.17 days), T_6 (2.09 days) and T_7 (2.75 days) (Figure 1).

Application of inorganic fertilizer in recommended dose facilitate early curd initiation might be due to the release of nitrogen and phosphorus in the soil enabling plants to use them which leads to increase plant hormonal activities resulting to produce earlier curd initiation of broccoli. Similar result was also obtained by Mohanta *et al.* (2018).



[T_0: Control (without fertilizer); T_1: Cow dung @ 15 ton/ha; T_2: Recommend fertilizer dose @ CD_{10}t N_{150}kg P_{150}kg K_{120}kg/ha; T_3: Vermicompost @ 10 ton/ha and Trichoderma @ 22 kg/ha; T_4: Vermicompost @ 10 ton/ha and biochar 150 kg/ha; T_5: Kitchen compost @ 8 ton/ha; T_6: Mushroom compost @ 5 ton/ha; T_7: Vermicompost (50%) + Cowdung (50%) and T_8: Mushroom Spent compost @ 5 ton/ha (60%) + Vermicompost (20%) + Trichoderma (20%)]

Figure 1. Effect of organic and inorganic fertilizers on the days required for curd initiation in broccoli

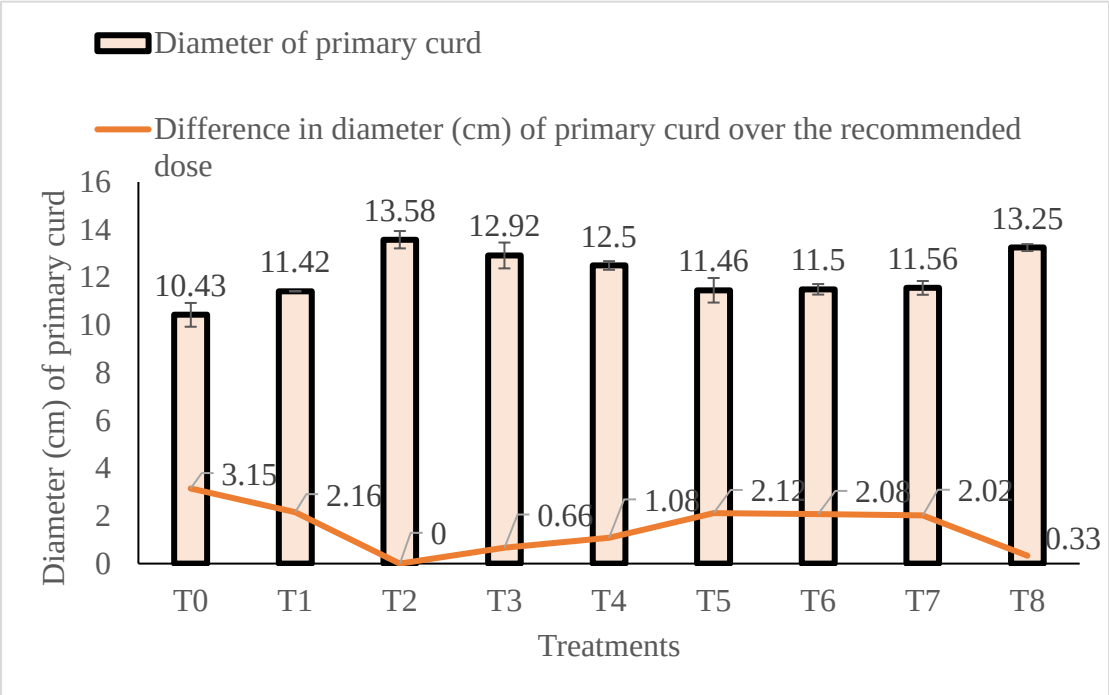
4.7 Diameter of primary curd (cm)

Application of organic and inorganic fertilizers exhibited a significant influence on curd diameter of broccoli plants (Figure 2 and Appendix XI). Main curd diameter ranged from 10.43 cm to 13.58 cm. The maximum diameter of primary curd (13.58 cm) was recorded from T_2 (Recommend fertilizer dose @ CD_{10}t N_{150}kg P_{150}kg K_{120}kg/ha) which was statistically similar with T_8 (13.25 cm) and T_3 (12.92 cm). On the other hand, the minimum curd diameter (10.43 cm) was found in T_0 (Control).

Considering the difference in diameter (cm) of primary curd over the recommended dose, the lowest difference in diameter (cm) of primary curd over the recommended dose was observed (0.33 cm) in T_8, followed by T_3 (0.66 cm), T_4 (1.08 cm) and T_7 (2.02 cm). Whereas the highest difference in diameter (cm) of primary curd over the recommended dose was observed in T_0 (10.43 cm), followed by T_1 (2.16 cm), T_5 (2.12 cm), and T_6 (2.08 cm) (Figure 2).

It was revealed that the curd diameter increased with inorganic fertilizer application. This might be due to slow and continuous nutrient supply. That helps in uniform curd formation. During curd formation continuous nutrient supply is very much essential. Increased head diameter might be due to the soil microbial activities, high absorption of nutrients from the soil which also affected the photosynthesis process. Application of all inorganic fertilizer as recommended dose influences the plant metabolism by increasing the availability of applied all nutrients and moisture retention capacity. Positive response of organic source of nutrient and inorganic fertilizers on head diameter may be due to the better availability of micro and macro nutrient in the soil that produced healthy plants with large vegetative growth, which reflected head diameter. Similar result has been reported of Mohanta *et al.,* (2018) and Singh *et al.,*

(2018).



[T_0: Control (without fertilizer); T_1: Cow dung @ 15 ton/ha; T_2: Recommend fertilizer dose @ CD_{10}t N_{150}kg P_{150}kg K_{120}kg/ha; T_3: Vermicompost @ 10 ton/ha and Trichoderma @ 22 kg/ha; T_4: Vermicompost @ 10 ton/ha and biochar 150 kg/ha; T_5: Kitchen compost @ 8 ton/ha; T_6: Mushroom compost @ 5 ton/ha; T_7: Vermicompost (50%) + Cowdung (50%) and T_8: Mushroom Spent compost @ 5 ton/ha (60%) + Vermicompost (20%) + Trichoderma (20%)]

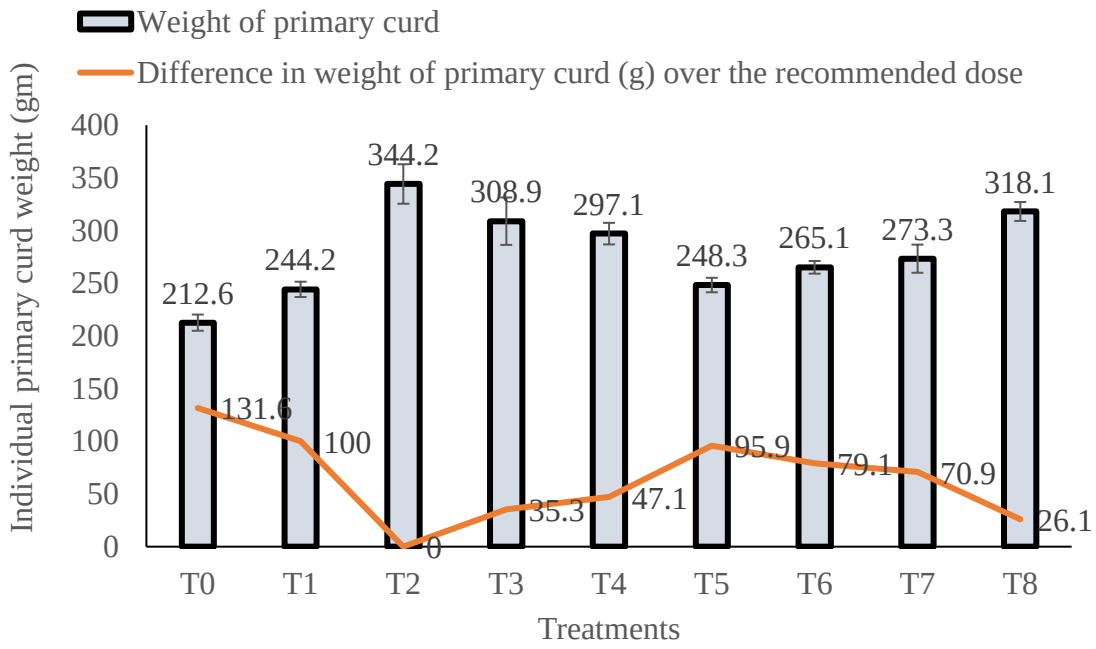
Figure 2. Effect of organic and inorganic fertilizers on diameter of primary curd of broccoli

4.8 Weight of primary curd (g)

Application of organic and inorganic fertilizers exhibited a significant influence on weight of primary curd of broccoli plants (Figure 3 and Appendix XI). The maximum primary curd weight (344.2 g) was measured from T_2 (Recommend fertilizer dose @ CD_{10}t N_{150}kg P_{150}kg K_{120}kg/ha) followed by T_8 (318.1 g), while the minimum primary curd weight (212.6 g) was recorded from T_0 (Control) followed by T_1 (244.2 g). Considering the difference in weight (g) of primary curd over the recommended dose, the lowest difference in weight (g) of primary curd over the recommended dose was observed (26.1 g) in T_8, followed by T_3 (35.3 g), T_4 (47.1 g) and T_7 (70.9 g). Whereas

the highest difference in weight (g) of primary curd over the recommended dose was observed in T_0 (131.6 g), followed by T_1 (100.0 g), T_5 (95.9 g), and T_6 (70.9 g) (Figure 3).

It was revealed that the primary curd weight increased with inorganic fertilizer application. Spent mushroom compost with vermicompst and Trichoderma provided more or less similar yield. Results related to fresh weight per curd (g) of Broccoli found to be close agreement with that of Jeyab and Kuppuswamy (2001), Sharma *et al.* (2004), Zaki *et al.* (2009) and Lal *et al.* (2021).



[T_0: Control (without fertilizer); T_1: Cow dung @ 15 ton/ha; T_2: Recommend fertilizer dose @ CD_{10}t N_{150}kg P_{150}kg K_{120}kg/ha; T_3: Vermicompost @ 10 ton/ha and Trichoderma @ 22 kg/ha; T_4: Vermicompost @ 10 ton/ha and biochar 150 kg/ha; T_5: Kitchen compost @ 8 ton/ha; T_6: Mushroom compost @ 5 ton/ha; T_7: Vermicompost (50%) + Cowdung (50%) and T_8: Mushroom Spent compost @ 5 ton/ha (60%) + Vermicompost (20%) + Trichoderma (20%)]

Figure 3. Effect of organic and inorganic fertilizers on diameter of primary curd of broccoli

4.9 Number of secondary curd plant^{-1}

The secondary curds were those, which develop after harvest of the primary curd. Number of secondary curds of broccoli plant is important for increasing total production. Application of organic and inorganic fertilizers exhibited a significant influence on number of secondary curds of broccoli plants (Table 7 and Appendix XII). The maximum numbers of secondary curds (6.67) were observed T_2 (Recommend fertilizer dose @ CD_{10}t N_{150}kg P_{150}kg K_{120}kg/ha) which was statistically identical from all other treatments, while the minimum number of secondary curd (4.17) was recorded from T_0 (Control) which was statistically similar to T_1, T_5 and T_6, respectively.

4.10 Weight of secondary curd

Weight of individual secondary curd of broccoli plant is important for increasing total yield. Application of organic and inorganic fertilizers exhibited a significant influence on weight of secondary curd of broccoli plants (Table 7 and Appendix XII). The maximum secondary curd weight (210 g) per plant was measured from T_2 (Recommend fertilizer dose @ CD_{10}t N_{150}kg P_{150}kg K_{120}kg/ha) which was statistically similar to T_8 and T_3, respectively, while the minimum secondary curd weight (125.8 g) was recorded from T_0 (Control) which was statistically similar to T_1 (125.8 g) and T_5 (137.7 g), respectively.

Table 7. Effect of organic and inorganic fertilizers on number of secondary curd per plant and weight of individual secondary curd of broccoli

Treatments	Number of secondary curd plant^{-1}	Weight of individual secondary curd (g)
T_0	4.17 e	125.8 f
T_1	4.58 de	133.8 ef
T_2	6.67 a	210.0 a
T_3	5.50 bc	184.0 abc
T_4	5.42 bcd	175.4 bc
T_5	4.67 cde	137.7 def
T_6	4.83 bcde	161.0 cde
T_7	5.25 bcd	168.3 cd
T_8	5.58 b	205.8 ab
$LSD_{(0.05)}$	0.78	29.29
CV (%)	8.65	10.14

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

[T_0: Control (without fertilizer); T_1: Cow dung @ 15 ton/ha; T_2: Recommend fertilizer dose @ CD_{10}t N_{150}kg P_{150}kg K_{120}kg/ha; T_3: Vermicompost @ 10 ton/ha and Trichoderma @ 22 kg/ha; T_4: Vermicompost @ 10 ton/ha and biochar 150 kg/ha; T_5: Kitchen compost @ 8 ton/ha; T_6: Mushroom compost @ 5 ton/ha; T_7: Vermicompost (50%) + Cowdung (50%) and T_8: Mushroom Spent compost @ 5 ton/ha (60%) + Vermicompost (20%) + Trichoderma (20%)]

4.11 Dry matter content of curd (%)

The application of organic and inorganic fertilizers had a significant effect on the production of dry matter content of broccoli curd (Table 8 and Appendix XIII). The maximum dry matter content of curd (9.86%) was recorded from T_2 (Recommend fertilizer dose @ CD_{10}t N_{150}kg P_{150}kg K_{120}kg/ha) followed by T_8 (9.24%), while T_0 (Control) treatment gave the minimum (7.77%) dry matter content of curd.

4.12 Dry matter content of leaf (%)

The application of organic and inorganic fertilizers had a significant effect on the production of dry matter content of leaf of broccoli (Table 8 and Appendix XIII). The

maximum dry matter content of leaf (13.23%) was recorded from T_2 (Recommend fertilizer dose @ CD_{10}t N_{150}kg P_{150}kg K_{120}kg/ha) which was statistically similar to T_8 (12.51%), while T_0 (Control) treatment gave the minimum (9.67%) dry matter content of leaf which was statistically identical with T_1, T_5 and T_6, respectively.

Table 8. Effect of organic and inorganic fertilizers on dry matter content of curd and dry matter content of leaf of broccoli

Treatments	Dry matter content of curd (%)	Dry matter content of leaf (%)
T_0	7.77 c	9.67 c
T_1	8.12 bc	10.27 c
T_2	9.86 a	13.23 a
T_3	9.11 abc	11.47 bc
T_4	8.70 abc	11.42 bc
T_5	8.42 bc	10.49 c
T_6	8.46 bc	10.59 c
T_7	8.53 abc	10.82 bc
T_8	9.24 ab	12.51 ab
$LSD_{(0.05)}$	1.21	1.650
CV (%)	8.07	8.50

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

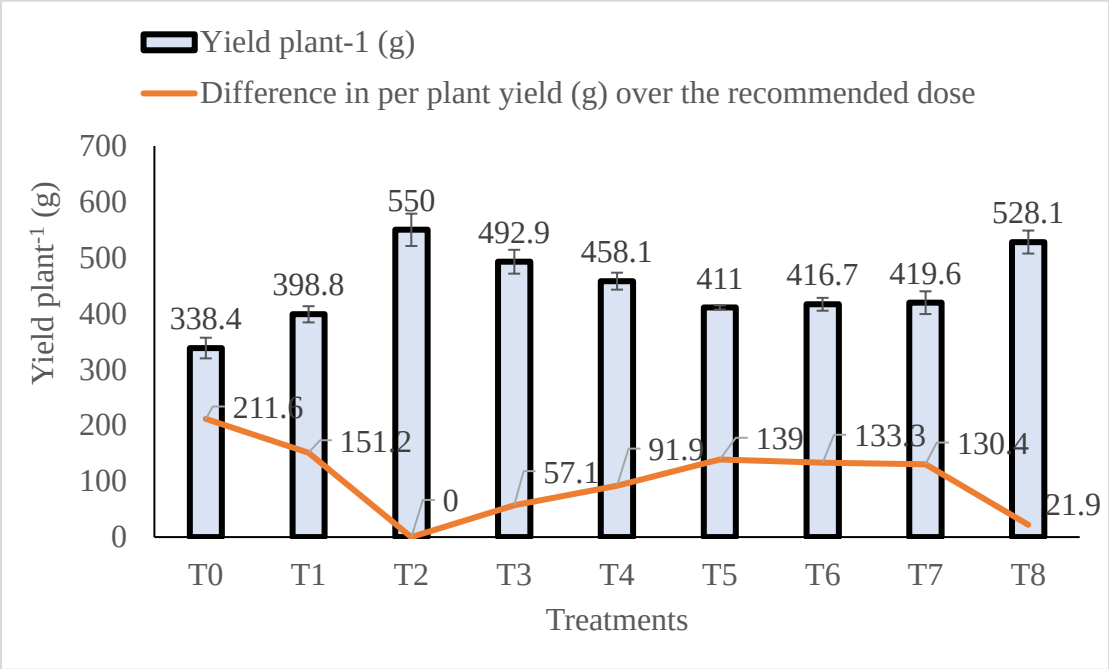
[T_0: Control (without fertilizer); T_1: Cow dung @ 15 ton/ha; T_2: Recommend fertilizer dose @ CD_{10}t N_{150}kg P_{150}kg K_{120}kg/ha; T_3: Vermicompost @ 10 ton/ha and Trichoderma @ 22 kg/ha; T_4: Vermicompost @ 10 ton/ha and biochar 150 kg/ha; T_5: Kitchen compost @ 8 ton/ha; T_6: Mushroom compost @ 5 ton/ha; T_7: Vermicompost (50%) + Cowdung (50%) and T_8: Mushroom Spent compost @ 5 ton/ha (60%) + Vermicompost (20%) + Trichoderma (20%)]

4.13 Yield plant^{-1}

Yield per plant is important for increasing total yield. Application of organic and inorganic fertilizers exhibited as significant influences on total yield per broccoli plant (Figure 4 and Appendix XIV). The maximum yield per plant (550.0 g) was recorded from T_2 (Recommend fertilizer dose @ CD_{10}t N_{150}kg P_{150}kg K_{120}kg/ha) followed by

T_8 (528.1 g), while T_0 (Control) treatment gave the minimum (338.4 g) yield per plant. The significant improvement in yield and yield attributing parameters on account of integrated form using in organic and inorganic fertilizers might have attributed to the optimum levels of nutrients were found to significantly improve on yield per plant (g).

Considering the difference in per plant yield (g) of broccoli over the recommended dose, the lowest difference in per plant yield (g) of broccoli over the recommended dose was observed (21.9 g) in T_8, followed by T_3 (57.1 g), T_4 (91.9 g) and T_7 (130.4 g). Whereas the highest difference in per plant yield (g) of broccoli over the recommended dose was observed in T_0 (211.5 g), followed by T_1 (151.2 g), T_5 (139.0 g), and T_6 (133.3 g) (Figure 4).



[T_0: Control (without fertilizer); T_1: Cow dung @ 15 ton/ha; T_2: Recommend fertilizer dose @ CD_{10}t N_{150}kg P_{150}kg K_{120}kg/ha; T_3: Vermicompost @ 10 ton/ha and Trichoderma @ 22 kg/ha; T_4: Vermicompost @ 10 ton/ha and biochar 150 kg/ha; T_5: Kitchen compost @ 8 ton/ha; T_6: Mushroom compost @ 5 ton/ha; T_7: Vermicompost (50%) + Cowdung (50%) and T_8: Mushroom Spent compost @ 5 ton/ha (60%) + Vermicompost (20%) + Trichoderma (20%)]

Figure 4. Effect of organic and inorganic fertilizers on yield per plant of broccoli

4.14 Yield plot^{-1} (kg)

The yield per plot of broccoli consists of the main curd and the secondary curd those develop after the removal of the main one. Application of organic and inorganic fertilizers exhibited as significant influences on yield per plot of broccoli plant (Table 9 and Appendix XIV). The maximum yield per plot (4.95 kg) was recorded from T_2 (Recommend fertilizer dose @ CD_{10}t N_{150}kg P_{150}kg K_{120}kg/ha) which was statistically similar to T_8 (4.75 kg), while T_0 (Control) treatment gave the minimum (3.05 kg) yield per plot. The enhanced yield of broccoli might be due to the application of inorganic fertilizer in recommend dose increases the micro and macro nutrient in the soil, microbial and enzyme activities and also have increased the rate of photosynthesis with further increase in vegetative growth providing more sites for translocation of photosynthesizes with an ultimate increase in yield. Similar result was also obtained by Ola *et al.* (2019), Mohanta *et al.* (2018) and Singh *et al.* (2018). Maurya *et al.,* (2008) also record highest values of yield related traits with application of recommended fertilizers. These results are in close conformity with the finding of Devi *et al.,* (2003) in Cabbage, Manivannan and Singh (2004) in Broccoli, and Wani *et al.,* (2011) in Cauliflower.

4.15 Yield hectare^{-1} (t)

Application of organic and inorganic fertilizers exhibited as significant influences on yield per hectare of broccoli plant (Table 9 and Appendix XIV). The maximum yield (26.76 t ha^{-1}) was recorded from T_2 (Recommend fertilizer dose @ CD_{10}t N_{150}kg P_{150}kg K_{120}kg/ha) which was statistically similar to T_8 and T_3, respectively, while T_0 (Control) treatment gave the minimum (16.46 t ha^{-1}) yield.

Considering the difference in yield (t/ha) of broccoli over the recommended dose, the lowest difference in yield (t/ha) of broccoli over the recommended dose was observed

(1.07 t/ha)) in T_8, followed by T_3 (2.78 t/ha), T_4 (4.34 t/ha) and T_7 (6.35 t/ha). Whereas the highest difference in yield (t/ha) of broccoli over the recommended dose was observed in T_0 (10.3 t/ha), followed by T_1 (7.36 t/ha), T_5 (6.77 t/ha), and T_6 (6.49 t/ha) (Table 9).

Continuous and uniform supply of N that caused optimum growth and induced maximum marketable head yield. Inorganic fertilizer supplied more available N and other macro and micro nutrients to crop where maximum vegetative growth was occurred. The lowest head yield of broccoli might be owing to insufficient supply of nutrients leading to limited carbon assimilation, resulting in reduction of plant productivity (Lawlor 2002; Shangguan *et al.* 2000). Similar result was also obtained by Ola *et al.* (2019), Mohanta *et al.* (2018) and Singh *et al.* (2018).

Table 9. Effect of organic and inorganic fertilizers on yield of broccoli

Treatments	Yield/plot (kg)	Yield/ha (t)	Difference of yield/ha over the recommended dose (t)
T_0	3.05 f	16.46 e	10.3
T_1	3.59 e	19.40 de	7.36
T_2	4.95 a	26.76 a	0
T_3	4.44 bc	23.98 abc	2.78
T_4	4.12 cd	22.42 bcd	4.34
T_5	3.70 de	19.99 cde	6.77
T_6	3.75 de	20.27 cde	6.49
T_7	3.78 de	20.41 cde	6.35
T_8	4.75 ab	25.69 ab	1.07
$LSD_{(0.05)}$	0.46	2.749	
CV (%)	6.65	6.65	

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

[T_0: Control (without fertilizer); T_1: Cow dung @ 15 ton/ha; T_2: Recommend fertilizer dose @ CD_{10}t N_{150}kg P_{150}kg K_{120}kg/ha; T_3: Vermicompost @ 10 ton/ha and Trichoderma @ 22 kg/ha; T_4: Vermicompost @ 10 ton/ha and biochar 150 kg/ha; T_5: Kitchen compost @ 8 ton/ha; T_6: Mushroom compost @ 5 ton/ha; T_7: Vermicompost (50%) + Cowdung (50%) and T_8: Mushroom Spent compost @ 5 ton/ha (60%) + Vermicompost (20%) + Trichoderma (20%)]

4.16 Economic analysis

Input costs for land preparation, fertilizer, irrigation and manpower required for all the operations from seed sowing to harvesting of broccoli were recorded as per experimental plot and converted into cost per hectare (Appendix-XV). Price of broccoli was considered as per market rate. The economic analysis presented under the following headings-

4.16.1 Gross return

Different organic and inorganic fertilizers showed different value in terms of gross return under the trial (Table 10). The highest gross return (Tk. 802,800) was obtained

from the treatment T_2 and the second highest gross return (Tk. 770,700) was found in T_8. The lowest gross return (Tk. 493,800) was obtained from T_0.

4.16.2 Net return

In case of net return, different organic and inorganic fertilizers showed different levels of net return under the present trial (Table 10). The highest net return (Tk. 566,514) was found from the treatment T_2 and the second highest net return (Tk. 455,203) was obtained from the T_8. The lowest (Tk. 115,712) net return was obtained T_4.

4.16.3 Benefit cost ratio

By using different organic and inorganic fertilizer in broccoli cultivation, the highest benefit cost ratio (3.40) was noted from the treatment of T_2 and the second highest benefit cost ratio (2.51) was estimated from T_1 and the lowest benefit cost ratio (1.21) was obtained from T_4 treatment (Table 10). From economic point of view, it is apparent from the above results that the T_2 was more profitable treatment than rest of the treatment.

Table 10. Cost and return of broccoli cultivation as influenced by different organic and inorganic fertilizers

Treatment combination	Cost of production (tk/ha)	Yield (t/ha)	Gross return (tk/ha)	Net return (tk/ha	Benefit cost ration
T_0	214704	16.46	493800	279096	2.30
T_1	231477.8	19.40	582000	350522	2.51
T_2	236286.2	26.76	802800	566514	3.40
T_3	550917	23.98	719400	168483	1.31
T_4	556888.5	22.42	672600	115712	1.21
T_5	483084	19.99	599700	116616	1.24
T_6	270616.5	20.27	608100	337484	2.25
T_7	390828.4	20.41	612300	221472	1.57
T_8	315497.5	25.69	770700	455203	2.44

[T_0: Control (without fertilizer); T_1: Cow dung @ 15 ton/ha; T_2: Recommend fertilizer dose @ CD_{10}t N_{150}kg P_{150}kg K_{120}kg/ha; T_3: Vermicompost @ 10 ton/ha and Trichoderma @ 22 kg/ha; T_4: Vermicompost @ 10 ton/ha and biochar 150 kg/ha; T_5: Kitchen compost @ 8 ton/ha; T_6: Mushroom compost @ 5 ton/ha; T_7: Vermicompost (50%) + Cowdung (50%) and T_8: Mushroom Spent compost @ 5 ton/ha (60%) + Vermicompost (20%) + Trichoderma (20%)]

Market price of broccoli @ 30 tk/kg

Net return = Gross return - Total cost of production

Benefit Cost Ratio (BCR) = Gross return/Total cost of production

CHAPTER V

SUMMARY AND CONCLUSION

An experiment was conducted at the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh, during the period from November 2021 to March 2022 to study the effect of organic and inorganic fertilizer managements for the growth and yield of broccoli (*Brassica oleracea* var. *italica*). The experiment comprised 9 different treatments of organic and inorganic fertilizer and their combination viz., T_0: Control (without fertilizer); T_1: Cow dung @ 15 ton/ha; T_2: Recommend fertilizer dose @ CD_{10}t N_{150}kg P_{150}kg K_{120}kg/ha; T_3: Vermicompost @ 10 ton/ha and Trichoderma @ 22 kg/ha; T_4: Vermicompost @ 10 ton/ha and biochar 150 kg/ha; T_5: Kitchen compost @ 8 ton/ha; T_6: Mushroom compost @ 5 ton/ha; T_7: Vermicompost (50%) + Cowdung (50%) and T_8: Mushroom Spent compost @ 5 ton/ha (60%) + Vermicompost (20%) + Trichoderma (20%). The size of unit plot was 1.85 m^2 (1.85 m × 1 m). The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data on different growth and yield parameters such as plant height, number of leaves per plant, leaf length, leaf breadth, diameter of stem, days required for curd initiation, diameter of primary curd, weight of primary curd, weight of secondary curd, number of secondary curd per plant, dry matter content of leaf and curd, yield per plant, yield per plot and yield per ha were recorded and analyzed statistically.

SUMMARY

The different organic and inorganic fertilizers independently had significant effect on plant height of broccoli at 20, 40 and 60 days after transplanting (DAT). Application of inorganic fertilizer at recommended dose @ CD_{10}t N_{150}kg P_{150}kg K_{120}kg/ha produced the tallest plant (13.42, 43.08, and 53.92 cm at 20, 40 and 60 DAT, respectively) and

the control treatment gave the lowest plant height (10.08, 33.17 and 44.50 cm at 20, 40 and 60 DAT, respectively). Number of leaves plant^{-1} was significantly influenced by application of different organic and inorganic fertilizer at days after transplanting (DAT). Application of inorganic fertilizer at recommended dose @ CD_{10}t N_{150}kg P_{150}kg K_{120}kg/ha produced the maximum number of leaves plant^{-1} (8.42, 11.33 and 19.83 20, 40 and 60 DAT, respectively) and the control treatment gave the lowest result.

Application of inorganic fertilizer at recommended dose @ CD_{10}t N_{150}kg P_{150}kg K_{120}kg/ha produced the tallest leaf (16.33, 40.83 and 45.33 cm at 20, 40 and 60 DAT, respectively) and the control treatment gave the lowest result. Highest leaf breadth (8.33, 20.17 and 21.83 cm) at 20, 40 and 60 DAT, respectively also found by the application of inorganic fertilizer at recommended dose @ CD_{10}t N_{150}kg P_{150}kg K_{120}kg/ha and the control treatment gave the lowest result. Similarly, application of organic and inorganic fertilizers had significant influences on stem diameter of broccoli. Application of inorganic fertilizer at recommended dose @ CD_{10}t N_{150}kg P_{150}kg K_{120}kg/ha gave the highest stem diameter (0.57, 1.80 and 3.23 cm at 20, 40 and 60 DAT, respectively), while the control gave the lowest result. Early curd initiation (44.33 days), maximum curd diameter (13.58 cm), maximum weight of primary curd (344.2 g), maximum number of secondary curd (6.67), maximum weight of secondary curd (210 g) and maximum dry matter content of curd were found by the application of inorganic fertilizer at recommended dose @ CD_{10}t N_{150}kg P_{150}kg K_{120}kg/ha, while the control treatment gave the lowest.

The highest yield plant^{-1} (550 g), yield plot^{-1} (4.95 kg) and yield ha^{-1} (26.76 t) was also found by the application of inorganic fertilizer at recommended dose @ CD_{10}t N_{150}kg P_{150}kg K_{120}kg/ha, while the control treatment gave the lowest.

Considering the differences in various parameter over the recommended dose, the lowest differences of plant height (1.57 cm) at 60 DAT, more 0.67 days required to curd initiation, lowest difference in diameter (0.33 cm) of primary curd, lowest difference in weight (26.1 g) of primary curd, lowest difference in per plant yield (21.9 g) and lowest difference in yield (1.07 t/ha) of broccoli over the recommended dose was observed in T_8 treatment.

The highest gross return (BDT 802800), net return (BDT 566514) and benefit cost ratio (3.40) was obtained from the T_2 treatment (CD_{10}t N_{150}kg P_{150}kg K_{120}kg/ha) and the lowest net return (BDT 115712) and benefit cost ratio (1.21) was obtained from the T_4 treatment.

Among the treatment T_2 was more effective for growth, yield and profitable than rest of the treatment combination and T_8 was best among the organic fertilizer in respect of plant growth and yield.

The results in this study indicated that the plant performed better in respect of growth and yield in T_2 treatment compared to the rest. Control treatment (T_0) showed the worst performance in all respect. But among the organic fertilizer, the combination of Mushroom Spent compost @ 5 ton/ha (60%) + Vermicompost (20%) + Trichoderma (20%) (T_8) performed the best in respect of growth and yield of Broccoli. Fertilizer treatments evaluated in the experiment were in the following order with respect to their yield performance, $T_2 > T_8 > T_3 > T_4 > T_7 > T_6 > T_5 > T_1 > T_0$.

The result of the present study generated some information which may help increase the higher yield of broccoli. Hence, the present study may be concluded as follows:

Application of inorganic fertilizer at recommended dose @ CD_{10}t N_{150}kg P_{150}kg K_{120}kg/ha and in case of organic farming, application of the combination of Mushroom Spent compost @ 5 ton/ha (60%) + Vermicompost (20%) + Trichoderma (20%) might

be optimum for profitable production of broccoli cultivation under Agro-ecological zone of Modhupur Tract, AEZ-28 of Bangladesh.

RECOMMENDATION

1. Application of inorganic fertilizer at recommended dose @ CD_{10}t N_{150}kg P_{150}kg K_{120}kg/ha was suitable for broccoli cultivation.
2. In organic farming, application of the combination of Mushroom Spent compost @ 5 ton/ha (60%) + Vermicompost (20%) + Trichoderma (20%) was suitable for broccoli cultivation.
3. The study might be conducted at the same Agro Ecological Condition for the conformation of the result.
4. Further study should be needed in different locations of Bangladesh for accuracy of the results obtained from the present experiment.

CHAPTER VI

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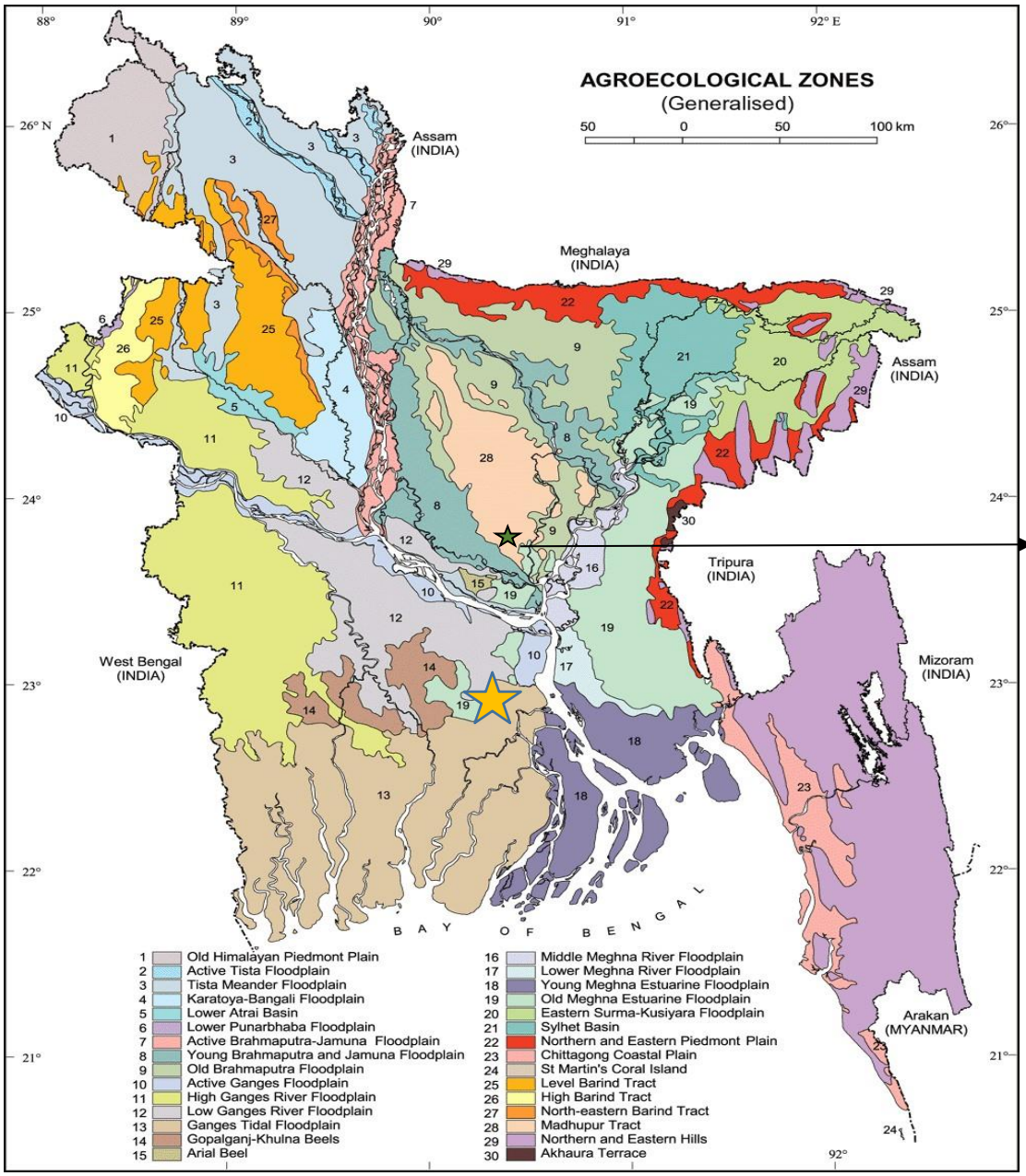
CHAPTER VII

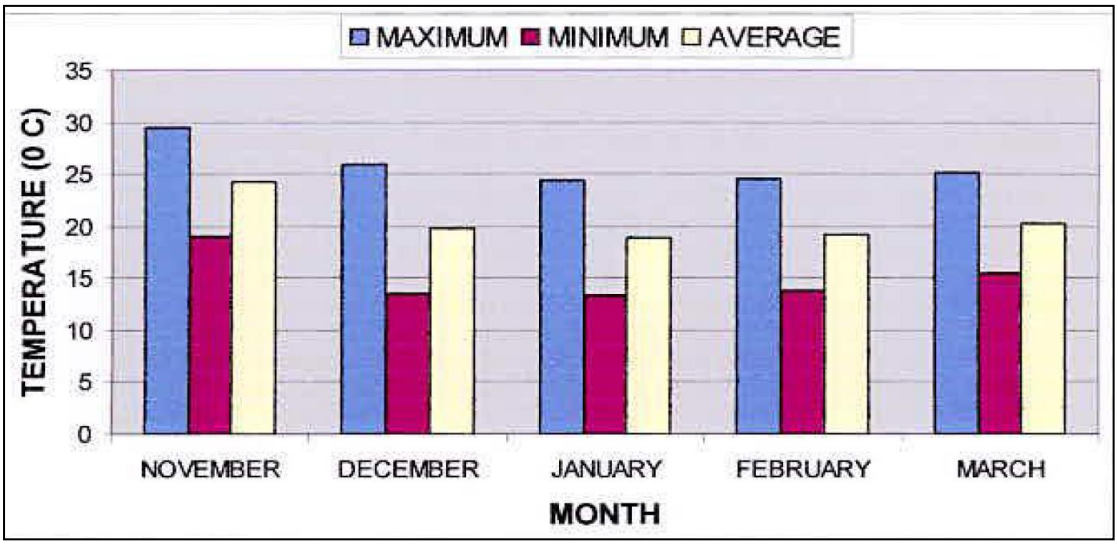
APPENDICES

Appendix I: Map showing the experimental site

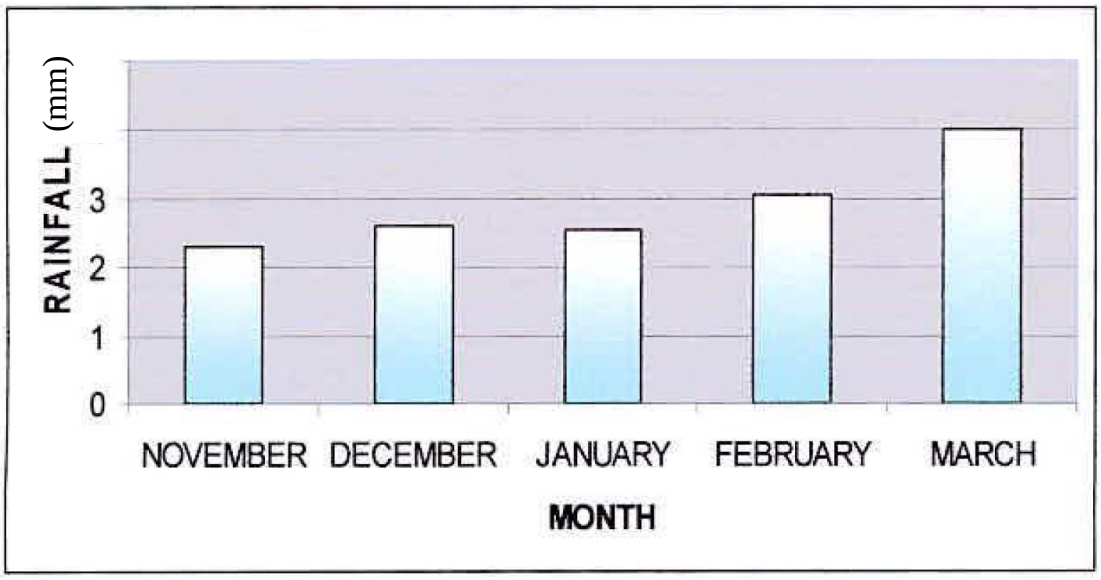


The experimental site

Appendix II: Monthly average, maximum and minimum air temperature (^{0}C) of the experimental site, Dhaka during the growing time (November, 2020 to March 2021)



Appendix III: Monthly total rainfall (mm) of the experimental site, Dhaka during the growing period (November, 2020 to March 2021)



Appendix IV: Morphological Characteristics of the Experimental Field

Morphology	Characteristics
Location	SAU farm, Dhaka
Agro-ecological zone	Madhupur Tract (AEZ-28)
General Soil Type	Deep Red Brown Terrace Soil
Parent material	Madhupur Clay
Topography	Fairly level
Drainage	Well drained
Flood level	Above flood level

(FAO and UNDP, 1988)

Appendix V: Initial Physical and Chemical Characteristics of the Soil

Characteristics		Value
Mechanical fraction:	% Sand (2.0-0.02 mm)	22.26
	% Silt (0.02-0.002 mm)	56.72
	% Clay (<0.002 mm)	20.75
Textural Class		Silt Loam
pH (1:2.5 Soil-water)		5.9
Organic Matter (%)		1.09
Total N (%)		0.06
Available K (ppm)		15.63
Available P (ppm)		10.99
Available S (ppm)		6.07

Appendix-VI. Analysis of variance of data on plant height of broccoli at different days after transplanting

Source of variation	Degrees of freedom (df)	Mean Square of plant height (cm)		
		20 DAT	40 DAT	60 DAT
Replication	2	1.021	25.516	22.704
Fertilizers (A)	8	3.536**	38.367**	26.068*
Error	16	1.302	13.698	11.464

* Significant at 0.05 level of probability; ** Significant at 0.01 level of probability and NS Non-significant

Appendix-VII. Analysis of variance of data on number of leaves per broccoli plant at different days after transplanting

Source of variation	Degrees of freedom (df)	Mean Square of number of leaves plant^{-1}		
		20 DAT	40 DAT	60 DAT
Replication	2	0.063	4.808	6.141
Fertilizers (A)	8	2.620*	2.355**	26.660**
Error	16	1.068	0.615	2.407

* Significant at 0.05 level of probability; ** Significant at 0.01 level of probability and NS Non-significant

Appendix-VIII. Analysis of variance of data on leaf length of broccoli at different days after transplanting

Source of variation	Degrees of freedom (df)	Mean Square of leaf length (cm)		
		20 DAT	40 DAT	60 DAT
Replication	2	9.308	38.725	10.049
Fertilizers (A)	8	7.935*	35.405*	13.885*
Error	16	4.180	19.253	11.223

* Significant at 0.05 level of probability; ** Significant at 0.01 level of probability and NS Non-significant

Appendix-IX. Analysis of variance of data on leaf breadth of broccoli at different days after transplanting

Source of variation	Degrees of freedom (df)	Mean Square of leaf breadth (cm)		
		20 DAT	40 DAT	60 DAT
Replication	2	1.183	17.444	8.961
Fertilizers (A)	8	1.985*	10.859*	10.622**
Error	16	0.886	4.285	3.599

* Significant at 0.05 level of probability; ** Significant at 0.01 level of probability and NS Non-significant

Appendix-X. Analysis of variance of data on diameter of stem of broccoli at different days after transplanting

Source of variation	Degrees of freedom (df)	Mean Square of diameter of stem (cm)		
		20 DAT	40 DAT	60 DAT
Replication	2	0.053	0.004	0.338
Fertilizers (A)	8	0.018**	0.111^{NS}	0.414**
Error	16	0.003	0.137	0.087

* Significant at 0.05 level of probability; ** Significant at 0.01 level of probability and ^{NS} Non-significant

Appendix-XI. Analysis of variance of data on days required for curd initiation, diameter of primary curd (cm), and weight of primary curd (g) of broccoli at different days after transplanting

Source of variation	Degrees of freedom (df)	Mean Square of		
		Days for curd initiation	Diameter of primary curd (cm)	Weight of primary curd (g)
Replication	2	34.322	0.501	1503.896
Fertilizers (A)	8	19.263**	3.244**	5170.094**
Error	16	3.580	0.360	342.982

* Significant at 0.05 level of probability; ** Significant at 0.01 level of probability and ^{NS} Non-significant

Appendix-XII. Analysis of variance of data on number of secondary curd per plant and weight of secondary curd (g) of broccoli at different days after transplanting

Source of variation	Degrees of freedom (df)	Mean Square of	
		Number of secondary curd per plant	Weight of secondary curd (g)
Replication	2	0.100	77.655
Fertilizers (A)	8	1.613**	2780.698**
Error	16	0.201	286.337

* Significant at 0.05 level of probability; ** Significant at 0.01 level of probability and ^{NS} Non-significant

Appendix-XIII. Analysis of variance of data on dry matter content of curd and dry matter content of leaf of broccoli at different days after transplanting

Source of variation	Degrees of freedom (df)	Mean Square of	
		Dry matter content of curd (%)	Dry matter content of leaf (%)
Replication	2	0.698	0.185
Fertilizers (A)	8	1.191*	3.815**
Error	16	0.491	0.909

* Significant at 0.05 level of probability; ** Significant at 0.01 level of probability and NS Non-significant

Appendix-XIV. Analysis of variance of data on yield per plant (g), yield per plot (kg) and yield per ha (t/ha) of broccoli at different days after transplanting

Source of variation	Degrees of freedom (df)	Mean Square of		
		Yield per plant (g)	Yield per plot (kg)	Yield per ha (t/ha)
Replication	2	2174.370	0.175	6.255
Fertilizers (A)	8	13681.120**	1.113**	39.323**
Error	16	877.456	0.071	2.522

* Significant at 0.05 level of probability; ** Significant at 0.01 level of probability and NS Non-significant

Appendix-XV. Per hectare production cost of broccoli as influenced by different organic and inorganic fertilizers

- Labour cost @ 500 tk/day
- Seed cost 300 g @ 120 tk/gm = 36,000 tk

Treatment cost

- T_1 (Cowdung @ 15 ton/ha) = 1000 x 15 = 15,000/- [Cowdung @ Tk. 1000/ton]
- T_2 (Fertilizer dose @ $CD_{10\ t/ha}$ $N_{150\ kg/ha}$ $P_{150\ kg/ha}$ $K_{120\ kg/ha}$) = (1000 x 10 + 22 x 150 + 24 x 150 + 20 x 120) = 19,300/- [Cowdung @ Tk. 1000/ton; Urea @ Tk. 22/kg; TSP @ Tk. 24/kg and MoP @ Tk. 20/kg]
- T_3 (Vermicompost @ 10 ton/ha and Trichoderma @ 22 kg/ha) = (30000 x 10 + 30 x 22) = 3,00,660/- [Vermicompost @ Tk. 30000/ton and Trichoderma @ Tk. 30/kg]
- T_4 (Vermicompost @ 10 ton/ha and biochar 150 kg/ha) = (30000 x 10 + 40 x 150) = 3,06,000/- [Vermicompost @ Tk. 30000/ton and biochar @ Tk. 40/kg)
- T_5 (Kitchen compost @ 8 ton/ha) = (30000 x 8) = 2,40,000/- [Kitchen compost @ 30000/ton]

- T_6 (Mushroom compost @ 5 ton/ha) = (10000 x 5) = 50,000/- [Mushroom compost @ Tk. 10000/ton]
- T_7 (Vermicompost (50%) + Cowdung (50%)) = (30000 x 5 + 1000 x 7.5) = 1,57,500/-
- T_8 (Mushroom Spent compost @ 5 ton/ha (60%) + Vermicompost (20%) + Trichoderma (20%)) = (10000 x 3 + 30000 x 2 + 30 x 4.5) = 90,135/-

A. Input cost

Treatment	Labour cost (tk)	Seed cost (tk)	Ploughing cost (tk)	Pesticide cost (tk)	Irrigation cost (tk)	Fertilizer cost (tk)	Pesticide cost (tk)	Fertilizer cost (tk)	Miscellaneous (tk)	Sub-total (tk)
T_0	28000	36000	18000	6000	15000	9000	10000	-	10000	132000
T_1	28000	36000	18000	6000	15000	9000	10000	15000	10000	147000
T_2	28000	36000	18000	6000	15000	9000	10000	19300	10000	151300
T_3	28000	36000	18000	6000	15000	9000	10000	300660	10000	432660
T_4	28000	36000	18000	6000	15000	9000	10000	306000	10000	438000
T_5	28000	36000	18000	6000	15000	9000	10000	240000	10000	372000
T_6	28000	36000	18000	6000	15000	9000	10000	50000	10000	182000
T_7	28000	36000	18000	6000	15000	9000	10000	157500	10000	289500
T_8	28000	36000	18000	6000	15000	9000	10000	90135	10000	222135

Total cost of production

Treatment	B. Cost of lease of land for 6 months (Tk 120000/year)	Sub-total cost of production (A+B)	C. Interest on running capital for 6 months (tk. 13% of cost /year)	Total cost (A+B+C) tk	Miscellaneous cost (tk 5% of the input cost)	Grand total cost of production
T_0	60000	192000	12480	204480	10224	214704
T_1	60000	207000	13455	220455	11022.75	231477.8
T_2	60000	211300	13734.5	225034.5	11251.73	236286.2
T_3	60000	492660	32022.9	524682.9	26234.15	550917
T_4	60000	498000	32370	530370	26518.5	556888.5
T_5	60000	432000	28080	460080	23004	483084
T_6	60000	242000	15730	257730	12886.5	270616.5
T_7	60000	349500	22717.5	372217.5	18610.88	390828.4
T_8	60000	282135	18338.78	300473.8	15023.69	315497.5

Plate

Plate 1: Seedbed preparation

Plate 2: Seedling on the seedbed

Plate 3: Treatment preparation

Plate 4: Application of insecticide

Plate 5: Gap filling activities

Plate 6: Main field

Plate 7: Healthy curd

Plate 8: Secondary curd

Plate 9: Field visited by supervisor

Plate 10: Harvested curd

Plate 11: Data collection