# RESPONSE OF BROCCOLI (*Brassica oleracea* var. *italica* L.) ON NUTRIENTS AND MULCH MATERIALS

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# *CERTIFICATE*

*This is to certify that the thesis entitled, "**RESPONSE OF BROCCOLI (Brassica oleracea var. italica L.) ON NUTRIENTS AND MULCH MATERIALS**" submitted to the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, in the 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 **MD. ASHRAF ALI,** Registration No. **16-07575** 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.*

**Dated:** December, 2017
**Dhaka, Bangladesh**

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***The Author***

# RESPONSE OF BROCCOLI *(Brassica oleracea* var. *italica* L.) ON NUTRIENTS AND MULCH MATERIALS

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## ABSTRACT

An experiment was conducted at the Horticulture Farm, Sher-e-Bangla Agricultural University and Dhaka, Bangladesh during the period from October 2017 to February 2018. Broccoli was selected for experimental crop. The experiment consisted of two factors. Factor A: four levels nutrients i.e. $N_0$-No nutrients (Control), $N_1$-Organic manure (Vermicompost (5t/ha) + Cowdung (7t/ha) +MOC (3t/ha)), $N_2$-Inorganic fertilizer ($N_{120}P_{100}K_{140}S_{20}B_{1.5}$ Kg/ha), $N_3$-Organic + Inorganic (1/2+1/2) and Factor B: Four levels of mulch materials i.e $M_0$-No Mulch (Control), $M_1$-Black polythene, $M_2$-Water hyacinth, $M_3$- Ash. This experiment was laid out in a Randomized Complete Blocked Design with three replications. Nutrients and mulch materials influenced significantly on most of the parameters. For nutrients $N_3$ performed best in diameter of curd (20.12 cm), weight of primary curd (447.82 g) and yield 15.25 t/ha and minimum in $N_0$ treatment. For mulch $M_1$ performed best curd (16.77 cm), weight of main curd (417.32 g) and yield 15.86 t/ha and minimum in $M_0$. In combined effect, the highest yield (16.77 t/ha) was obtained from $N_3M_1$ and the lowest (7.63 t/ha) in $N_0M_0$ treatment combination. So organic and inorganic fertilizer with black polythene mulch combinedly performed the best for the growth and curd formation of broccoli. The highest Benefit Cost Ratio 2.46 was noted from the combination of $N_3M_1$ treatment combination and the lowest 1.72 from $N_0M_0$. So, the combination of organic and inorganic fertilizer with black polythene mulching can be used for commercial broccoli production.

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## ABBREVIATIONS AND ACRONYMS

| ABBREVIATIONS | ELABORATIONS |
|---|---|
| AEZ | : Agro-Ecological Zone |
| ANOVA | : Analysis of Variance |
| CV% | : Percentage of Coefficient of Variation |
| df | : Degrees of freedom |
| DM | : Dry matter |
| *et al.* | : and others |
| FAO | : Food and Agricultural Organaization |
| SAU | : Sher-e-Bangla Agricultural University |
| BAU | : Bangladesh Agricultural Universiry |
| BBS | : Bangladesh Bureau of Statistics |
| DAT | : Day after Transplanting |
| LSD | : Least Significant Difference |

# CHAPTER I

# INTRODUCTION

Broccoli (*Brassica oleracea* var. *italica* L.) is an important vegetable crop of a member of the family Cruciferae. The broccoli derived its name from the Latin word Brachium meaning an arm or branch (Ambrosino, 2007). It is one the uncommon winter vegetable in Bangladesh. Although it was originated from temperate region and it has been distributed in the tropical and sub-tropical areas and introduced in Bangladesh several years ago. Its cultivation was not been extended much beyond the farm of different agricultural organizations. This is mainly due to the lack of awareness regarding its nutrified value and appropriate cultural management and postharvest technology. At present Broccoli is cultivated in Europe, America and most of the Asian countries in Europe, America and most of the Asian countries. In western countries broccoli is highly popular as fresh as well as frozen vegetable.

Broccoli is rich in vitamin and minerals such as carotene and ascorbic acid and contains appreciable quantities of thiamin, riboflavin niacin, calcium and iron (Thompson and Kelly, 1985). Analytical data represented that broccoli is more nutrition than other 'Cole crops' such as Cabbage, cauliflower and kohlrabi (Nieuwhof, 1969). It was also reported that it is more easily digestible than cauliflower (Roshid, 1976).

Broccoli is a minor vegetable in Bangladesh. It is grown by small cultivators in Rangpur, Dinajpur, Dhaka Gazipur and other districts. Broccoli can be grown on a wide range of soil types, ranging from light sand to heavy loam or, even clay that are well supplied with organic matter (Katayal, 1994). Its production can be increased by adopting improved cultural practices among them, proper fertilizer and soil moisture management are important. Broccoli plants responds generally major and minor essential elements like N, P, K, B and S in respect of its growth and yield (Cutcliffe and Munro, 1976).The continuous use of chemical fertilizer is badly affecting the soil texture and structure of soil and decreasing soil organic matter and reduce soil microbial activities. On the other hand organic manure like cowdung, vermicompost, mustard oil cake when applied help improving soil texture, structure, humus, color, water holding capacity and microbial activity of the soil. The application of the organic and inorganic manure influence broccoli production. All these, in return, increase production and reduce environmental pollution (Pare and Schnitzer, 2000).

Any particle that acts as a barrier to the evaporation of water or heat from the soil surface can be defined as mulch. Soil mulching is one of the elements of ecological cultivation of vegetables. The effect of mulching on the soil properties and plant yield depends on the climatic and soil conditions, this treatment gives better results in less favourable soil conditions, in areas with a high abundance of weeds and at lower soil nutrients (Iwuafor and Kang 1994; Dobromilska *et al*., 1995, Zibilske and Makus, 2009). By limiting the growth of weeds, maintaining proper moisture and reducing the daily temperature fluctuations,

mulch improves soil conditions for plant growth and development, resulting in a positive effect on vegetable yield (Nakhone and Tabatabai, 2008; Saeed and Ahmad, 2009). Mulches also reduce the water loss from the soil by evaporation and reduce the irrigation requirements (Amal *et al.,* 1990). Therefore, mulching may be helpful in conserving soil moisture of the preceding season and may be exploited to produce broccoli successfully particularly where rainfall and irrigation facilities are scarce. Generally broccoli is cultivated in Bangladesh during in winter season when rainfall is scanty. But for the whole growth period broccoli require 250-300 mm water with more emphasis to transplanting and curd formation stage. In most of the time irrigation expenses increase the cost of production resulting in unprofitable production of broccoli and make growers frustrated. Therefore, mulching in this regards may be helpful in consuming soil moisture of the production season and even where irrigation is available, mulching may be used as the substituted to minimize the cost of production. The aim of the investigation will be evaluated the growth and yield performance of broccoli influenced by organic and inorganic fertilizer with mulching. **Objectives:** The present research will be undertaken with the following objectives:

i) to find out the effect of nutrients on growth and yield of broccoli.

ii) to identify the actual mulch material on growth and yield of broccoli.

iii) to find out the suitable combination of nutrients with mulch material on growth and yield of broccoli.

# CHAPTER II

# REVIEW OF LITERATURE

Growth and yield of broccoli have been studied in various parts of the world, but a little study has been done on this crop under the agro-ecological condition of Bangladesh. However, available information portioning to this study was reviewed in the following headings.

## 2.1 Effect of nutrients on growth and yield of broccoli

Ying *et al*. (1997) conducted a pot experiment to determine the effect of N P and K on yield and quality of broccoli. They observed K was the most important element for yield and dry weight. Additive effects were observed on yield and 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. Nitrogen application advanced the harvesting date. Significant positive correlations were found between yield and dry weight of leaves and plant size. They also suggested that N, P and K application should be balanced to obtain high yields and quality of broccoli.

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.

Boari *et al*. (2010) conducted a field experiment to study the effects of fertilization and cultivar on yield and quality of broccoli in organic farming, are reported. The research was carried out during 2004-05. Three levels of organic fertilization (0-40 and 80 kg $ha^{-1}$ of Aminosprint, respectively indicated with $F_1$-$F_2$ and $F_3$) on 4 cultivar of broccoli, were compared. Any effect of fertilization levels was observed on broccoli yield and quality, probably because of low quantity of main nutritional elements contained in the Aminosprint. The most productive cultivar was 'Chevalier'. The nitrate content was low mainly in 'Lord', 'Marathon' and 'Chevalier', and a good ascorbic acid content was observed in 'Chevalier' and 'Switch.

Cai *et al*. (1999) conducted an experiment on the amount of N and K application on broccoli raised in compound media. In this experiment broccoli was grown in compound media mixed with sawdust, slag and cotton seed coats. Results indicated that applying 15 g urea + 10 g potassium chloride per plant produced the earliest curds of high quality and high yields. Applying 30 urea + 10 g potassium chloride per plant produced the highest yields applying 30 g urea + 30 g potassium chloride per plant gave the least satisfactory results.

Puenayan *et al.* (2010) using Legacy cultivar, found that the best response in fresh lump yield was obtained with fertilizations of 150+200 kg.ha$^{-1}$ of N+$P_2O_5$ ; 150+80 kg.ha$^{-1}$ of N+$K_2O$ and 150+200+80 kg.ha$^{-1}$ of N+ $P_2O_5$ +$K_2O$. This results were explained due to the acidity produced from urea decomposition favored the phosphorous absorption, while potassium incremented efficiency in nitrogen usage of the crop.

Yoldas *et al.* (2008) conducted an experiment to find out effect of nitrogen on yield, quality, and nutrient content in broccoli heads. Treatments consisted of 0, 150, 300, 450, and 600 kg N/ha. Application of nitrogen rates significantly increased yield, average weight of main and secondary heads, and the diameter in broccoli. The highest total yield (346.31 q/ha) was obtained at 300 kg N/ha. Potassium (K), calcium (Ca), magnesium (Mg), iron (Fe), and zinc (Zn) content increased with increase in nitrogen treatments but, phosphorus (P), copper (Cu), manganese (Mn), boron (B), and sodium (Na) contents were not influenced. It also, removed nutrients by broccoli head.

Ouda and Mahadeen (2008) conducted an experiment with nitrogen @ 0, 30 and 60 kg/ha to find out effects of fertilization on growth, yield quality and certain nutrient contents in broccoli. It was reported that head number per plant, chlorophyll content, head diameter and total yield was significantly higher when a combination of organic and inorganic fertilizers was added as compared with their individual addition. Application of 60 kg nitrogen as inorganic fertilizers with 60 tonnes of organic manure per hectare produced the highest broccoli yield (40.05 t/ha), whereas fresh and dry weight of broccoli shoots were not

significantly affected by the application of different doses of fertilizers. Leaf macro-(N, P and K) and micronutrient (Fe, Mn and Zn) contents increased with the application of either organic manure or inorganic fertilizer compared to the control.

Giri *et al*. (2013), at Rampur-Chitwan (Nepal), using Calabrese and Green Sprouting cultivars under different nitrogen dose, found that increasing up to 200 k $ha^{-1}$ the doses of N, a 33% higher than the used by Puenayan *et al.* (2010), significant inflorescence yield continued growing (14.5 t $ha^{-1}$) because of a mayor photosynthates production available for inflorescence filling.

El-Helaly (2012) studied the effects of nitrogen, sulphur and growing seasons on yield and the content of nitrate and vitamin C on broccoli (*Brassica oleracea* L. var *italica*). Three N fertilizers (ammonium sulphates, ammonium nitrate and urea) were side-dressed, while two levels of sulphur (0.0 and 0.5%) were sprayed on broccoli plants grown in both spring and fall-winter seasons. It was reported that application of urea as N-source decreased the yield by approximately 13-15% than other N-source.

Cutcliffe *et al.* (2013) studied the effects of nitrogen @ 0, 40, 80 and 120 kg/fed, phosphorus and potassium and their interaction on vegetative growth, yield and quality as well as chemical composition of broccoli. It was reported that an increase in nitrogen dose up to 80kg/fed considerably improved curd weight. While, dry matter was reduced with increased application of nitrogen led to improve vitamin C and sulforaphane by nitrogen levels up to 120 kg/fed and 40 kg/fed respectively.

Fabek *et al.* (2012) studied the effect of nitrogen @ 0, 60, 120, 240 kg/ha on nitrate accumulation, the minerals and glucosinolates in two broccoli cultivar (Marathon and Parthenon). There was significant effect of cultivar and nitrogen fertilization on nutritional quality of broccoli top inflorescence for two seasons. It was reported that marathon applied with nitrogen @ 120 or 240 kg/ha gave the highest values of glucosinolates and some nitrate minerals with nitrate content in permissible limit.

El-Magd *et al.* (2014) recorded the highest yield of broccoli with the application of N @ 120 Kg/faddan, it was followed by nitrogen @ 90 kg/faddan. Application of biofertilizers along with nitrogen, phosphorus and potassium was quite beneficial in improving the vegetative growth of broccoli.

Giri *et al.* (2013) evaluated the effect of nitrogen rates on growth and yield of two varieties of broccoli i.e. Green sprouting and Calabrese in western chitwan, Nepal using 5 nitrogen levels @ 0, 50, 100, 150 and 200 kg/ha. It was reported that yield was significantly influenced with cultivar and nitrogen. There was increase in curd production up to 200 kg N/ha which was 14.47 t/ha. While, Green sprouting produced 11% higher total curd than another cultivar.

Nitrogen applications increased broccoli yield and quality (Rooster *et al*., 1999; Babic and Elkner, 2000; Belec *et al.*, 2001).

Wojciechowska *et al.* (2005) studied that the foliar urea application significantly lowered concentration of nitrates in broccoli heads in comparison with the plants

not treated with urea. Additionally, the foliar nutrition increased soluble sugars content in all N treatments.

Singh and Singh (2000) in another study evaluated treatments containing nitrogen @ 0, 125, 150 and 175 kg/ha and potassium. They reported that N and K had a pronounced role on head yield and associated character of broccoli. They recorded a linear increase in plant height was due to synthesis of chlorophyll and amino acids. Delay in marketable maturity was observed due to nitrogen level beyond 150 kg/ha.

Hsieh *et al*. (1996) showed an experiment on conventional farming and partial organic farming and showed that growth and yield of broccoli in the organic treatments were greater than in the control. Poultry manure compost treatment gave the highest yield, which was 26.28% higher than that of the control, followed by pig manure compost treatment, which was 18.38% higher.

Sharma *et al. (*1995) a trial carried out on dates of planting and plant density on growth of curd and seed yield in sprouting broccoli at 45×45, 60×45 or 60×60 cm. Of the planting dates, 15 September resulted in the greatest curd and seed yields (98.72 q/ha and 17.94 g/plant, respectively). Among the spacing treatments, inflorescence yield was highest (104.97 q/ha) at 60×45 cm, while seed yield per plant was highest (20.51g) at 60×60 cm.

Rouchaud *et al.* (1992) a field experiment was conducted with Pig slurry, cow manure, city refuse or mushroom cultivation compost to study the effects of organic fertilizers on the rate of biodegradation of soil insecticides in cauliflower

crops. After planting, an emulsion of chlorpyrifos, chlorfenvinphos or carbofuran was applied to the soil around cauliflower stems and observed that the rate of biodegradation of the insecticides was slower in treated than in untreated plots. This paper was presented at the International Symposium on Crop Protection held in Gent, Belgium.

Hochmuth *et al.* (1993) conducted an experiment to investigate the response of cabbage yields, head quality and leaf nutrient status to poultry manure fertilization. They reported that the marketable yield of cauliflower responded quadratically to increasing rates of poultry manure, with the maximum yield (24.4 t/ha) being obtained by 18.8 t/ha. The results showed that manuring efficiency was initially higher with commercial fertilizer than the poultry manure alone, since lower amounts of total nutrients were applied using commercial fertilizer.

Steffen *et al.* (1994) carried out an experiment, on short-term and long-term impact of an initial large scale spent mushroom soil (SMS) amendment on vegetable crop productivity and resource use efficiency at Pennsylvania University, USA. They observed the effect of organic matter (spent mushroom compost at 64 Mt/ha + rotten cattle manure at 57 Mt/ha) applied in spring 1990 on growth and yield of broccoli. No fertilizer or other amendments were added to previously amended treatments, but 100 percent recommended NPK was added to all control treatments in all years. Broccoli yield and curd diameter were greater in the amended treatment.

Makinde and Ayoola (2012) said that okra fruit production can be alternatively supported with application of organic manures, to reduce the use of chemical fertilizers. Experiments were conducted to assess the growth and yield of okra (Variety: NH47-4) with cowdung (CD) and poultry manure (PM) applications at 0, 5, 10, 15 and 20 t $ha^{-1}$. The manures were applied at land preparation, 4 weeks before planting. Plant heights were generally lower from 4-8 weeks after planting (WAP) with cowdung (CD) application. Plant heights with poultry manure (PM) were similar with the unfertilized plants at 6 and 8 WAP. Plants were generally taller at 6 and 8 WAP with PM than CD. Application of 20 t $ha^{-1}$ gave the tallest plants of 34 cm with CD and 83 cm with PM at 8 WAP. Plant stem girths were all similar at 2 WAP with both manures. They were generally higher with PM relative to CD. At 8 WAP, 20 t $ha^{-1}$ gave the highest of 9 mm with CD and 24 mm with PM applications. Average number of leaves per plant at 8 WAP were all similar with PM, ranging from 10.2 to 13.7. With CD, 15 and 20 t $ha^{-1}$ applications had the highest average of 8.3 leaves which were significantly higher than from either 10 or 5 t $ha^{-1}$ that had average of 8.1 and 7.9 leaves per plant, respectively. Okra pod yields were lower with PM relative to CD 10 t $ha^{-1}$ PM gave the highest yield of 640 kg $ha^{-1}$ while the highest of 1297 kg $ha^{-1}$, with 15 t $ha^{-1}$ was got with CD. Poultry manure supports more of vegetative growth of okra while cowdung gives higher fruit yields.

Akter *et al.* (1996) carried out an experiment at Joydebpur to find out the effects of poultry manure (PM) and cowdung (CD) in presence and absence of chemical fertilizer on growth and yield of broccoli and reported that 10 ton/ha of poultry

manure with recommended dose of nutrients produced the highest curd yield of broccoli. The application of only PM and CD caused yield depression even at higher doses. The highest curd yield of 20.70 and 16.75 tons per hectare were obtained with PM and CD against 9.0 tons per hectare in the control treatment. In absence of NKPS only organic manure could not produce higher yield of curd.

Roe and Cornforth (2000) conducted an experiment on government regulations and public pressures have resulted in the use of composting as an alternative waste handling system for dairies. Utilization of locally produced manures by vegetable production operations may increase crop yields with less conventional fertilizer. Despite its ability to stabilize nutrients and lower manure volume, composting has costs in time and equipment, so some growers prefer using uncomposted manure. Dairy manure compost at 22 (LC), 45 (MC), or 90 (HC) $Mg.ha^{-1}$ or uncomposted dairy lot scrapings at 45 $Mg.ha^{-1}$ (DL) were tilled into soil before seeding a dry land muskmelon (Cucumis melo L.) crop. All plots, including an unamended control, were fertilized with a total of 23N-14P-0K ($kg.ha^{-1}$). All rates of compost or manure increased yields of cantaloupe, and the subsequent broccoli crop. Use of the manure resulted in highest increase in potential net income from sales of muskmelon and broccoli.

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.

Thakur and Shingh (2001) Conducted an experiment on cauliflower cv. Pusa Snowball $K^{-1}$ plants were supplied with 0 ($T_0$), 600 ($T_1$), 800 ($T_2$) and 1000 ($T_3$) kg recycled commercial organic manure (ORGO)/ha in a field experiment conducted in Himachal Pradesh, India during 1998-99 to determine the effects of ORGO on the seed yield of cauliflower. Plant mortality was highest with $T_2$ (11%) and lowest with $T_3$ application (6%). Seed yield per plot and total yield were highest in plants supplied with $T_2$ (839.90 g/plot and 8.20 q/ha, respectively) and lowest in those supplied with $T_3$ (540.15 g/plot and 5.27 q/ha, respectively). No significant differences among the treatments in terms of the number of outer leaves of cauliflower were observed.

Chaterjee *et al*. (2005) observed 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.

Sanwal *et al*. (2005) conducted a field experiment in Meghalaya, India during 2003-04 and 2004-05 to investigate the effects of organic manures and natural growth regulators on the chemical composition of flowers and stems of broccoli cv. Hybrid Fiesta. The treatments included: farmyard manure (FYM) at 20 t/ha; poultry manure 10 t/ha; pig manure at 11 t/ha; rabbit manure at 11 t/ha; neem shield 4.5 t/ha; FYM at 16 t/ha + 4 sprays of panchakavya; FYM at 16 t/ha + 4 sprays of amritpani; poultry manure at 8 t/ha + 4 sprays of panchakavya; poultry manure at 8 t/ha + 4 sprays of amritpani; and NPK. Foliar spray of panchavkaya and amritpani at 10% was made at 15, 30, 45 and 60 days after planting. Floral parts showed higher values for dry matter, carotenoid, total soluble solids, acidity, ascorbic acid, carotenoid and protein; but lower values for pH fibre content, reducing sugars, total sugars and nitrate than the stem. Integrated use of organic manures and natural growth promoters resulted in higher dry matter content, pH, ascorbic acid content, total soluble solids, reducing sugars and total sugars, but lower fibre contents in stems and flowers than NPK treatment.

Babik and Kowalczyk (2005) conducted a field experiment to study the effects of compost of plant materials as substrate and soil amendment on the growth and yield of greenhouse lettuce and field broccoli. Addition of compost at 10% of peat substrate as growing media for greenhouse lettuce significantly increased the yield and head size of lettuce compared to mineral fertilizer application only. Higher amount of compost added to substrate did not result in higher yield of lettuce. 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.

**2.2 Effect of Mulch on growth and yield of broccoli**

Islam *et al.* (2002) investigated the effect of planting time, mulching and irrigation on the growth and yield of cabbage cv. Atlas-70. Mulching and irrigation significantly affected the growth and yield of cabbage. The highest gross yield (71.85 kg/plot) was obtained from the black polyethylene mulch followed by water hyacinth mulch (65.99 kg/plot). Considering marketable yield, both black polyethylene mulch (103.01 t/ha) and water hyacinth mulch (90.99 t/ha) exerted statistically similar effects followed by irrigation at 15 days interval (85.85 t/ha), whereas non-mulching and non-irrigated plots (control) exhibited the lowest marketable yield (38.87 t/ha).

Kashyap *et al.* (2009) who conducted an investigation on sandy loam soil to find the effect of different irrigation regimes and polythene mulch on yield, quality and water used efficiency of the broccoli variety Pusa Broccoli KTS-1 at Assam Agricultural University, Jorhat. The highest plant height (71.90 cm), number of leaves plant-1 (38.51), leaf size index (753.15 $cm^2$), plant spread (92.25 cm), curd diameter (14.36) and curd yield (17.89 t $ha^{-1}$) was obtained with black polythene mulch treatment. This treatment was found superior to paddy straw

mulch @ 5 t/ha and no mulch (control). The lowest growth, yield parameters and curd yield were registered with no mulch treatment.

Mollah *et al*. (2009) evaluated the effect of different mulching on growth and yield contributing characters of broccoli (*Brassica oleracea* L. var. italica. Sub-var. cymosa). Four levels of mulching, viz. $M_0$=Control, $M_1$=Rice straw, $M_2$=Water hyacinth and $M_3$=Black polythene, were used as treatments in the experiment. The maximum plant height (55.49 cm), number of leaves per plant (18.15), leaf length (46.10 cm), breadth of leaf (70.42 cm) and plant canopy (70.42 cm) at 60 DAT, stem diameter (3.76 cm), shoot length (31.92 cm), fresh shoot weight (1263 g), length of root (28.00 cm), root weight (80.83 g), minimum days required to primary curd initiation (52.75 days), fresh weight of leaf (641.7 g), weight of primary curd (265.8 g), curd diameter (16.48 cm), number of secondary curd per plant (6.25), weight of secondary curd per plant (94.42 g), dry weight of shoot (8.70 g), dry weight of curd (8.80 g), dry weight of leaf (16.42 g), yield per plant (360.2 g) and yield per hectare(13.33 t) were recorded from $M_3$ treatment of black polythene mulch whereas the minimum values of the above parameters at all growth stages found in $M_0$ treatment.

Kosterna (2014) evaluated the effect of plants covering and the kind of organic mulch applied to soil mulching on the yield and selected component of nutritive value in Milady $F_1$ broccoli cultivated for early harvest. The application of polypropylene fibre contributed to a significant increase in the marketable yield of broccoli on average by 5.25 t/ha, weight of head by 0.10 kg and length of arc by 1.44 cm. Increase of the content of chemical components as a result of plants

covering amounted to 1.76% for dry matte, 2.50 mg/100 g fresh matter (FM) for ascorbic acid, 0.65% FM for total sugar and 0.15% FM for monosaccharides. All kinds of straw contributed to an increase in the broccoli yield and improvement its parameters. The highest marketable yield and weight of head was obtained in the plots mulched with buckwheat straw. Irrespective of covering, cultivation on the mulch with buckwheat straw contributed to a slight decrease in dry matter, total sugars content, whereas cultivation on the rye straw decreased ascorbic acid content.

Salim *et al.* (2008) found a positive impact of mulch on yield and yield attributes of the cauliflower crops. The highest marketable yield (31.32t/ha) was obtained from hybrid variety Snow crown with mulch was 35.16% higher than without mulch. Other two varieties also produced higher yield under mulched condition than the without mulch. The production cost was higher in mulched treatment by Tk. 1510. A net additional return of Tk. 97800, 41040 and 30840 from the varieties Snow crown, Poushali and IPSA-1 respectively, was obtained due to mulching.

Ekwu *et al.* (2010) studied the effect of mulching (grass mulch) on the vegetative growth and green pod yield of okra. The results showed that mulched plots, which received 140 kg N/ha produced the highest number of fruits. The weight and length of fruits was higher on the mulched plots. Non-mulched plots consistently produced least values in all the parameters that were measured.

Anisuzzaman *et al.* (2009) evaluated effects of planting time and mulches on bulb growth and seed production of onion they observed that mulches had

significant influence on almost all parameters studied. Growth and seed production was accelerated by black polythene. Seed yield was 529.06 kg/ha where black polythene mulch was used.

Lopes *et al*. (2011) evaluated the growth of tomato plants under the mulching with uncovered soil, black polyethylene film, silver polyethylene film, white polyethylene film and black polypropylene TNT. They reported that mulching influenced the development of dry matter accumulation in leaves, branches and fruits and the TNT promoted the highest averages. The fruits behaved as the preferential drain of the plant. The TNT was the mulching that has promoted the highest average for the leaf area index and absolute and relative growth rates. The leaf area ratio, specific leaf area and net assimilation rate were not influenced by cover crops.

Karaye and Yakubu (2006) indicated that the number of leaves/plant, weed growth and cured bulb yield responded significantly to intra-row spacing and mulching, except in 2000/2001 trial, when the effect of mulching on cured bulb yield was not significant. Based on the results obtained, it could be concluded that for optimum bulb yield in garlic, the intra-row spacing of 10 cm and 9 t/ha mulching rate should be adopted.

Filippi *et al*. (2009) checked the behavior of two new black biodegradable mulching films (Mater-BI) on cauliflower (*Brassica oleracea* var. *botrytis* L.), comparing them to a traditional l dpe film and naked soil and at different irrigation systems (dripping irrigation, spray irrigation, without irrigation). The results showed that the water wasted reached the highest values in naked soil and

the lowest in the ldpe film, while biodegradable films showed middle values. They also presented excellent results both for plant's growth and production, even higher than ldpe. About the degradation, both the biodegradable films showed good mechanical properties till the end of the cycle.

Bahadur *et al.* (2009) studied the effect of drip irrigation quantity and mulching on crop growth, yield and water use efficiency (WUE) of tomato grown during the rabi seasons of 2007 and 2008. Results indicated that the photosynthetic traits such as; chlorophyll content, initial fluorescence ($F_0$), and maximum quantum yield of photo system II (Fv/Fm) were significantly higher under I1 (Irrigation with V value of water) and black polythene mulch. Polythene mulching remarkably improved the plant bio mass and plants mulched with black polythene registered 94.7% higher dry matter over unmulched control. Maximum fruit yield (2.66 kg per plant and 851.59 q/ha) was recorded with black polythene mulch. All kinds of plastic mulches gave significant weed control, however, the highest weed reduction (89% over control) was observed with black polythene mulch. Maximum WUE of 49.60 kg/mm/ha was obtained in I2 (irrigation with 0.5 V value of water), whereas, among mulches WUE was maximum with black polythene (46.03 kg/mm/ha).

Bajkowska *et al.* (2009) investigated the effect of soil mulching with rye straw (*Secale cereale*) applied at a rate of 5 t/ha on a weed infestation in cabbage (*Brassica oleracea* L. var. *capitata* L. *f. rubra*) cultivated in the first year, and onion (*Allium cepa* L. var. *cepa* Helm.) grown in the second year after mulching. Straw mulch was applied during the final 10 days of July and plough-

incorporated on three dates (in the autumn, the final 10 days of October; in the spring of the next year, the second 10 days of May; mulch non-incorporated until the time of cabbage harvest). The mulching effect of 5 t/ha rye straw was compared to conventional farmyard manure fertilization at a dose of 40 t/ha, as well as a control without manure fertilization or mulching. The weed infestation of plots where straw mulch was left until the time of cabbage harvest was significantly smaller in comparison with the autumn- and spring-incorporation of straw. In the period of cabbage growth, the fresh mass and number of weeds in the plots with non-incorporated mulch were significantly lower than in the control without mulching and farmyard manure-fertilized plots.

Faysal (2006) conducted an experiment at the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka to study the effect of different sources of organic manures on the growth and yield of broccoli. The experiment consisted of five different sources of manures; control (no manure), cowdung (26.5t/ha), water hyacinth compost (10.6 t/ha), poultry litter (16.56 t/ha) and vermicompost (12.26t/ha). Different sources of manures had significant influence on plant height, height up to curd, number of leaves per plant, length of leaf, breadth of leaf, plant canopy, and diameter of curd, diameter of stem, weight of primary curd, dry weight of curd, number of secondary curd, weight of secondary curd, yield per plant, yield per unit plot and yield per hectare. The maximum yield (14.50 t/ha) was obtained from poultry litter followed by vermicompost and the minimum yield (7.37 t/ha) was recorded by no manure.

# CHAPTER III

# MATERIALS AND METHODS

There are many information require to conducted this experiment, these includes this chapter regarding methodology that was used in execution of the experiment. It contains a short description of location of the experimental site, climatic condition, materials used for the experiment, treatments of the experiment, data collection procedure and statistical analysis etc.

## 3.1 Experimental period

The experiment was conducted from October 2017 to February 2018.

## 3.2 Location

The experiment was conducted at the Central Farm of the Sher-e-Bangla Agricultural University, Dhaka during the period from October, 2017 to February, 2018. The Latitude of the site is $90.2^0$ N and $23.5^0$ E and the altitude of 8.2 m from the sea level.

## 3.3 Characteristics of soil

The characteristic of the soil of the experiment site was Non- calcareous, dark gray, medium high land. The texture of soil was silty loam with a pH 6.7. The experimental plot soil samples were collected from a depth of 0 to 30 cm before conducting the experiment. Soil was analyzed in the Soil Resources Development Institute (SRDI) Farmgate Dhaka. The experimental site was a medium high land.

### 3.4 Climatic condition

The experimental site was under the sub-tropical monsoon climate, which is characterized by heavy rainfall during Kharif season and scanty in the Rabi season (October to March). There was no rainfall during the month of October, November, December and January. The average maximum temperature during the period of experiment was 26.82˚C and the average minimum temperature was 17.14˚C. Details of the meteorological data in respect of temperature, rainfall and relative humidity during the period of the experiment were collected from Weather Station of Agargaon, Dhaka.

### 3.5 Agro-ecological region

The experimental site belongs to the agro-ecological region of the Modhupur Tract (AEZ-28). The landscape comprises level upland, closely or broadly dissected terraces related with either shallow or broad, deep valleys.

### 3.6 Experimental materials

"Paraiso" a variety of broccoli has been used as experimental material.

### 3.7 Experimental treatments

Factor A: Four levels of nutrient combination

1) $N_0$-No nutrients (Control)
2) $N_1$-Organic Manure (Vermicompost 5t/ha+Cowdung 7t/ha+MOC 3t/ha)
3) $N_2$-Inorganic fertilizer($N_{120}P_{100}K_{140}S_{20}B_{1.5}$ kg/ha)
4) $N_3$-Organic +Inorganic (1/2+1/2)

Factor B: four level of mulching

1) $M_0$-No Mulching and no irrigation (control)

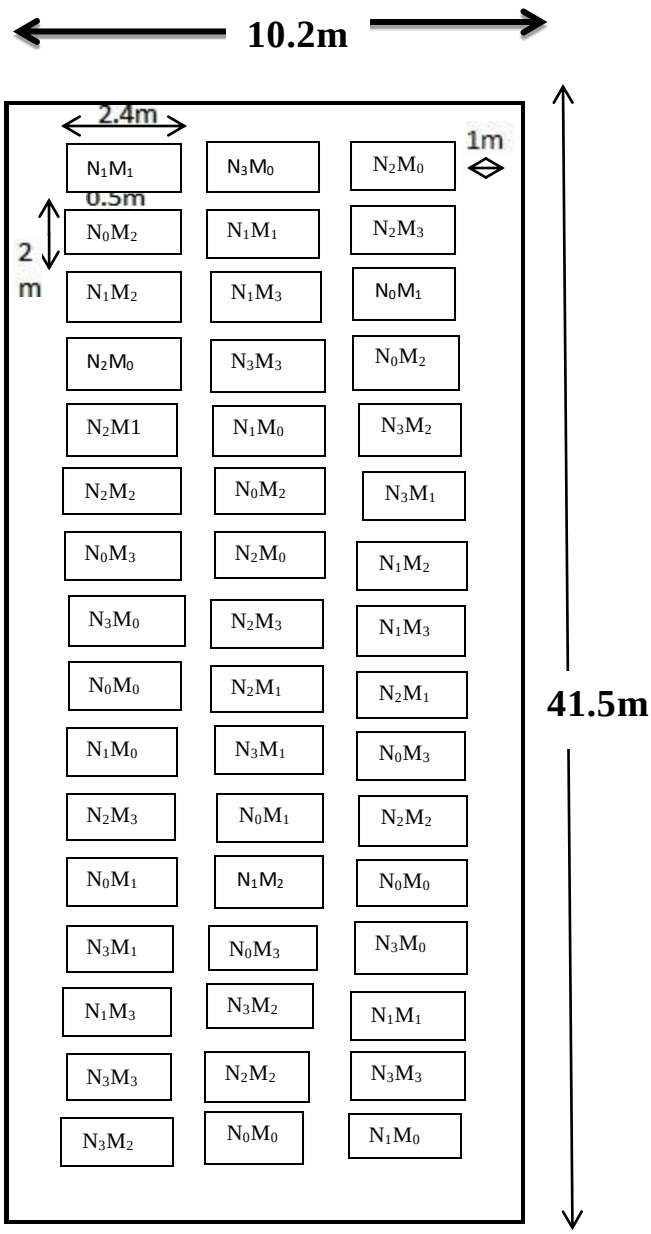
2) $M_1$-Black polythene

3) $M_2$-Water hyacinth

4) $M_3$-Dry Ash

### 3.8 Experimental design and layout

The experimental treatments were laid out in a Randomized Complete Block Design (RCBD) with three replications. The experimental field was divided into 3 blocks with 16 unit plots of 4.8$m^2$ (2.4 m x 2 m) size in each block. Thus the total number of unit plots were 3 x 16 = 48. The distance maintained between two unit plots was 0.5 m and that between blocks 1.0 m.




Plot size: 2.4m x 2.0m

Spacing: 60 cm x 40 cm

Spacing between plot: 50 cm

Spacing between row: 1.0m

Treatments were as follows:

A. Nutrients

1) $N_0$ = No nutrient applied(control)
2) $N_1$ = Organic Manure (Vermicompost 5t/ha + Cowdung 7t/ha + MOC 3t/ha)
3) $N_2$ = Inorganic fertilizer($N_{120}P_{100}K_{140}S_{20}B_{1.5}$ kg/ha)
4) $N_3$= ( ½ Organic Manure + ½ Inorganic fertilizer)

B. Mulch materials

1) $M_0$ = No mulch material (control)
2) $M_1$ = Black polythine
3) $M_2$ = Water hyacinth
4) $M_3$ = Dry Ash

Fig. 1. The layout of the experiment

### 3.9 Crop husbandry

#### 3.9.1 Raising of seedlings

For raising seedlings, the soil was ploughed and converted into loose friable and dried masses. All weeds, stubbles and dead roots were removed. Cowdung was applied to the prepared seed beds at the rate of 10 t/ha. The seeds were sown in the seed beds of 2.5 m x l m size on 27 October 2017. After sowing, the seeds were covered with a thin layer of soil. When the seeds germinated, shade by bamboo mat (Chatai) was provided to protect the young seedlings from scorching sun-shine and rain. Light watering, weeding and mulching were done as and when necessary. No chemical fertilizers were applied for raising the seedlings. Seedlings were not attacked by any kind of insects or diseases. Seed germination started at 31 October 2017. The healthy 30 days old seedlings were transplanted in the experimental field on 26 November 2017.

#### 3.9.2 Land preparation

The land was preparation was started at 18 November 2017 by ploughing and cross ploughing followed by laddering. The corner of the land was spaded and visible large clods were broken into small pieces. Weeds and stubbles were removed from the field. The layout of the experiment was done in accordance with the design adopted. Finally, individual plots were prepared by using spade before organic manure application.

### 3.9.3 Application of nutrient and mulch materials treatments

There were four manure treatments. $N_0$-No nutrient applied (Control), $N_1$-Organic Manure (Vermicompost 5 t/ha + Cowdung 7 t/ha + MOC 3 t/ha), $N_2$-Inorganic fertilizer ($N_{120}P_{100}K_{140}S_{20}B_{1.5}$ kg/ha), $N_3$-organic manure + Inorganic fertilizer (1/2+1/2). The whole amount of Urea, TSP, MoP, Ammonium sulfate and Borax applied to the experimental plots as percentage. The total amount of organic manure and TSP, Ammonium Sulfate, Borax were applied as basal dose at the final land preparation maintaining dose as per table-1. The total amount of Urea and MoP were applied in the two equal installment at 20 and 40 DAT.

**Table 1: Dose and method of applied of manure and fertilizer in broccoli**

| Fertilizer/Manure | Dose/Hectare |
|---|---|
| Cowdung | 5 ton |
| Vermicompost | 5 ton |
| Mustard Oil Cake | 3 ton |
| Urea | 120 kg |
| TSP | 100 kg |
| MoP | 140 kg |
| Ammonium Sulphate | 20 kg |
| Borax | 1.5 kg |

**Source: Fertilizer recommendation guide (2014). BARC.**

### 3.9.4 Application of mulch materials

Four types of mulching materials viz; Black polythene, water hyacinth and dry ash were used. Semi dried water hyacinth was cut into small pieces and black

polythene sheet with small opening which were made maintaining proper plant to plant distance and row to row distance before planting over the plots. The thickness of water hyacinth and ash was 6-8 cm. No irrigation was given to the mulching treatment after placement of mulching and no irrigation was also given to the non-mulched (Control) plot.

### 3.9.5 Transplanting and after care

Healthy 30 days old seedlings were transplanted on 27 November, 2017 in the afternoon and light irrigation was given around each seedling for their better establishment. Each unit plot accommodated 20 plants. The transplanted seedlings were protected from scorching sunlight early in the morning by providing shed using banana leaf sheath and remove just before sun set daily, until the seedlings were established. A number of seedlings were planted in the border of the experimental plots for gap filling.

### 3.9.6 Gap filing

Dead, injured and weak seedlings were replaced by new healthy seedlings from the stock kept on the border line of the experiment.

### 3.9.7 Intercultural operation

### 3.9.8 Weeding

Weeding was done three times in each plot to keep the plot clear.

### 3.9.9 Pest and Disease control

Few plants were damaged by mole crickets and cut worms after the seedlings were transplanted in the experimental plots. Cut worms were controlled both mechanically and spraying Diazinon 60 EC @ 0.55 Kg per hectare. Some of the plants were infected by *Alternaria brassicae*. To prevent the spread of the disease Rovral @ 2g /liter of water was sprayed in the field. Bird pests such as Nightingale (Common Bulbuli) visited the fields from 8 to 11 a.m. and 4 to 6 p.m. The birds were found to make puncture in the soft leaves and initiating curd and they were controlled by striking of a metallic container.

### 3.9.10 Harvesting

The harvesting was not possible to be done on a particular date because curd initiations as well as curd maturation period in different plants were not similar probably due to use of different manures. The compact mature curds were only harvested. After harvesting the main curd, secondary shoots were developed from the leaf axils and produced small secondary curds. Those were harvested over a period of time. The crop under investigation was harvested for the first time on 22 January, 2018 and the last harvesting was done on 20 February, 2018. The curds were harvested in compact condition before the flower buds were opened (Thompson and Kelly, 1985).

## 3.10 Methods of data collection

The data pertaining to the following characters were recorded from five plants randomly selected from each unit plot, except yield of curds which was recorded

plot wise. Data on plant height was collected at 20, 40 and 60 days after transplanting and also at harvest. All other parameters were recorded at harvest.

### 3.10.1 Plant height (cm)

The height of each sample plant was measured unit plot wise from the base to the tip of main stem of the five randomly selected plants and then averaged.

### 3.10.2 Number of leaves per plant

The number of leaves of each sample plant was counted unit plot wise from five randomly selected plants and then averaged.

### 3.10.3 Leaf length (cm)

A meter scale was used to measure the length of leaves. Leaf length of five randomly selected plants was measured in centimeter (cm) at harvest. It was measured from the base of the petiole to the tip of the leaf. All the leaves of each plant were measured separately. Only the smallest young leaves at the growing point of the plant were excluded from measuring.

### 3.10.4 Leaf breadth (cm)

Leaf breadth of five randomly selected plants was measured in centimeter (cm) at harvest from the widest part of the lamina with a meter scale and average breadth was recorded. All the leaves of each plant were measured separately. Only the smallest young leaves at the growing point of the plant were excluded from measuring.

### 3.10.5 Days to curd initiation

Total number of days from the date of transplanting to the date of visible curd initiation was recorded.

### 3.10.6 Diameter of stem (cm)

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

### 3.10.7 Diameter of primary curd (cm)

Primary curd diameter was taken 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).

### 3.10.8 Weight of primary curd (g)

Weight of the central curd was recorded excluding the weight of all secondary marketable curds and expressed in kilogram (kg).

### 3.10.9 Number of secondary curd per plant

When the secondary curds reached marketable size, they were counted and the small shoots were taken into consideration.

### 3.10.10 Average weight of secondary curd (g)

Weight of secondary curd was recorded by weighing the total marketable auxiliary curds of an individual plant and recorded in gram (g).

### 3.10.11 Percent dry matter of curd

A sample of 100 g of curd was collected and was dried under direct sunshine for 72 hours and then dried in an oven at 70 $^{0}$C for 3 days. After oven drying, curds

were weighed. The dry weight was recorded in gram (g) with an electric balance. The percentage of dry matter was calculated by the following formula:

$$\text{Percent dry matter} = \frac{\text{Weight of dry matter}}{\text{Fresh weight}} \text{ x } 100$$

### 3.10.12 Percent dry matter of leaf

A sample of 100 g of leaves was collected and dried under direct sunshine for 72 hours and then dried in an oven at 70 $^0$C for 3 days. After oven drying, leaves were weighed. The dry weight was recorded in gram (g) with an electric balance. The percentage of dry matter was calculated by the following formula:

$$\text{Percent dry matter} = \frac{\text{Weight of dry matter}}{\text{Fresh weight}} \text{ x } 100$$

### 3.10.13 Yield per plant (g)

The yield per plant was calculated by averaging the weights of ten randomly harvested curds and secondary curds and expressed in kilogram (kg).

### 3.10.14 Yield per plot (kg)

The yield per unit plot was calculated by adding the yields of all plants of each unit plot and expressed in kilogram (kg).

### 3.10.15 Yield per hectare (t/ha)

The yield of curd per hectare was calculated by conversion of the curd weight per plot and recorded in ton.

### 3.11 Statistical analysis

The data obtained were statistically analyzed to find out the variation resulting from experimental treatments following F variance test. The difference between treatments was adjusted by Least Significant Difference Test (LSD) (Gomez and Gomez, 1984).

### 3.12 Economic analysis

The cost of production was analyzed in order to find out the most economic combination of different pinching method and gibberellic acid for broccoli cultivation. All input cost included the cost for lease of land and interests on running capital in computing the cost of production. The interests were calculated @ 12% in simple rate. The market price of broccoli was considered as local market for estimating the cost and return. Economic analyses were done according to the procedure of Alam *et al*. (1989). The benefit cost ratio (BCR) was calculated as follows:

$$\text{Percent dry matter}(\%) = \frac{\text{Gross return per hectare (TK.)}}{\text{Total cost of production per hectare (TK.)}}$$

## CHAPTER IV

# Results and Discussion

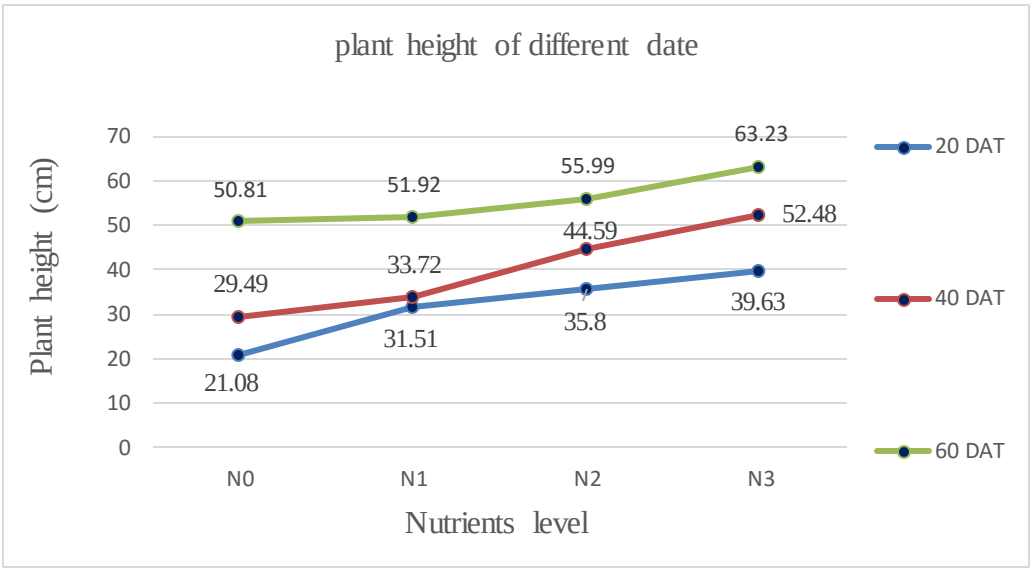
The results of the study regarding the effect of organic manure and inorganic fertilizer with mulching on growth characters, yield and yield related traits of broccoli have been presented and possible interpretations have been made in this chapter which is given below:

### 4.1 Morphological parameter

#### 4.1.1 Plant height

Application of nutrient exhibited a significant influence on the plant height of broccoli plants at different days after transplanting (Figure 2, Appendix: II) at 20, 40, and 60 DAT. At 20 DAT the Longest (39.63 cm) plant was found in organic manure and inorganic fertilizer ($N_3$) which was statistically identical to that of $N_2$ treatment and the shortest (21.08 cm) plant was found from $N_0$ treatment. At 40 DAT, the longest (52.48cm) plant height was recorded from $N_3$ treatment which is similar to that $N_2$ treatment and the smallest plant (29.49 cm) was found from $N_0$ treatment. At 60 DAT the tallest plant height (63.23 cm) was recorded from $N_3$ treatment which was statistically similar to that of $N_2$ treatment and shortest plant (50.80 cm) was recorded from $N_0$ treatment. It was observed that plant height reached its maximum stage at harvest in all the treatments. The plant height was found statistically different from 20 DAT to harvesting time. The highest plant height was obtained from $N_3$ treatment. This height due to the

fact that combination manures and fertilizers supplied adequate plant nutrients for better vegetable growth, which ultimately increased plant height. Similar results observed of Farooque and Islam (1989). They reported that application of cowdung, oil cake, TSP, MoP combinedly gave better growth and maximum yield of broccoli.




$N_0$-No nutrient applied (Control),

$N_1$-Organic Manure (Vermicompost 5t/ha + Cowdung 7t/ha + MOC 3t/ha),

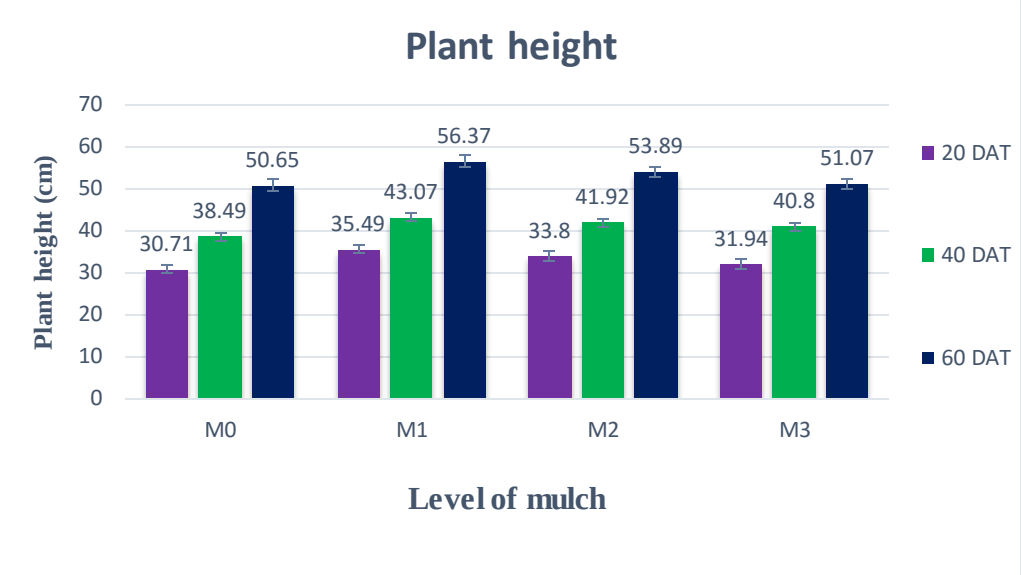
$N_2$-Inorganic fertilizer ($N_{120}P_{100}K_{140}S_{20}B_{1.5}$ kg/ha),

$N_3$-Organic +Inorganic (1/2+1/2)

**Fig. 2. Effect of nutrients on plant height of broccoli**

Application of mulch materials had showed significant influence on the height of broccoli plants at 20, 40 and 60 DAT (Figure 2, Appendix: II). At 20 DAT, the tallest plant (35.49 cm) was measured from black polythene ($M_1$) treatment which was statistically similar to that of water hyacinth ($M_2$) treatment and the shortest (30.71 cm) was recorded from $M_0$ treatment. At 40 DAT, the tallest plant height (43.07 cm) was recorded from $M_1$ treatment which was statistically similar to that of $M_2$ treatment and the shortest (38.49 cm) was recorded from $M_0$ treatment. At 60 DAT, the highest plant height (56.37 cm) was measured from $M_1$ treatment which was statistically similar to that of $M_2$ treatment and the

lowest height (50.65 cm) was recorded from $M_0$ treatment. It was revealed that the plot covered by mulching gave better plant height then control. This might be due to mulching increased crop growth rate (CGR), net assimilation rate (NAR), leaf area index (LAI) and relative growth rate (RGR). Similar result was found by Roy *et al*. (1990) on growth of Broccoli.




$M_0$-No mulch (Control),

$M_1$-Black Polythene,

$M_2$-Water hyacinth,

$M_3$-Dry Ash

**Fig. 3. Effect of different levels of mulch materials on plant height of broccoli**

The plant height was significantly influenced by the combination effect of nutrients and mulch material at 20, 40 and 60 DAT (Figure 3 Appendix: II). At 20 DAT, the highest plant height (45.57 cm) was measured from the combination of $N_3M_1$ treatment combination and the lowest (18.56 cm) was recorded from $N_0M_0$ treatment combination. At 40 DAT, the highest plant height (57.75 cm) was measured from $N_3M_1$ treatment combination which is statistically similar to $N_3M_2$ treatment combination and the lowest (28.07 cm) from $N_0M_0$ treatment combination. At 60 DAT, the tallest plant height (65.76 cm) was measured from

$N_3M_1$ treatment combination and the shortest (44.53 cm) was recorded from $N_0M_0$ treatment combination. From the results, it is obvious that organic manure and mulching are helpful for increasing plant height of broccoli. In this study combinedly application of organic and inorganic fertilizer along with black polythene possibly maintained a higher moisture control and more uniformly temperature distributed in soil and resulted more released of plant nutrients elements from organic and inorganic sources which ultimately reflected in the higher plant growth.

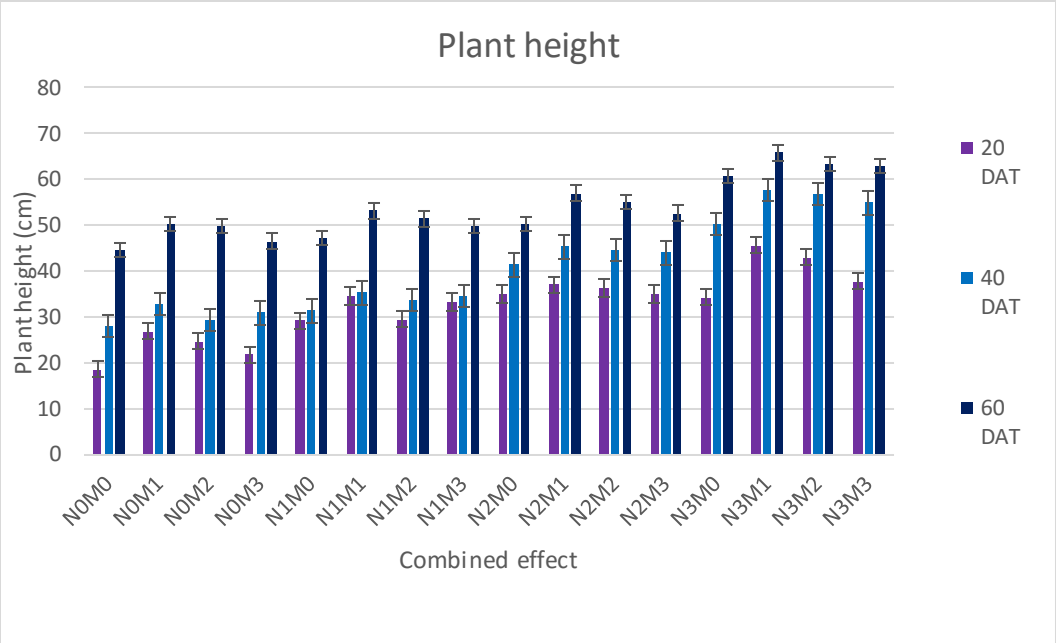



**Fig. 4. The combined effect of different levels of nutrients and mulch materials on plant height of broccoli**

### 4.1.2 Number of leaves per plant

Application of nutrients showed a significant influence on the number of leaves of broccoli plants at 20, 40 and 60 DAT which showed Table 02 (Appendix: III). Maximum number of leaves (11.68) was found from organic manure and

inorganic fertilizer ($N_3$) treatment and minimum number of leaves (3.34) was found from $N_0$ treatment at 20 DAT per plant. At 40 DAT, the maximum number of leaves (11.77) was found from $N_3$ treatment which is statistically similar to $N_2$ treatment and the minimum number of leaves (4.22) was found from $N_0$ treatment. At 60 DAT, the maximum number of leaves (15.57) was found from $N_3$ treatment and the minimum number of leaves (5.59) was found from $N_0$ treatment (Table 2). From this result of the present study indicated that combined of organic and inorganic fertilizer might have influence better growth condition perhaps due to supply of additional plant nutrients which ultimately predicted more number of leaves per plant of broccoli. This result was coincided with those reported by Abou *et al*. (2006).

**Table 02. Effect of different levels of nutrients on leave number of Broccoli**

| Treatment | leaf Number | | |
|---|---|---|---|
| | 20 DAT | 40 DAT | 60 DAT |
| $N_0$ | 3.34 d | 4.22 c | 5.59 d |
| $N_1$ | 5.34 c | 6.47 b | 8.11 c |
| $N_2$ | 9.89 b | 11.20 ab | 13.32 b |
| $N_3$ | 11.68 a | 11.77 a | 15.57a |
| LSD (0.01) | 1.487 | 1.102 | 1.543 |
| CV% | 8.56 | 5.69 | 6.31 |

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.01 level of probability
N0=Control, N1=Organic Manure (Cowdung 4t/ha+Vermicompost 3t/ha+ MOC 1.5t/ha), N2=Inorganic Fertilizer (N120P100K140S20B1.5 kg/ha), N3= Organic+ Inorganic Fertilizer (1/2+1/2).

Application of mulch material was significantly influenced on the number of leavf of broccoli plants at 20, 40 and 60 DAT which showed Table 03 (Appendix: III). At 20 DAT, the maximum numbers of leaves (10.80) were found in $M_1$ that was statistically similar to that of $M_2$ while the minimum (4.38) were found in $M_0$. At 40 DAT the maximum numbers of leaves (12.23) were observed from $M_1$

that was statistically similar to that of $M_2$ while the minimum (6.16) were found in $M_0$. At 60 DAT, the maximum numbers of leaves (12.33) were observed from $M_1$ which was statistically similar to that of $M_2$ while the minimum (7.75) were found in $M_0$. The number of leaves per plant increased with the increase in water hyacinth mulching application. Similar result was obtained by other investigators such as Roy *et al*. (1990) and Hossain (1999). This might be due to mulching increased crop growth rate (CGR), net assimilation rate (NAR), leaf area index (LAI) and relative growth rate (RGR).

**Table 03. Effect of different levels of mulch materials on leave number of broccoli**

| Treatment | leaf Number | | |
|---|---|---|---|
| | 20 DAT | 40 DAT | 60 DAT |
| $M_0$ | 4.38 d | 6.16 cd | 7.75 c |
| $M_1$ | 10.80 a | 12.23 a | 12.33 a |
| $M_2$ | 7.54 b | 9.96 b | 10.47 b |
| $M_3$ | 6.51 c | 8.31 c | 8.97 bc |
| LSD (0.01) | 0.94 | 1.55 | 1.46 |
| CV% | 8.56 | 5.69 | 6.31 |

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.01 level of probability
$M_0$ = Control (No mulch material), $M_1$ = Black polythene, $M_2$ = Water hyacinth, $M_3$ = Dry Ash

The leave number per plant was significantly influenced by the combined effect of organic and inorganic manure combination along with mulching at 20, 40 and 60 DAT (Appendix: III). At 20 DAT, the maximum leave number (12.47) was showed from the combination of $N_3M_1$ combined treatment and the minimum number of leave (3.00) was recorded from $N_0M_0$ combined treatment. At 40 DAT, the maximum leave number (14.12) was found from $N_3M_1$ combined treatment and the minimum number of leave (3.98) was found from $N_0M_0$ combined treatment. At 60 DAT, the maximum leave number (17.13) was found

from $N_3M_1$ combined treatment and the minimum number of leave (4.63) was recorded from $N_0M_0$ combined treatment. Thompson and Kelly (1988) study that the rate of release of plant nutrient from manure depends on the soil temperature, higher is the temperature faster is the release of nitrogen from soil provided with the manure. In the present study black polythene mulch maintained higher and more uniform temperature in the soil than unmulched soil which ultimately helped in releasing nutrients rapidly. From the results, it is obvious that organic manure and mulching are helpful for increasing leave number per plant of broccoli. Similar result was coincided with those reported by Abou *et al.* (2006).

**Table 04. The combined effect of different levels nutrients and mulch materials on leave number of broccoli**

| Treatment | Leaf Number | | |
|---|---|---|---|
| | 20 DAT | 40 DAT | 60 DAT |
| $N_0M_0$ | 3.00 j | 3.98 lm | 4.63 j |
| $N_0M_1$ | 4.87 hi | 5.98 i | 6.85 h |
| $N_0M_2$ | 3.97 i | 4.47 l | 5.81 i |
| $N_0M_3$ | 3.79 ij | 4.67 k | 5.63 ij |
| $N_1M_0$ | 4.69 hij | 5.69 j | 6.78 h |
| $N_1M_1$ | 6.03 g | 8.27 g | 10.24 f |
| $N_1M_2$ | 5.78 gh | 7.18 gh | 8.27 g |
| $N_1M_3$ | 4.89 h | 6.99 hi | 7.40 gh |
| $N_2M_0$ | 8.28 f | 9.84 f | 10.97 f |
| $N_2M_1$ | 11.83 b | 12.03 bc | 16.25 ab |
| $N_2M_2$ | 10.89 cd | 11.47 c | 15.93 b |
| $N_2M_3$ | 10.47 de | 10.48 e | 14.89 c |
| $N_3M_0$ | 9.93 e | 10.28 ef | 11.59 e |
| $N_3M_1$ | 12.47 a | 14.12 a | 17.13 a |
| $N_3M_2$ | 11.45 bc | 12.57 b | 15.58 bc |
| $N_3M_3$ | 10.96 c | 11.12 cd | 14.13 c |
| LSD (0.01) | 0.7437 | 1.42 | 1.38 |
| CV% | 8.56 | 5.69 | 6.31 |

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.01 level of probability

$N_0$=Control, $N_1$=Organic Manure (Cowdung 4t/ha+Vermicompost 3t/ha+ MOC 1.5t/ha), $N_2$=Inorganic Fertilizer ($N_{120}P_{100}K_{140}S_{20}B_{1.5}$ kg/ha), $N_3$= Organic+ Inorganic Fertilizer (1/2+1/2), $M_0$ = Control (No mulch material), $M_1$ = Black polythene, $M_2$ = Water hyacinth, $M_3$ = Dry Ash

### 4.1.3 Leaf length

Organic manure and inorganic fertilizer had a significant influence on the length of leaves of broccoli plants at 20, 40 and 60 DAT (Appendix: IV). At 20 DAT, leaf length ranged from 18.36 cm to 42.91 cm. Organic manure and inorganic fertilizer ($N_3$) produced the longest leaf (42.91 cm), while the lowest (18.03 cm) was found in control plots ($N_0$). At 40 DAT, leaf length ranged from 26.59 cm to 42.88 cm. The largest leaf (42.88 cm) was recorded from $N_3$, while the smallest leaf (26.59 cm) was recorded from $N_0$. At 60 DAT, leaf length ranged from 31.07 cm to 45.35 cm. The longest leaf (45.35 cm) was recorded from $N_3$, while the smallest (31.07 cm) was recorded from $N_0$. Organic manures have slow release nutrients all over the growth season. Consequently highest leaf length was found by organic manure and inorganic fertilizer. Similar result was obtained by other investigator such as Abou *et al.* (2006).

**Table 05. Effect of different levels of nutrients on leave length of broccoli**

| Treatment | leaf length(cm) | | |
|---|---|---|---|
| | 20 DAT | 40 DAT | 60 DAT |
| $N_0$ | 18.36 d | 26.59 d | 31.07 b |
| $N_1$ | 22.99 c | 32.41 c | 33.31 b |
| $N_2$ | 35.65 b | 40.88 b | 43.87 a |
| $N_3$ | 42.91 a | 42.88 a | 45.35 a |
| LSD (0.01) | 2.661 | 1.993 | 3.248 |
| CV% | 3.87 | 2.43 | 3.70 |

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.01 level of probability

$N_0$=Control, $N_1$=Organic Manure (Cowdung 4t/ha+Vermicompost 3t/ha+ MOC 1.5t/ha), $N_2$=Inorganic Fertilizer ($N_{120}P_{100}K_{140}S_{20}B_{1.5}$ kg/ha), $N_3$= Organic+ Inorganic Fertilizer (1/2+1/2).

The leave length of broccoli plant was significantly influenced by application of mulch material at 20, 40 and 60 DAT (Appendix: IV). At 20 DAT, the height leave length (34.37 cm) were found from black polythene ($M_1$) that was statistically similar to that of water hyacinth ($M_2$) while the minimum (27.83 cm) were found in $M_0$. Black polythene and Water hyacinth mulching showed more

or less similar result in number of leaves length per plant of broccoli. At 40 DAT, the highest leaves length (36.76 cm) were observed from $M_1$ that was statistically similar to that of $M_2$ while the minimum (30.89 cm) were found in $M_0$. At 60 DAT, the highest leaves length (39.64 cm) were observed from $M_1$ treatment which was statistically similar to that of $M_2$ treatment while the minimum (32.92 cm) were found in $M_0$ treatment. Similar result was obtained by other investigators such as Roy *et al.* (1990).This might be due to mulch material increased crop growth rate (CGR), net assimilation rate (NAR), leaf area index (LAI) and relative growth rate (RGR). This might be due to mulching has profound influence on plant growth viz., leaf area index (LAI), net assimilation rate (NAR), crop growth rate (CGR), relative growth rate (RGR), also influence on soil temperature and moisture. Miedema (1982); Awal and Khan (1999) found the same results in their investigations.

**Table 06. Effect of different levels of mulch materials on leaf length of broccoli**

| Treatment | leaf length (cm) | | |
|---|---|---|---|
| | 20 DAT | 40 DAT | 60 DAT |
| $M_0$ | 27.83 c | 30.89 d | 32.92 c |
| $M_1$ | 34.37 a | 36.76 a | 39.64 a |
| $M_2$ | 31.01 b | 33.54 b | 36.37 b |
| $M_3$ | 30.36 bc | 31.56 c | 34.95 bc |
| LSD (0.01) | 2.78 | 1.83 | 1.34 |
| CV% | 3.87 | 2.43 | 3.70 |

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.01 level of probability

$M_0$ = Control (No mulch material), $M_1$ = Black polythene, $M_2$ = Water hyacinth, $M_3$ = Dry Ash

The treatment combination of organic and inorganic fertilizer and mulching significantly influenced the length of leaves at 20, 40 and 60 DAT (Appendix: IV). At 20 DAT, leaf length ranged from 16.30 cm to 46.28 cm. The largest leaf

(46.28 cm) was observed in treatment combination of $N_3M_2$, while the smallest (16.30 cm) was recorded from $N_0M_0$ treatment. At 40 DAT, leaf length ranged from 45.03 cm to 24.53 cm. The largest leaf length (45.03 cm) was observed in $N_3M_2$ treatment combination, while the smallest (24.53 cm) was recorded from $N_0M_0$ treatment. At 60 DAT, leaf length ranged from 27.81 cm to 47.13 cm.

**Table 07. The combined effect of different levels nutrients and mulch materials on leave length of broccoli**

| Treatment | Leave Length (cm) | | |
|---|---|---|---|
| | 20 DAT | 40 DAT | 60 DAT |
| $N_0M_0$ | 16.30lm | 24.53k | 27.81i |
| $N_0M_1$ | 23.96hi | 29.47i | 33.02f |
| $N_0M_2$ | 19.22k | 27.37j | 32.52fg |
| $N_0M_3$ | 18.65kl | 26.17jk | 30.92h |
| $N_1M_0$ | 20.34j | 30.37h | 31.59g |
| $N_1M_1$ | 26.06g | 38.79e | 35.79e |
| $N_1M_2$ | 24.77h | 34.18f | 34.80ef |
| $N_1M_3$ | 22.80ij | 32.77g | 32.17fg |
| $N_2M_0$ | 33.35fg | 31.47h | 39.38de |
| $N_2M_1$ | 40.22cd | 42.13cd | 45.74b |
| $N_2M_2$ | 35.55e | 41.67d | 44.39c |
| $N_2M_3$ | 34.52ef | 40.93d | 42.11c-e |
| $N_3M_0$ | 39.19d | 37.85e | 40.82d |
| $N_3M_1$ | 46.28a | 45.03a | 47.13a |
| $N_3M_2$ | 43.86b | 43.36b | 46.54ab |
| $N_3M_3$ | 41.30c | 42.28c | 43.62cd |
| LSD (0.01) | 1.331 | 0.94 | 1.52 |
| CV% | 3.87 | 2.43 | 3.70 |

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.01 level of probability

$N_0$=Control, $N_1$=Organic Manure (Cowdung 4t/ha+Vermicompost 3t/ha+ MOC 1.5t/ha), $N_2$=Inorganic Fertilizer ($N_{120}P_{100}K_{140}S_{20}B_{1.5}$ kg/ha), $N_3$= Organic+ Inorganic Fertilizer (1/2+1/2), $M_0$ = Control (No mulch material), $M_1$ = Black polythene, $M_2$ = Water hyacinth, $M_3$ = Dry Ash

The largest leaf length (47.13 cm) was observed in $N_3M_2$ treatment combination, while the smallest (27.81 cm) was recorded from $N_0M_0$ treatment combination. These result indicate that organic and inorganic fertilizer combinedly used which as applied balanced nutrient for plant growth. The black polythene mulched

maintain higher soil moisture content than unmulched soil which ultimately produced longer leaves.

### 4.1.4 Leaf breadth

Statistically significant differences was observed in leaf breath of broccoli plant as affected by organic and inorganic fertilizer at 20, 40 and 60 DAT (Appendix: V). At 20 DAT, leaf breath ranged from 8.17 cm to 17.55 cm. At 20 DAT, Organic manure and inorganic fertilizer ($N_3$) produced the maximum leaf breath (17.55 cm), while the minimum (8.17 cm) was found in control plots ($N_0$). At 40 DAT, leaf breath ranged from 10.73 cm to 20.42 cm. The highest leaf breath (20.42 cm) was recorded from $N_3$ treatment, while the smallest leaf breath (10.73 cm) was recorded from $N_0$ treatment. At 60 DAT, leaf breath ranged from 10.56 cm to 22.78 cm. The maximum leaf breath (22.78 cm) was recorded from $N_3$ treatment which is statistically similar to $N_2$ treatment, while the smallest (10.56 cm) was recorded from $N_0$ treatment. Organic manures have slow release nutrients all over the growth season. Consequently highest leaf length was found by organic manure and inorganic fertilizer. Similar result was obtained by other investigator such as Abou *et al*. (2006).

**Table 08. The effect of nutrients on leave breath of broccoli**

| Treatment | leaf breath(cm) | | |
|---|---|---|---|
| | 20 DAT | 40 DAT | 60 DAT |
| $N_0$ | 8.17 d | 10.73 cd | 10.56 bc |
| $N_1$ | 9.67 c | 11.75 c | 13.94 b |
| $N_2$ | 11.76 b | 17.08 b | 20.46 ab |
| $N_3$ | 17.55 a | 20.42 a | 22.78 a |
| LSD (0.01) | 1.42 | 1.31 | 2.81 |
| CV% | 6.03 | 3.88 | 7.33 |

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.01 level of probability

$N_0$=Control, $N_1$=Organic Manure (Cowdung 4t/ha+Vermicompost 3t/ha+ MOC 1.5t/ha), $N_2$=Inorganic Fertilizer ($N_{120}P_{100}K_{140}S_{20}B_{1.5}$ kg/ha), $N_3$= Organic+ Inorganic Fertilizer (1/2+1/2)

There was a significant variation in the leave breath of broccoli plant influenced by application of mulching at 20, 40 and 60 DAT (Appendix: V). At 20 DAT, the height leave breath (12.58 cm) were found in black polythene ($M_1$) that was statistically similar to that of water hyacinth ($M_2$) while the minimum (10.79 cm) were found in $M_0$ treatment. Black polythene and Water hyacinth mulching showed more or less similar result in number of leaves breath per plant of broccoli. At 40 DAT, the highest leaves breath (15.11 cm) were observed from $M_1$ treatment that was statistically similar to that of $M_2$ treatment while the minimum (11.14 cm) were found in $M_0$ treatment. At 60 DAT, the highest leaves breath (17.55 cm) were observed from $M_1$ treatment which was statistically similar to that of $M_2$ treatment while the minimum (12.75 cm) were found in $M_0$ treatment.

**Table 09. The effect of different levels of mulch materials on leaf breath of broccoli**

| Mulching | leaf breath(cm) | | |
|---|---|---|---|
| | 20 DAT | 40 DAT | 60 DAT |
| M0 | 10.79 **c** | 11.14 c | 12.75 d |
| M1 | 12.58 a | 15.11 a | 17.55 a |
| M2 | 11.86 ab | 13.67 b | 15.87 b |
| M3 | 11.19 b | 12.34 bc | 13.79 c |
| LSD (0.01) | 1.61 | 1.31 | 1.57 |
| CV% | 6.03 | 3.88 | 7.33 |

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.01 level of probability.
$M_0$ = Control (No mulch material), $M_1$ = Black polythene, $M_2$ = Water hyacinth, $M_3$ = Dry Ash

The leaf breadth was significantly influenced by the combined effect of organic manure and inorganic fertilizer along with mulching at 20, 40 and 60 DAT (Appendix: V). At 20 DAT, the highest leaf breadth (19.56 cm) was recorded from $N_3M_1$ treatment combination which was statistically similar to that of $N_3M_2$ treatment combination while the lowest (7.61 cm) was recorded from $N_0M_0$ treatment combination. At 40 DAT, the highest leaf breadth (21.44 cm) was measured from $N_3M_1$ treatment combination which was statistically similar to that of $N_3M_2$ treatment combination while the lowest (8.90 cm) was recorded from $N_0M_0$ treatment combination. At 60 DAT, the highest leaf breadth (24.31 cm) was measured from $N_3M_1$ treatment combination which was statistically similar to that of $N_3M_2$ while the lowest (9.99 cm) was recorded from $N_0M_0$ treatment combination.

**Table 10. The combined effect of different levels of nutrients and mulch materials on leaf breath of broccoli**

| Treatment | Leaf Breath (cm) | | |
|---|---|---|---|
| | 20 DAT | 40 DAT | 60 DAT |
| $N_0M_0$ | 7.61 j | 8.90 i | 9.99 j |
| $N_0M_1$ | 8.66 hi | 10.85 gh | 11.59 gh |
| $N_0M_2$ | 8.21 ij | 9.99 hi | 10.60 hi |
| $N_0M_3$ | 7.94 ij | 9.94 hij | 10.05 ij |
| $N_1M_0$ | 9.47 gh | 9.98 h | 11.91 gh |
| $N_1M_1$ | 10.69 f | 16.25 ef | 15.25 e |
| $N_1M_2$ | 9.16 gh | 11.52 fg | 13.43 f |
| $N_1M_3$ | 7.86 ij | 10.97 g | 12.57 fg |
| $N_2M_0$ | 9.77 g | 12.61 f | 19.20 d |
| $N_2M_1$ | 15.05 c | 19.42 c | 22.11 b |
| $N_2M_2$ | 13.76 d | 18.17 d | 21.40 bc |
| $N_2M_3$ | 12.62 e | 16.93 e | 20.86 bc |
| $N_3M_0$ | 11.77 e | 16.67 ef | 20.39 cd |
| $N_3M_1$ | 19.56 a | 21.44 a | 24.31 a |
| $N_3M_2$ | 17.53 b | 20.53 b | 22.16 b |
| $N_3M_3$ | 15.87 c | 20.24 bc | 21.92 bc |
| LSD (0.01) | 0.81 | 0.65 | 1.45 |
| CV% | 6.03 | 3.88 | 7.33 |

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.01 level of probability

$N_0$=No nutrietion, $N_1$=Organic Manure (Cowdung 4t/ha+Vermicompost 3t/ha+ MOC 1.5t/ha), $N_2$=Inorganic Fertilizer ($N_{120}P_{100}K_{140}S_{20}B_{1.5}$ kg/ha), $N_3$= Organic+ Inorganic Fertilizer (1/2+1/2), $M_0$ = Control (No mulch material), $M_1$ = Black polythene, $M_2$ = Water hyacinth, $M_3$ = Dry Ash

## 4.2 Yield parameter

### 4.2.1 Days to require for curd initiation

Days to curd initiation of broccoli showed significant difference due to application of nutrients (Table 11, Appendix: VI). It was ranged from 52.43 to 56.38 days. The lowest (52.43 days) days were required curd initiation by the application of organic manure and inorganic fertilizer ($N_3$) and the highest (56.38 days) days were required in control treatment ($N_0$). The result indicated organic and inorganic fertilizer plays role for vegetative growth and forced the plants to reach reproductive stages earlier. Effect of organic manure (Vermicompost) due to the fact high content of phosphorus is mainly responsible for improving the

quality and quantity of produce by way of increasing metabolic activities in the plant system. Mitra *et al.* (2013) reported that application of phosphorus has tended the crop to reach reproductive stage, which was agreed with the present finding.

The different level of mulch materials also show the significantly influenced on the number of days required for curd imitation (Table 12, Appendix VI). It was ranged from 52.33 to 56.67 days. The lowest (52.33 days) days were required for curd initiation performed by polythene mulching ($M_1$) and the highest (56.67 days) days were required by control ($M_0$) treatment.

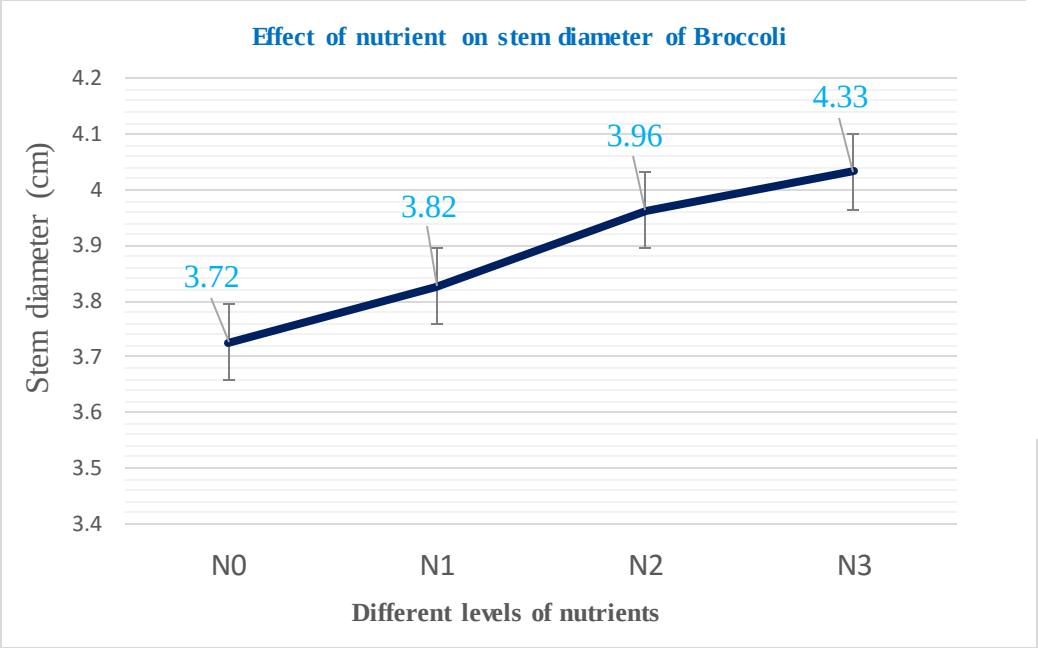
There was combined effect of organic and inorganic fertilizer along with different mulch materials should statistically significant variation on days to curd initiation of broccoli plant (Table 13, Appendix VI). The maximum days (58.50 days) were required in the treatment combination of $N_3M_1$, while the minimum (55.00 days) days required for curd initiation in the combination of $N_0M_0$ treatment. From the present study it was observed that the curd initiation period required in plants decreased with the combinedly application organic and inorganic fertilizer along with mulch materials while the period was maximum when manure and fertilizer were not applied. This might be fact that balanced absorption of plant nutrients is importance physiological activities, which results the endogenous growth hormone synthesis for early curd initiation in plants.

### 4.2.2 Stem diameter of broccoli

Stem diameter of broccoli significant influence of different level of organic and inorganic fertilizer application (Appendix: VI). The maximum stem diameter

(4.33 cm) was recorded from $N_3$ treatment and the minimum (3.72 cm) from $N_0$ treatment. The present study show that the application of organic manure and inorganic fertilizer combinedly held to increase the stem diameter of broccoli plant.

**Fig. 5. Effect of different levels of nutrients on stem diameter of broccoli**




$N_0$=No nutrietion,

$N_1$=Organic Manure (Cowdung 4t/ha+Vermicompost 3t/ha+ MOC 1.5t/ha),

$N_2$=Inorganic Fertilizer ($N_{120}P_{100}K_{140}S_{20}B_{1.5}$ kg/ha),

$N_3$=Organic+Inorganic Fertilizer (1/2+1/2)

Different level of mulching had a significant influence on stem diameter of broccoli plants (figure 5, Appendix VI). The maximum stem diameter (4.05cm) was recorded from black polythene ($M_1$) and statistically similar water hyacinth ($M_2$), while the minimum stem diameter was recorded (3.34cm) was observed from $M_0$ treatment.

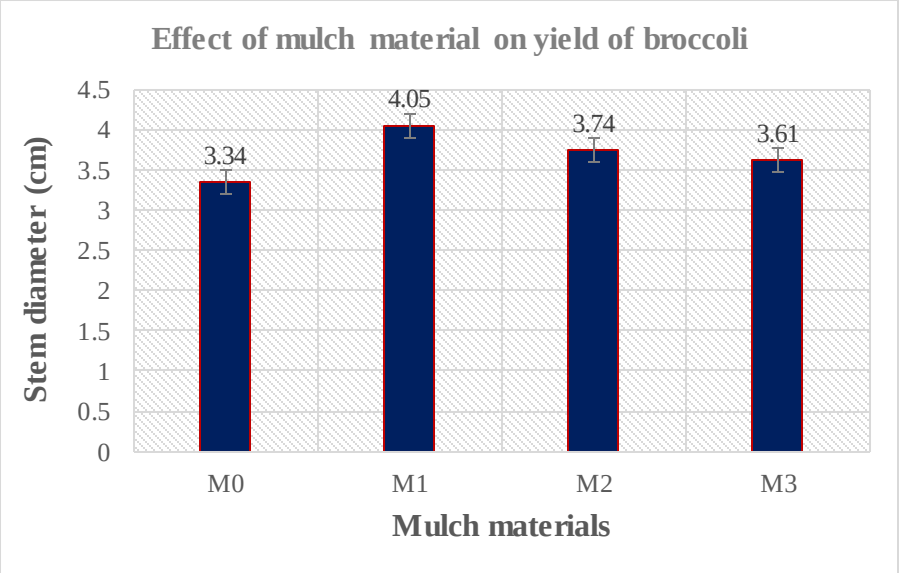



**Fig. 6. Effect of different levels of mulching on stem diameter of broccoli**

Stem diameter of broccoli plant was significantly influenced by the treatment combinations of organic manure and inorganic fertilizer with mulching of broccoli (Figure 6, Appendix VI). The maximum stem diameter (4.67 cm) was observed in the treatment combination of $N_3M_2$ which is statistically similar with $N_3M_1$, while the smallest (3.60 cm) was recorded from the combination of $N_0M_0$.

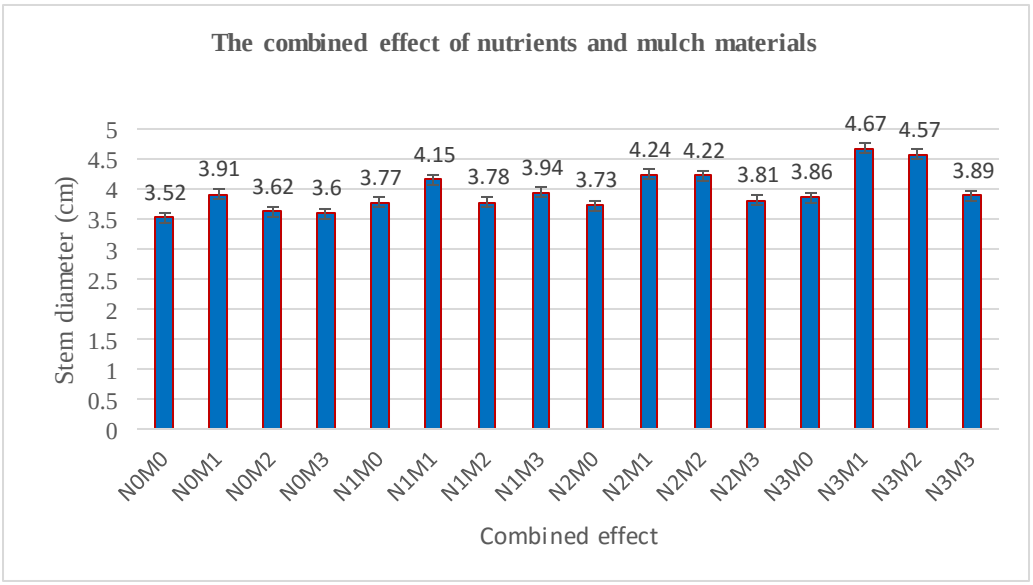



**Fig. 7. The combined effect of different nutrients and mulch materials on stem diameter of broccoli**

### 4.2.3 Primary curd diameter

Application of organic manure and inorganic fertilizer showed a significant influence on main curd diameter of broccoli plants (Table 11, Appendix VI). The maximum curd diameter (20.12 cm) was recorded from organic manure and inorganic fertilizer ($N_3$), while the minimum curd diameter (12.14 cm) was observed in control treatment ($N_0$). Formation of higher diameter at the application of combinedly organic and inorganic fertilizer probably due to the availability of more nutrients and absorption by the plants the other hand, in control plants formation small curd due to lack of availability of plant nutrients Steffen *et al*. (1994) also reported that broccoli yield and curd diameter in the combined treatment. The curd diameter increased for the application of organic manure (vermicompost) and inorganic (Phosphorus) due to the fact high content of phosphorus. Phosphorus plays role of energy storage, cell division and cell enlargement. Sharma *et al*. (2002) and Singh (2004) were found same result.

**Table 11. Effect of different levels of nutrients on yield and yield attributes of broccoli**

| Treatment | Days required for curd initiation | Curd Diameter (cm) | Stem Diameter (cm) | Main Curd weight (gm) | Curd dry weight per (100g) (gm) | Leave dry weight (100g) (gm) |
|---|---|---|---|---|---|---|
| $N_0$ | 56.00 ab | 12.14 d | 3.72 | 213.17 d | 12.64 d | 7.75 d |
| $N_1$ | 56.38 a | 13.75 c | 3.82 | 284.67 c | 17.52 c | 9.59 c |
| $N_2$ | 55.63 b | 18.20 b | 3.96 | 379.25 b | 21.88 b | 13.85 b |
| $N_3$ | 52.43 c | 20.12 a | 4.33 | 447.82 a | 23.88 a | 16.49 a |
| LSD(0.01) | 0.68 | 0.37 | NS | 7.74 | 1.12 | 1.24 |
| CV% | 1.99 | 1.03 | 10.54 | 0.64 | 2.55 | 4.75 |

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.01 level of probability.
$N_0$=No nutrient, $N_1$=Organic Manure (Cowdung 4t/ha+Vermicompost 3t/ha+ MOC 1.5t/ha), $N_2$=Inorganic Fertilizer ($N_{120}P_{100}K_{140}S_{20}B_{1.5}$ kg/ha), $N_3$= Organic+ Inorganic Fertilizer (1/2+1/2).

The variation due to different mulch materials under study was significant in respect of curd diameter showed (Table 12, Appendix VI). The maximum curd diameter (16.77 cm) was recorded from $M_1$ treatment while the minimum curd diameter (12.54 cm) was observed in $M_0$ treatment. This result was revealed that the curd diameter differ with the different mulch materials. It was observed that the applied of black polythene mulch level. The curd diameter of broccoli and follower by water hyacinth ash mulch. This effected may be attributed to the presence of sufficient amount of soil moisture present under black polythene mulch which subsequently has contributed in the formation of larger and comparietincely broader curd of broccoli.

The combined effect of nutrients and mulch materials had significant influence on the primary curd diameter of broccoli (Table 13, Appendix VI). The maximum curd diameter (20.65 cm) was observed in the treatment combination of $N_3M_1$, while the minimum curd diameter (10.95 cm) was recorded from the combination of $N_0M_0$. Main curd diameter is important for curd yield.

### 4.2.4 Weight of primary curd

Different source plant nutrients that organic manure and inorganic fertilizer should exhibited a significant influence on primary curd weight of broccoli (Table 11, Appendix VI). The maximum primary curd weight (447.82 g) was recorded from $N_3$ treatment while the minimum primary curd weight 213.17 g was observed in control treatment ($N_0$). It was probably due to the fact that the combination of nutrients provided good soil conditions for plant growth as well as supplied sufficient plant nutrients while inorganic fertilizer supplied rapidly

available of macro and micro nutrients that helped the production of large size of curd with maximum weight. Similar trend of the result was found by other scientists like Balyan *et al.* (1988) and Singh (2004).

Different levels of mulching had a significant influence on primary curd weight of broccoli plants (Table 12, Appendix VI). The maximum primary curd weight (417.32 g) was recorded from black polythene ($M_1$) which statistically similar water hyacinth ($M_2$) while the minimum primary curd weight (221.43 g) was observed from $M_0$ treatment. The results of the present study is supported by the finding of Rahman *et al.* (1989)

**Table 12. Effect of different levels of mulch material on yield and yield attributes of broccoli**

$M_0$ = Control (No mulch material), $M_1$ = Black polythene, $M_2$ = Water hyacinth, $M_3$ = Dry Ash
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

| Treatment | Days required for curd initiation | Curd Diameter (cm) | Stem Diameter (cm) | Primary Curd weight (gm) | Curd dry weight(100g) (gm) | Leave dry weight (100g) (gm) |
|---|---|---|---|---|---|---|
| $M_0$ | 56.67 a | 12.54 d | 3.34 | 221.43 d | 17.33 c | 9.56 d |
| $M_1$ | 52.33 c | 16.77 a | 4.05 | 417.32 a | 19.76 a | 12.58 a |
| $M_2$ | 55.17 bc | 15.88 b | 3.74 | 387.29 b | 19.24 ab | 11.48 b |
| $M_3$ | 55.83 b | 14.12 c | 3.61 | 337.51 c | 18.64 b | 10.33 c |
| LSD (0.01) | 0.78 | 0.74 | NS | 7.74 | 0.94 | 1.27 |
| CV% | 1.99 | 1.03 | 10.54 | 0.64 | 2.55 | 4.75 |

The combined effect of organic manure and inorganic fertilizer with mulch material had significant influence on the primary curd weight of broccoli (Table 13, Appendix VI). The maximum primary curd weight (467.58 g) was observed in the treatment combination of $N_3M_1$ which statistically similar $N_2M_1$ treatment while the smallest (209.31 g) was recorded from the combination of $N_0M_0$

treatment. Main curd weight of broccoli plant is important for increasing total production.

**Table 13. The combined effect of different levels of nutrients and mulch materials on yield and yield attributes of broccoli**

| Treatment | Days required for curd initiation | Curd Diameter (cm) | Stem Diameter (cm) | Primary Curd weight (g) | Curd dry weight per (100g) | Leave dry weight (100g) |
|---|---|---|---|---|---|---|
| $N_0M_0$ | 58.50 | 10.95 m | 3.52 | 209.31 jk | 11.98 l | 6.87 k |
| $N_0M_1$ | 55.00 | 13.03 ij | 3.91 | 297.89 i | 13.15 j | 8.37 i |
| $N_0M_2$ | 56.50 | 12.40 j | 3.62 | 291.34 ij | 12.88 k | 7.78 j |
| $N_0M_3$ | 56.25 | 11.20 lm | 3.57 | 229.67 j | 12.55 jk | 7.71 jk |
| $N_1M_0$ | 57.00 | 11.32 l | 3.77 | 307.54 g | 16.21 i | 8.17 ij |
| $N_1M_1$ | 55.00 | 15.38 h | 4.15 | 387.16 ef | 18.87 g | 10.95 gh |
| $N_1M_2$ | 55.25 | 13.92 i | 3.94 | 364.19 fg | 17.96 h | 9.94 h |
| $N_1M_3$ | 56.00 | 12.38 jk | 3.78 | 321.69 gh | 17.06 hi | 9.37 hi |
| $N_2M_0$ | 56.00 | 16.83 g | 3.73 | 328.62 g | 20.87 f | 11.77 g |
| $N_2M_1$ | 55.75 | 19.66 cd | 4.24 | 438.34 bc | 23.69 b | 14.18 de |
| $N_2M_2$ | 55.85 | 18.45 de | 4.22 | 413.21 d | 22.35 de | 13.97 e |
| $N_2M_3$ | 55.75 | 17.86 f | 3.81 | 398.87 e | 21.50 e | 12.40 f |
| $N_3M_0$ | 56.00 | 18.90 d | 3.86 | 379.28 f | 20.80 fg | 14.72 d |
| $N_3M_1$ | 55.27 | 20.65 a | 4.67 | 467.58 a | 24.21 a | 17.26 a |
| $N_3M_2$ | 55.87 | 20.27 b | 4.57 | 443.87 b | 23.03 bc | 16.47 b |
| $N_3M_3$ | 55.15 | 19.90 c | 3.89 | 426.51 c | 22.61 d | 15.17 c |
| LSD (0.01) | NS | 0.1888 | NS | 3.87 | 0.55 | 0.63 |
| CV% | 1.99 | 1.03% | 10.54 | 0.64 | 2.55 | 4.75 |

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.01 level of probability

$N_0$=No nutrient, $N_1$=Organic Manure (Cowdung 4t/ha+Vermicompost 3t/ha+ MOC 1.5t/ha), $N_2$=Inorganic Fertilizer ($N_{120}P_{100}K_{140}S_{20}B_{1.5}$ kg/ha), $N_3$= Organic+ Inorganic Fertilizer (1/2+1/2), $M_0$ = Control (No mulch material), $M_1$ = Black polythene, $M_2$ = Water hyacinth, $M_3$ = Dry Ash

### 4.2.5 Number of secondary curd per plant

The secondary curds were those, which develop after harvest of the main curd. Number of secondary curd of broccoli plant is important for increasing total production. Application of organic manure and inorganic fertilizer exhibited a significant influence on number of secondary curd of broccoli plants (Table 14,

Appendix VII). The maximum numbers of secondary curds (1.83) were recorded from the application of organic and inorganic fertilizer ($N_3$) treatment, while the Minimum (1.00) were observed in control treatment ($N_0$). This might be caused of photosynthesis, cell division and cell enlargement. In organic manure (vermicompost) has higher content phosphorus and inorganic application of phosphorus help to increase the yield. Similar effect has been reported by Sharma *et al.* (2002).

**Table 14.Effect of different levels nutrients on yield and yield attributes of broccoli**

| Nutrients treatment | Secondary Number of Curd/Plant | Secondary Curd Weight (g) | Yield/Plant (g) | Yield/Plot (kg) | Yield/ hectare (ton) |
|---|---|---|---|---|---|
| $N_0$ | 1.00 | 68.95 d | 282.70 d | 3.385 d | 7.53 d |
| $N_1$ | 1.24 | 78.26 c | 381.75 c | 4.580 c | 9.54 c |
| $N_2$ | 1.33 | 84.21 b | 491.12 b | 5.894 b | 12.28 b |
| $N_3$ | 1.83 | 88.67 a | 610.80 a | 7.321 a | 15.25 a |
| LSD (0.01) | NS | 4.31 | 0.11 | 1.27 | 2.63 |
| CV% | 13.38 | 13.67 | 2.65 | 7.45 | 5.74 |

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.01 level of probability

$N_0$=Control, $N_1$=Organic Manure (Cowdung 4t/ha+Vermicompost 3t/ha+ MOC 1.5t/ha), $N_2$=Inorganic Fertilizer ($N_{120}P_{100}K_{140}S_{20}B_{1.5}$ kg/ha), $N_3$= Organic+ Inorganic Fertilizer (1/2+1/2),

Different level of mulch materials exhibited a nonsignificantly influence on number of secondary curds of broccoli plants (Table 15, Appendix VII). The maximum numbers of secondary curds (2.21) were recorded from black polythene mulching ($M_1$), while the minimum number of secondary curds (1.22) was observed in $M_0$.

Number of secondary curds was nonsignificantly influenced by the treatment combinations of organic & inorganic manure with mulching (Table 15, Appendix VII). The maximum number of secondary curds (2.21) was observed

in the treatment combination of $N_3M_1$, while the minimum (1.24) were recorded from the combination of $N_0M_0$ treatment.

**Table 15.Effect of different levels mulch materials on yield and yield attributes of broccoli**

| Treatment | Secondary Number of Curd/Plant | Secondary Curd Weight (g) | Yield/Plant (g) | Yield/Plot (kg) | Yield/ hectare (ton) |
|---|---|---|---|---|---|
| $M_0$ | 1.22 | 74.92 d | 318.30 c | 3.818 d | 7.95 d |
| $M_1$ | 2.21 | 98.23 a | 634.28 a | 7.612 a | 15.86 a |
| $M_2$ | 1.23 | 81.37 b | 487.35 b | 5.848 b | 12.18 b |
| $M_3$ | 1.18 | 79.31 c | 425.28 bc | 5.110 c | 10.64 c |
| LSD (0.01) | NS | 1.95 | 0.17 | 0.67 | 0.24 |
| CV% | 13.38 | 13.67 | 1.87 | 7.45 | 1.58% |

$M_0$ = Control (No mulch material), $M_1$ = Black polythene, $M_2$ = Water hyacinth, $M_3$ = Dry Ash
In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.01 level of probability

### 4.2.6 Secondary curd weight

Secondary curd weight of broccoli plant is important for increasing total yield. Organic and inorganic manure had a significant influence on secondary curd weight of broccoli plants (Table 14, Appendix VII). The maximum secondary curd weight (88.67 g) was recorded from $N_3$ treatment which is statistically similar to $N_2$ treatment and the minimum (68.85 g) was observed in $N_0$ treatment. This might be caused of photosynthesis, cell division and cell enlargement. Similar effects of have been reported by Sharma *et al.* (2002).

Different mulch materials showed exhibited a significant influence on secondary curd weight of broccoli plants (Table 15, Appendix VII). The maximum

secondary curd weight (98.23 g) was recorded from black polythene ($M_1$) treatment while the minimum (74.92 g) was observed in $M_0$ treatment.

Secondary curd weight was significantly influenced by the treatments combination of organic and inorganic manures with mulching (Table 16, Appendix VII). The maximum secondary curd weight (99.37g) was observed in $N_3M_1$ treatment and the minimum (76.23g) was recorded from $N_0M_0$ treatment.

### 4.2.7 Percent dry matter of curd (100 g)

Organic manure and inorganic fertilizer showed a significant influence on curd dry weight of broccoli plants (Table 11, Appendix VI). The maximum curd dry weight (23.88g) was recorded from $N_3$ treatment while the minimum main curd weight (12.64g) was observed in control treatment ($N_0$). Phosphorus was mainly responsible for improving the quality and quantity by the way of increasing metabolic activities. Such effect of phosphorus was due to the fact of use of phosphorus in broccoli plant. Similar trend of the result was found by other scientists like Balyan *et al.* (1988) and Singh (2004).

Different levels of mulch materials had a significant influence on curd dry weight of broccoli plants (Table 12, Appendix VI). The maximum percent dry matter of curd (19.76 g) was recorded from black polythene ($M_1$) which is statistically similar water hyacinth ($M_2$), while the minimum percent dry matter of curd (17.33 g) was observed from $M_0$ treatment.

Percent dry matter of curd was significantly influenced by the treatment combinations of organic manure and inorganic fertilizer with mulching of

broccoli (Table 13, Appendix VI). The maximum percent dry matter of curd (24.21 g) was observed in the treatment combination of $N_3M_1$ while the lowest curd dry weight (11.98 g) was recorded from the combination of $N_0M_0$ treatment. Primary curd weight of broccoli plant is important for increasing total production.

**Table 16. The combined effect of nutrients and mulch materials on yield and yield attributes of broccoli**

| The Combined Effect | Secondary Number of Curd/Plant | Secondary Curd Weight (g) | Yield/Plant (g) | Yield/Plot (kg) | Yield/ hectare (ton) |
|---|---|---|---|---|---|
| $N_0M_0$ | 1.24 | 76.23 l | 305.67 jk | 3.663 ij | 7.63 l |
| $N_0M_1$ | 2.00 | 91.31 d | 494.25 f | 5.936 f | 12.36 g |
| $N_0M_2$ | 1.33 | 82.34 i | 400.37 i | 4.810 hi | 10.02 j |
| $N_0M_3$ | 1.67 | 81.29 ij | 365.35 j | 4.385 i | 9.13 k |
| $N_1M_0$ | 1.27 | 86.29 g | 417.54 hi | 5.005 h | 10.42 ij |
| $N_1M_1$ | 1.62 | 92.13 c | 535.37 d-f | 6.420 c-e | 13.37 d-f |
| $N_1M_2$ | 1.20 | 90.15 e | 483.24 fg | 5.801 fg | 12.08 gh |
| $N_1M_3$ | 1.64 | 76.53 kl | 446.27 gh | 5.360 g | 11.16 hi |
| $N_2M_0$ | 1.13 | 76.74 k | 427.25 h | 5.128 gh | 10.68 i |
| $N_2M_1$ | 1.89 | 98.39 b | 608.63 b | 7.304 b | 15.21 b |
| $N_2M_2$ | 1.86 | 87.26 fg | 555.01 c | 6.660 c | 13.87 c |
| $N_2M_3$ | 1.67 | 83.87 hi | 538.27 d | 6.467 cd | 13.47 d |
| $N_3M_0$ | 1.09 | 77.23 jk | 463.28 g | 5.561 f-h | 11.58 h |
| $N_3M_1$ | 2.21 | 99.37 a | 671.25 a | 8.054 a | 16.77 a |
| $N_3M_2$ | 2.00 | 87.38 f | 618.39 ab | 7.420 ab | 15.45 ab |
| $N_3M_3$ | 1.13 | 84.17 h | 521.27 e | 6.259 e | 13.04 f |
| LSD (0.01) | NS | 0.94 | 0.25 | 0.47 | 0.14 |
| CV% | 1.99 | 13.38 | 1.17 | 2.61 | 1.58 |

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.01 level of probability.

$N_0$=Control**,** $N_1$=Organic Manure (Cowdung 4t/ha+Vermicompost 3t/ha+ MOC 1.5t/ha), $N_2$=Inorganic Fertilizer ($N_{120}P_{100}K_{140}S_{20}B_{1.5}$ kg/ha), $N_3$= Organic+ Inorganic Fertilizer (1/2+1/2), $M_0$ = Control (No mulch material), $M_1$ = Black polythene, $M_2$ = Water hyacinth, $M_3$ = Dry Ash

### 4.2.8 Percent dry matter of leaf

Organic manure and inorganic fertilizer showed a significant influence on leave dry weight of broccoli plants (Table 11, Appendix VI). The maximum leave dry weight (16.49 g) was recorded from $N_3$, while the minimum main leave dry weight (7.75 g) was observed in control treatment ($N_0$).

Different levels of mulching had a significant influence on leave dry weight of broccoli plants (Table 12, Appendix VI). The maximum leave dry weight (12.52 g) was recorded from black polythene ($M_1$) which was statistically similar water hyacinth ($M_2$) treatment, while the minimum main leave dry weight (9.56 g) was observed from $M_0$ treatment.

Leaf dry weight was significantly influenced by the treatment combinations of organic and inorganic manure with mulching of broccoli (Table 13, Appendix VI). The maximum leave dry weight (17.26 g) was observed in the treatment combination of $N_3M_1$ treatment while the lowest (6.87 g) was recorded from the combination of $N_0M_0$ treatment.

### 4.2.9 Yield per plant

Yield per plant is important for increasing yield. Application of organic and inorganic manure exhibited a significant influence on yield per plant (Table 14, Appendix VII). The maximum yield (491.70 g) was recorded from $N_3$ treatment while the minimum (282.80 g) was observed in $N_0$ treatment. It was possible that combination organic and inorganic fertilizer provided availability of plant nutrients, improved good soil condition, increase water holding capacity and

microbial activity and possibly as source of growth promoting substance that helped in the production of higher curd yield of broccoli.

The curd yield per plant was significantly influenced due to the uses of different mulches materials (Table 15, Appendix VII). The maximum yield (634.28 g) was recorded from black polythene ($M_1$) while the minimum (318.30 g) was observed in $M_0$ treatment.

Combined effect of different manures showed a significant effect on yield per plant (Table 16, Appendix VII). The maximum yield (671.25 g) was observed in the treatment combination of $N_3M_1$ which is statistically similar $N_3M_2$ combined treatment while the minimum (305.67 g) was recorded from $N_0M_0$ combined treatment.

### 4.2.10 Yield per plot

The yield per plot in sprouting broccoli consists of the main curd and the secondary curd those develop after the removal of the main one. Application of organic and inorganic manure exhibited a significant influence on yield per plot of broccoli plants (Table 14, Appendix VII). The maximum yield (7.12 kg) was recorded from $N_3$ treatment while the minimum (3.38 kg) was observed in $N_0$ treatment.

Different levels of mulching also exhibited a significant influence on yield per plot of broccoli plants (Table 15, Appendix VII). The maximum yield (7.61 kg) was recorded in $M_1$ treatment while the minimum (3.81 kg) was observed in $M_0$ treatment.

Yield per plot was significantly influenced by the treatment combinations of organic manure (Table 16, Appendix VII). The maximum yield per plot (8.05 kg) was observed in $N_3M_1$ treatment which was statistically similar $N_3M_2$ treatment while the minimum (3.66 kg) was recorded from $N_0M_0$ treatment

### 4.2.11 Yield per hectare

Application of organic and inorganic manure exhibited a significant influence on yield per hectare of broccoli plants (Table 14, Appendix VII). The maximum yield (15.25 t/ha) was recorded from $N_3$ treatment while the minimum yield (7.53 t/ha) was observed in $N_0$ treatment.

Mulch material also showed a significant influence on yield per hectare of broccoli plants (Table 15, Appendix VII). The maximum yield (15.86 t/ha) was recorded from $M_1$ treatment while the minimum yield (7.95 t/ha) was observed in $M_0$ treatment.

Yield per hectare was significantly influenced by the treatments combination of organic and inorganic manure with mulching (table 16, Appendix VII). Yield per hectare ranged from 7.63 t to 16.77 t. The maximum yield per hectare (16.77 t/ha) was observed in $N_3M_1$ treatment which was statistically showed similar with $N_3M_2$ while the minimum (7.63 t/ha) was recorded from $N_0M_0$ treatment. The increase in the total yield resulting by organic and inorganic manuring may be attributed to that organic manuring enhanced soil aggregation, soil aeration and increasing water holding capacity and offers good environmental conditions for the broccoli plants. Vermicompost and cowdung is rich in nutrients content.

This favorable condition creates better nutrients absorption and favors the growth and development of curd weight which in true reflects better vegetative growth photosynthetic activity. Consequently higher total yield would be obtained by organic manure with black polythene. Similar trend of results was found by Abou *et al*. (2006).

### 4.3 Economic analysis

Input costs for land preparation, inorganic fertilizer, organic manure and manpower required for all the operations from seed sowing to harvesting of broccoli were recorded as per plot and converted into cost/hectare. Price of broccoli was considered as per present market rate basis. The economic analysis presented under the following headings-

#### 4.3.1 Gross return

The combination of organic and inorganic manure with mulching showed different value in terms of gross return under the trial (Table 17). The highest gross return (BDT 503390.5/ha) was obtained from the treatment combination $N_3M_1$ and the second highest gross return (BDT 463792.5/ha) was found in $N_3M_2$ treatment. The lowest gross return (BDT 228955.2/ha) was obtained from $N_0M_0$ treatment.

#### 4.3.2 Net return

In case of net return, organic and inorganic fertilizer with mulching material of net return under the present trial (Table 17). The highest net return (BDT 296098.5/ha) was found from the treatment combination $N_3M_1$ treatment and the second highest net return (BDT 278567.6/ha) was obtained from the combination

$N_2M_1$ treatment. The lowest net return (BDT 95605.2/ha) was obtained from $N_0M_0$ treatment.

### 4.3.3 Benefit cost ratio

In the organic and inorganic fertilizer with mulching material of the hightest benefit cost ratio (2.46) was noted from the combination of $N_3M_1$ treatment and the second highest benefit cost ratio (2.38) was estimated from the combination of $N_3M_2$ treatment. The lowest benefit cost ratio (1.72) was obtained from $N_0M_0$ treatment (Table 17). From economic point of view, it is apparent from the above results that the combination of $N_3M_1$ treatment was better than rest of the combination in broccoli cultivation. The benefit cost ratio (BCR) was calculated as follows:

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

**Table 17. Cost and return of broccoli cultivation as influenced by nutrients and mulch materials**

| Treatments combinations | Yield (ton/ha | Gross return (BDT/ha | Total Cost of Production | Net return (BDT/ha) | Benefit cost ratio |
|---|---|---|---|---|---|
| $N_0M_0$ | 7.63 | 228955.2 | 133,113.49 | 95841.71 | 1.72 |
| $N_0M_1$ | 12.37 | 371002.5 | 166,368.83 | 204633.7 | 2.23 |
| $N_0M_2$ | 10.02 | 300639.2 | 142,483.01 | 158156.1 | 2.11 |
| $N_0M_3$ | 9.14 | 274068.2 | 134,347.17 | 139721.1 | 2.04 |
| $N_1M_0$ | 10.43 | 312846.2 | 169,106.07 | 143740.2 | 1.85 |
| $N_1M_1$ | 13.38 | 401311.7 | 200,655.83 | 200655.8 | 2.00 |
| $N_1M_2$ | 12.09 | 362575.5 | 187,862.95 | 174712.5 | 1.93 |
| $N_1M_3$ | 11.17 | 335030.4 | 175,408.59 | 159621.8 | 1.91 |
| $N_2M_0$ | 10.68 | 320519.6 | 144,108.60 | 176411 | 2.22 |
| $N_2M_1$ | 15.22 | 456542.6 | 199,634.02 | 256908.6 | 2.29 |
| $N_2M_2$ | 13.88 | 416262.3 | 187,301.36 | 228960.9 | 2.22 |
| $N_2M_3$ | 13.47 | 404199.7 | 172,000.00 | 232199.7 | 2.35 |
| $N_3M_0$ | 11.59 | 347595.5 | 193,108.63 | 154486.9 | 1.80 |
| $N_3M_1$ | 16.78 | 503390.5 | 204,630.27 | 298760.2 | 2.46 |
| $N_3M_2$ | 15.46 | 463792.5 | 195,000.00 | 268792.5 | 2.38 |
| $N_3M_3$ | 13.04 | 391216.6 | 205,903.46 | 185313.1 | 1.90 |

1 ton broccoli =30,000 Tk

$N_0$=Control,
$N_1$=Organic Manure (Cowdung 4t/ha+Vermicompost 3t/ha+ MOC 1.5t/ha),
$N_2$=Inorganic Fertilizer ($N_{120}P_{100}K_{140}S_{20}B_{1.5}$ kg/ha),
$N_3$= Organic+ Inorganic Fertilizer (1/2+1/2),
$M_0$ = Control (No mulch material),
$M_1$ = Black polythene,
$M_2$ = Water hyacinth,
$M_3$ = Dry Ash

# CHAPTER V

## SUMMARY AND CONCLUSION

The experiment was carried out at the horticultural research field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh during the period from October 2017 to February 2018 to assess the response of broccoli *(Brassica oleracea* var. *italica* L.) on nutrients and mulch materials. The seeds of hybrid broccoli (*Brassica oleracea* var. *italic* L.) namely "PARAISO" (Takii seed) were used as planting materials for this experiment. The experiment consisted of two factors: Factor A: Organic and inorganic fertilizer (four levels) as- $N_0$=No nutrients (control), $N_1$=Organic manure (Vermicompost 5t/ha+Cowdung 7t/ha+MOC 3t/ha), $N_2$=Inorganic fertilizer ($N_{120}P_{100}K_{140}S_{20}B_{1.5}$kg/ha), $N_3$=Organic manure +Inorganic fertilizer (1/2+1/2) and Factor B: Mulch material (four levels) as- $M_0$ = No mulch material (Control), $M_1$ = Black polythene, $M_2$ = Water hyacinth, $M_3$ = Dry Ash. The two factor experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data on different growth, yield and quality parameters were recorded and statistically significant variation was observed for different recorded parameters.

For different nutrients treatment, at 20, 40, 60 DAT and at harvest, the tallest plant (39.63, 52.48 and 63.23 cm, respectively) was recorded from $N_3$, whereas the shortest plant (21.08, 29.49, 50.80 cm, respectively) from $N_0$. At 20, 40, 60 DAT and at harvest, the highest number of leaves per plant (11.68, 11.77, 15.57 respectively) was found from $N_3$ treatment, while the lowest number (3.34, 4.22, 5.59 respectively) from $N_0$ treatment. At 20, 40, 60 DAT and at harvest, the highest length of largest leaf (42.91, 42.88, 45.35 cm, respectively) was observed from $N_3$ treatment, whereas the lowest

length (18.36, 26.59, 31.07 cm, respectively) from $N_0$ treatment. At 20, 40, 60 DAT and at harvest, the highest breadth of largest leaf (17.55, 20.42, 22.78 cm, respectively) was recorded from $N_3$ treatment, whereas the lowest breadth (8.17, 10.73, 10.56 cm, respectively) from $N_0$. The maximum days to 1st curd initiation (56.38 days) were found from $N_0$ treatment, while the minimum days (52.43 days) were observed from $N_3$ treatment. The maximum stem diameter (4.33 cm) were recorded from $N_3$ treatment, while the minimum (3.72) from $N_0$ treatment.

The highest curd diameter (20.12 cm) was observed from $N_3$ treatment, while the lowest (12.14 cm) from $N_0$ treatment. The highest weight of primary curd (447.82 g) was observed from $N_3$ treatment, while the lowest weight (213.17 g) from $N_0$ treatment. The highest number of secondary curd (1.83) was recorded from $N_3$ treatment, whereas the lowest number of secondary curd (1.00) from $N_0$ treatment. The maximum secondary curd weight (88.67 g) was found from $N_3$ treatment, whereas the lowest (68.95 g) from $N_0$ treatment. The highest curd dry weight (23.88 g) $N_3$ treatment, whereas the lowest (12.64 g) was observed from $N_0$ treatment. The highest leave dry weight (16.49 g) was found from $N_3$ treatment, while the lowest (7.75 g) was recorded from $N_0$ treatment. The highest yield per plant (610.80 g) was found from $N_3$ treatment while the lowest (282.70 g) was recorded from $N_0$ treatment. The highest yield per plot (7.32 kg) was found from $N_3$ treatment while the lowest (3.38 kg) was recorded from $N_0$ treatment. The highest yield per hectare (15.25 ton) was found from $N_3$ treatment while the lowest (7.53 ton) was recorded from $N_0$ treatment.

In case of different mulch materials at 20, 40, 60 DAT and at harvest, the tallest plant (35.49, 43.07 and 56.37 cm, respectively) was recorded from $M_1$ treatment, whereas the

shortest plant (30.71, 38.49, 50.65 cm, respectively) from $M_0$ treatment. At 20, 40, 60 DAT and at harvest, the highest number of leaves per plant (10.80, 12.23, 12.33 respectively) was found from $M_1$ treatment, while the lowest number (4.38, 6.16, 7.75 respectively) from $M_0$ treatment. At 20, 40, 60 DAT and at harvest, the highest length of largest leaf (34.37, 36.76, 39.64 cm, respectively) was observed from $M_1$ treatment, whereas the lowest length (27.83, 30.89, 32.92 cm, respectively) from $M_0$ treatment. At 20, 40, 60 DAT and at harvest, the highest breadth of largest leaf (12.58, 15.11, 22.78 cm, respectively) was recorded from $M_1$ treatment, whereas the lowest breadth (10.79, 11.14, 12.75 cm, respectively) from $M_0$ treatment.

The maximum days to 1st curd initiation (56.67 days) were found from $M_0$ treatment, while the minimum days (52.33 days) were observed from $M_1$ treatment. The maximum stem diameter (4.05 cm) were recorded from $M_1$ treatment, while the minimum (3.34) from $M_0$ treatment. The highest curd diameter (16.77 cm) was observed from $M_1$ treatment, while the lowest (12.54 cm) from $M_0$ treatment. The highest weight of primary curd (417.32 g) was observed from $M_1$ treatment, while the lowest weight (221.43 g) from $M_0$ treatment. The highest number of secondary curd (2.21) was recorded from $M_1$ treatment, whereas the lowest number of secondary curd (1.22) from $M_0$ treatment. The maximum secondary curd weight (98.23 g) was found from $M_1$ treatment, whereas the lowest (74.92 g) from $M_0$ treatment. The highest curd dry weight (19.76 g) $M_1$ treatment, whereas the lowest (17.33 g) was observed from $M_0$ treatment. The highest leave dry weight (12.58 g) was found from $M_1$ treatment, while the lowest (9.56 g) was recorded from $M_0$ treatment. The highest yield per plant (634.28 g) was found from $M_1$ treatment while the lowest (318.30 g) was recorded from $M_0$ treatment.

The highest yield per plot (7.61 kg) was found from $M_1$ while the lowest (3.81 kg) was recorded from $M_0$ treatment. The highest yield per hectare (15.86 ton) was found from $M_1$ treatment while the lowest (7.95 ton) was recorded from $M_0$ treatment.

Due to the combined effect of different nutrients and mulch materials at 20, 40, 60 DAT and at harvest, the tallest plant (45.57, 57.75 and 65.76 cm, respectively) was recorded from $N_3M_1$ treatment combination, whereas the shortest plant (18.56, 28.07, 44.53 cm, respectively) from $N_0M_0$ treatment combination. At 20, 40, 60 DAT and at harvest, the highest number of leaves per plant (12.47, 14.12, 17.13 respectively) was found from $N_3M_1$ treatment, while the lowest number (3.00, 3.98, 4.63 respectively) was found from $N_0M_0$ treatment combination. At 20, 40, 60 DAT and at harvest, the highest length of largest leaf (46.28, 45.03, 47.13 cm, respectively) was observed from $N_3M_1$ treatment combination, whereas the lowest length (16.30, 24.53, 27.81 cm, respectively) was found from $N_0M_0$. At 20, 40, 60 DAT and at harvest, the highest breadth of largest leaf (19.56, 21.44, 24.31 cm, respectively) was recorded from $N_3M_1$ treatment, whereas the lowest breadth (7.61, 8.90, 9.99 cm, respectively) from $N_0M_0$ treatment combination. The maximum days to 1st curd initiation (58.50 days) were found from $N_0M_0$ treatment, while the minimum days (52.27 days) were observed from $N_3M_1$ treatment combination. The maximum stem diameter (4.22cm) were recorded from $N_3M_1$ treatment, while the minimum (3.77) from $N_0M_0$ treatment combination. The highest curd diameter (20.65 cm) was observed from $N_3M_1$ treatment, while the lowest (10.95 cm) from $N_0M_0$ treatment combination. The highest weight of primary curd (467.58 g) was observed from $N_3M_1$ treatment, while the lowest weight (209.31 g) from $N_0M_0$ treatment combination. The highest number of secondary curd (2.21) was recorded from

$N_3M_1$ treatment combination, whereas the lowest number of secondary curd (1.24) from $N_0M_0$ treatment combination. The maximum secondary curd weight (99.37 g) was found from $N_3M_1$ treatment combination, whereas the lowest (76.23 g) from $N_0M_0$ treatment combination. The highest curd dry weight (24.21 g) was observed from $N_3M_1$ treatment, whereas the lowest (11.98g) was observed from $N_0M_0$. The highest leave dry weight (17.26 g) was found from $N_3M_1$ treatment, while the lowest (6.87 g) was recorded from $N_0M_0$. The highest yield per plant (671.25 g) was found from $N_3M_1$ treatment combination while the lowest (305.67 g) was recorded from $N_0M_0$ treatment combination. The highest yield per plot (8.05 kg) was found from $N_3M_1$ while the lowest (3.66 kg) was recorded from $N_0M_0$ treatment combination. The highest yield per hectare (16.77 ton) was found from $N_3M_1$ treatment combination while the lowest (7.63 ton) was recorded from $N_0M_0$ treatment combination.

The highest gross return (BDT 503390.5/ha) was obtained from the treatment combination $N_3M_1$ and the lowest (BDT 228955.2/ha) from $N_0M_0$ treatment. The highest net return (BDT 298760.2/ha) was found from the treatment combination $N_3M_1$ and the lowest net return (BDT 95841.71/ha) from $N_0M_0$ treatment combination. The highest benefit cost ratio (2.46) was noted from the combination of $N_3M_1$ treatment combination and the lowest (1.72) was obtained from $N_0M_0$ treatment combination. From economic point of view, it is apparent from the above results that the combination of $N_3M_1$ treatment combination was better than rest of the combination in broccoli cultivation.

Based on the experimental results, it may be concluded that

1. The effect of nutrients and mulch materials had positive effect on growth characters, yield and yield attributes of broccoli.
2. The treatment combination of $N_3M_1$ (Organic+Inorganic+Black polythene seemed to be more suitable for getting higher yield in broccoli.
3. From economic point of view the treatment combination of $N_3M_2$ (Organic+Inorganic+water hyacinth) was more profitable under the present study.

**Recommendations**

Considering the situation of the present experiment, further studies in the following areas may be suggested:

1. Such study may be conducted in different agro-ecological zones (AEZ) and seasons of Bangladesh for exploitation of regional adaptability and other performances
2. Some other levels of organic+inorganic manure with mulching (Black ploythene of broccoli may be included in future program for more confirmation of the results.

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# APPENDICES

**Appendix I.** Monthly record of air temperature, relative humidity and rainfall of the experimental site during the period from October, 2017 to February 2018

| Month | Air temperature (0C) | | Relative humidity (%) | Rainfall (mm) |
|---|---|---|---|---|
| | Maximum | Minimum | | |
| October, 2017 | 26.5 | 19.4 | 81 | 22 |
| November, 2017 | 25.8 | 16.0 | 78 | 00 |
| December, 2017 | 22.4 | 13.5 | 74 | 00 |
| January, 2018 | 24.5 | 12.4 | 68 | 00 |
| February, 2018 | 27.1 | 16.7 | 67 | 30 |

Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka –1212

**A. Morphological characteristics of the soil of experimental field**

| **Morphological features** | **Characteristics** |
|---|---|
| Location | Expeimental Field , SAU, Dhaka |
| AEZ | Madhupur Tract (28) |
| General Soil Type | Shallow red brown terrace soil |
| Land type | High land |
| Soil series | Tejgaon |
| Topography | Fairly leveled |
| Flood level | Above flood level |

| | |
|---|---|
| Drainage | Well drained |

**B. Physical and chemical properties of the initial soil**

| **Characteristics** | **Value** |
|---|---|
| % Sand | 27 |
| % Silt | 43 |
| % Clay | 30 |
| Textural class | Silty-clay |
| pH | 5.6 |
| Organic carbon (%) | 0.45 |
| Organic matter (%) | 0.78 |
| Total N (%) | 0.03 |
| Available P (ppm) | 20.00 |
| Exchangeable K (me/100 g soil) | 0.10 |
| Available S (ppm) | 45 |

**Source:** Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka-1212

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

**Appendix-III. Analysis of variance of data on number of leaves at different days after transplanting of broccoli**

| **Source of variation** | | **Mean square of number of leaves at** |
|---|---|---|

| Source of variation | Degrees of freedom (df) | Mean square of plant height at | | |
|---|---|---|---|---|
| | | 20 DAT | 40 DAT | 60 DAT |
| Replication | 2 | 0.83 | 0.26 | 0.28 |
| Factor A (Organic and Inorganic Fertilizer) | 3 | 775.04** | 1306.46** | 379.76** |
| Factor B (Mulching) | 3 | 32.26** | 15.04** | 12.70** |
| Interaction (A×B) | 3 | 43.31** | 13.00** | 15.73** |
| Error | 30 | 3.044 | 4.084 | 6.12 |
| ** : Significant at 1% level of probability; NS: Not Significant | | | | |

| | Degrees of freedom (df) | 20 DAT | 40 DAT | 60 DAT |
|---|---|---|---|---|
| Replication | 2 | 0.47 | 0.01 | 0.205 |
| Factor A (Organic and Inorganic Fertilizer) | 3 | 180.45** | 161.68** | 251.140 ** |
| Factor B (Mulching) | 3 | 0.36NS | 1.633 ** | 16.400** |
| Interaction (A×B) | 9 | 2.05** | 0.912** | 4.404** |
| Error | 30 | 0.41 | 0.230 | 0.451 |
| ** : Significant at 1% level of probability; NS: Not Significant | | | | |

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

| Source of variation | Degrees of freedom (df) | Mean square of number of leaf length at | | |
|---|---|---|---|---|
| | | 20 DAT | 40 DAT | 60 DAT |
| Replication | 2 | 0.725 | 0.097 | 2.853 |
| Factor A (Organic and Inorganic Fertilizer) | 3 | 1563.939 ** | 688.412 ** | 597.847 ** |
| Factor B (Mulching) | 3 | 8.934NS | 7.322 ** | 15.562 ** |
| Interaction (A×B) | 9 | 17.686 ** | 6.253 ** | 15.780 ** |
| Error | 30 | 1.341 | 0.752 | 1.998 |
| ** : Significant at 1% level of probability; NS: Not Significant | | | | |

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

| Source of variation | Degrees of freedom (df) | Mean square of number of leaf breadth at | | |
|---|---|---|---|---|
| | | 20 DAT | 40 DAT | 60 DAT |
| Replication | 2 | 1.742 | 0.304 | 4.564 |
| Factor A (Organic and Inorganic Fertilizer) | 3 | 214.014 ** | 280.687 ** | 382.849 ** |
| Factor B (Mulching) | 3 | 7.084NS | 2.167 ** | 0.788 ** |
| Interaction (A×B) | 9 | 2.719 ** | 2.065 ** | 3.656 ** |
| Error | 30 | 0.489 | 0.326 | 1.495 |
| ** : Significant at 1% level of probability; NS: Not Significant | | | | |

**Appendix-VI. Analysis of variance of data on yield contributing characters of broccoli**

| Source of variation | Degrees of freedom (df) | Mean square of | | | | |
|---|---|---|---|---|---|---|
| | | Curd diameter (cm) | Stem diameter (cm) | Primary curd weight (gm) | Curd dry weight(100g) | Leaf dry weight (100g) |
| Replication | 2 | 0.004 | 0.258 | 0.072 | 0.173 | 0.598 |
| Factor A (Organic and Inorganic Fertilizer) | 3 | 168.961** | 0.228 * | 3268.407NS | 299.169 ** | 176.379 ** |
| Factor B (Mulching) | 3 | 3.410** | 0.113NS | 977.144NS | 4.781 ** | 3.673 ** |
| Interaction (A×B) | 9 | 0.674** | 0.126NS | 860.736NS | 0.803 ** | 2.204 ** |
| Error | 30 | 0.027 | 0.168NS | 11.372 | 0.234 | 0.310 |
| ** : Significant at 1% level of probability; NS: Not Significant | | | | | | |

**Appendix-VII. Analysis of variance of data on yield contributing characters of broccoli**

| Source of variation | Degrees of freedom (df) | Mean square of | | | | | |
|---|---|---|---|---|---|---|---|
| | | Days required for curd initiation) | Secondary Number of Curd/Plant) | Secondary Curd Weight (gm) | Yield/Plant (g) | Yield/Plot (kg) | Yield/ hectare (ton) |
| Replication | 2 | 0.694 | 0.02 | 0.00 | | 0.465 | 1.293 |
| Factor A (Organic and Inorganic Fertilizer) | 3 | 42.843** | 6.50** | 0.31** | 0.176** | 70.566** | 195.967** |
| Factor B (Mulching) | 3 | 32.028* | 0.56* | 0.19* | 0.009** | 3.437** | 9.542** |
| Interaction (A×B) | 9 | 39.287** | 0.549* | 0.24* | 0.001* | 0.381* | 1.056* |
| Error | 30 | 7.210 | 0.158 | 0.05 | 0.000 | 0.157NS | 0.435 |

** : Significant at 1% level of probability; * : Significant at 5% level of probability