EFFECT OF PLANTING TIME AND ORGANIC MANURE ON GROWTH AND YIELD OF BROCCOLI

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CERTIFICATE

This is to certify that the thesis entitled **"Effect of Planting Time and Organic Manure on Growth and Yield of Broccoli"** submitted to the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in HORTICULTURE**, embodies the result of a piece of *bona fide* research work carried out by **Shamima Akter Shapla**, Registration No. **06-01878** 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.

Dated: June, 2013
Dhaka, Bangladesh

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DEDICATED
TO
MY BELOVED PARENTS

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ABSTRACT

The study was conducted at the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from October 2011 to March 2012. The experiment consisted of two factors: Factor A: Planting time (three levels) as T_1: Planting at 13 November, 2011; T_2: Planting at 23 November, 2011; T_3: Planting at 03 December, 2011 and Factor B: Organic manure (four levels) as M_0: Control i.e. no manure application; M_1: Cowdung @ 15 t/ha; M_2: Poultry Manure @ 12 t/ha and M_3: Vermicompost @ 13 t/ha. The experiment was laid out with Randomized Complete Block Design with three replications. In planting time, the highest weight of primary curd per plant (427.8 g) and highest yield (10.6 t/ha) was recorded from T_2, while the lowest (404.2 g) and (9.91 t/ha) from T_3. For organic manure, the highest weight of primary curd per plant (484.7 g) and highest yield (12.0 t/ha) was recorded from M_2, while the lowest (253.9 g) and (6.45 t/ha) from M_0. Due to the interaction effect, the highest weight of primary curd per plant (532.3 g) and highest yield (13.4 t/ha) was recorded from T_2M_2 and the lowest (236.8 g) and (6.68 t/ha) from T_1M_0. The highest benefit cost ratio (2.31) was noted from T_2M_2 and the lowest (1.26) from T_1M_0. So, planting at 23 November with poultry manure was better for the broccoli production.

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CHAPTER I

INTRODUCTION

Broccoli (*Brassica oleracea* var. *italica* L.) belongs to the family Brassicaceae is a biennial and herbaceous “Cole” crops. At present broccoli is cultivated in Europe, America and most of the Asian countries. In western countries broccoli is highly popular as fresh and as well as frozen vegetables. In Bangladesh broccoli was introduced about two decade ago. The edible portion of the broccoli plant consists of tender stem and unopened flower buds. Unlike cauliflower, broccoli produces smaller flowering shoots (secondary curds) from the leaf axils after harvest of main apical curds which are also edible. It can be harvested for a wide period of time than cauliflower (Thompson and Kelly, 1988).

Total vegetable production in Bangladesh is far below of its actual requirements. In 2009- 2010, total vegetable (summer and winter season) production area was 645.04 thousand hectares of land with a total production of 1.87 million tons (BBS, 2011). The per capita production of vegetable in Bangladesh is very low as compared to that of other countries. Due to low production of vegetables, the present consumption is only about 30 g, with potato and sweet potato it is 70g/day/person. The per capita consumption of vegetable in Nepal (42 g), Pakistan (69 g), Srilanka (120 g) and India (135 g) which are higher than that of Bangladesh (Ramphall and Gill, 1990). Broccoli can play a vital role in elevating the nutritional status of Bangladesh, as it is rich in vitamins and minerals such as carotene, ascorbic acid and contains appreciable quantities of thiamin, riboflavin, niacin, calcium and iron (Thompson and Kelly, 1985). Broccoli is more nutritious than other “Cole” crops such as cabbage, cauliflower and kohlrabi (Nonnecke, 1989). It also reported to be more easily digestible than cauliflower. Broccoli has high nutritive value especially vitamin A and vitamin C. Therefore, it can be met up some degree of vitamin A and vitamin C requirement and can contribute to solve malnutrition problem in Bangladesh.

Broccoli is a minor vegetable in Bangladesh and a small-scale cultivation found in the Dhaka and Gazipur districts. Broccoli is known as thermo sensitive crop and grown in Bangladesh in short day condition during winter season. Its growth and curd development are greatly influenced by growing environment. The production of a crop depends on many factors such as quality of seed, proper management practices including time of planting, plant spacing, soil fertility management, intercultural operations etc. Planting time is an important factor for yield of crop. Broccoli needs cool temperature for its optimum growth and curd formation (Narendra *et al.*, 2007). Plants sensitive to higher temperature as bud clusters of head become loose quickly. Higher temperature also gives rise to bracts during developmental stage of head. In Bangladesh it is planted in early September to late November. However, the temperature remains fairly high up to mid-October, which gradually comes down to about 20^0C on an average in mid-December. This cool period extends up to mid-February and the temperature rises sharply thereafter. It is, therefore, important to observe the effect of planting for achieving optimum growth and yield of broccoli. The optimum planting time ensures plant to grow properly through efficient utilization of moisture, temperature, light etc. As a result, increased production may be expected (Emam, 2005).

Fertilizer management is one of the important factors that contribute in the production and yield of any crop. Adequate supply of nutrients increases the yield. Since, the land is limited in Bangladesh, it is important to increase the per hectare yield of any crop in this country through different possible efforts. In tropical to subtropical regions, the soils are seriously impoverished in plant nutrients due to intensive weathering and leaching. An early and rapid vegetative growth of plant is necessary for quality soft and succulent curd and stem of broccoli, which is believed to be influenced by the application of heterogeneous fertilizers to the soil and that can be ensured with the application of organic manure. Maintenance of soil fertility through the use of nutrients is important, about 50% of the world's crop production being attributed to organic fertilizer use (Pradhan, 1992).

Nutrients are applied to the soil through organic and inorganic means. Indiscriminate use of inorganic fertilizer is believed to cause deterioration of soil texture and structure, and hinders microbial activity, pollutes ground water and finally decreases soil fertility and production. On the other hand, the use of organic manures improves soil texture, structure, humus, colour, aeration, water holding capacity and microbial activity of soil. All these, in return, increase production and reduce environmental pollution (Pare *et al*., 2000). A good soil has an organic matter content of more than 3%. But in Bangladesh the soil of most of regions have less than 1.5% organic matter. Some soils even have less than 1% organic matter (BARC, 1997). In this country, the productivity of soils is declining due to depletion of organic matter caused by high cropping intensity. Application of organic manure in crop production is, therefore, important for ensuring satisfactory yield. Due to inadequate knowledge about organic manure, the farmers of this country are habituated in extensive use of inorganic fertilizers compared to organic one. On an average, well rotted cowdung contains 0.5% N, 0.2% P_2O_5 and 0.5% K_2O (Yawalkar *et al*., 1984). Application of vermicompost and poultry manure subsequently increase yield attributing characters and yield of broccoli (Sameera *et al*., 2005). In addition, the product from organic fertilizer is not harmful for health and not hazardous for the natural eco-system.

Therefore, the present investigation was carried out to find out the effect of planting time and organic manure on growth and yield of broccoli with the following objectives:

1. To find out the effect of planting time on growth and yield of broccoli.
2. To find out the effect of appropriate organic manure for better plant growth and maximum yield of broccoli.
3. To find out the suitable combined effect between planting time and organic manure on growth, yield and economic return of broccoli

CHAPTER II

REVIEW OF LITERATURE

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

2.1 Effect of planting time on the growth and yield of broccoli

In temperate regions, broccoli is cultivated in the spring and in tropical (worm temperature) regions it is growth during the winter months (Thompson and Kelly, 1985) As a result, broccoli is found to grow well in place where a mild temperature to moderate cool temperature exists. However, the yield of the crop, for obvious reason, depends on the environmental conditions prevailing during the growing season in a particular place.

Ahmed and Abdullah (1986) reported that the time of planting significantly influenced the head yield and other characters of broccoli. Among the five planting dates (September 15, October 1 & 15 and November 1 & 15) the earlier planting produced taller plants and took more number of days for flower bud initiation. The highest yield was obtained from the crop planted on October 15 followed by November 1, while September 15 planting produced the lowest yield.

Diputado and Nichols (1989) conducted a field experiment in New Zealand on four cultivars of broccoli with six different sowing dates (September 18, November 19, January 17, March 21, and July 21). The heat unit concept was applied to relate temperature differences over the different sowing dates with time to head initiation, time to head maturity and rate of head growth. The time to head initiation appeared to be dependent on a heat unit summation above a base temperature of 1^0C while the rate of head growth was related best to a heat summation above 3^0C. They reported that the head and total dry weight (DW) production varied with sowing dates and with cultivars.

Sterrett *et al.* (1990) carried out an experiment to explore the potential of sprouting broccoli with thirteen cultivars at East Virginia, USA and reported that the yield of some broccoli cultivars exceeded the target from the first sowing date (August 10) but it was below the target for the other two sowing dates (August 19 to September 10).

Begum *et al.* (1990) observed that wide variation in vegetative growth and head yield while transplanting of 30 days old broccoli seedling at an interval of 15 days from Septembers 14 to December 13. Planting during October 14 to November 13 resulted in increased vegetative growth and larger curd than earlier.

Bracy and Contantin (1991) reported from Louisiana, USA that the transplanting date significantly affected the yield. Three broccoli cultivars were planted on 11 different dates during the autumn and spring season of 1985-1987. The highest yields and head weights were obtained for transplanting during spring or early autumn. Transplanting during late October and November produced lower head weights. They also suggested that the best harvesting time of broccoli heads reached 3-4 inch's in diameter (0.30 to 0.44 lb/head) and florets were mature but not open.

Moel (1992) conducted an experiment in the Netherlands to observe the effect of planting dates (May 30 and July 30) on broccoli cultivar Roxie. He reported that small head size (375 g) and high percentage of first class heads were obtained from the early planted trial. He suggested that it might be due to the association of high temperature during harvest. With the later planting, the average head weight was 572g. The harvest period was from 15 October to 5 November. The total yield amounting to 15t/ha of which 89% was graded as class 1.

Dellacecca *et al*. (1996) examined in Italy the effect of three planting dates (August 20, September 24 and October 25), four topping regimes (none, topping at planting, 15 or 30 days later) on four broccoli cultivars. They reported that topping at planting and particularly in August result in the best and earliest yield of inflorescence with a relatively high weight, good firmness and small stem diameter.

Bianco (1996) conducted an experiment in Italy with 4 broccoli cultivars to observe the effect of four sowing dates (September 25, October 21, December 4 and January 19) on yield. He reported that the yield decreased as sowing dates was delayed. Sowing on December 4 and January 19 reduced marketable yield by 57 and 96% respectively, compared to sowing on September 25. Head yield was higher when crops were planted early and showed a linear decreasing trend with delayed planting dates.

Aboul and Ragab (2000) conducted an experiment on broccoli cv. Assiut I with two planting dates (October 1 and 15) and accumulated heat unit (AHU) on held quality at Assiut University, Egypt. They reported that average head weight and total yields were higher with later planting, which associated with 8.5 days longer growth before harvest. They also reported that head weight was positively correlated with AHU of the late vegetative stage.

Darnata *et al.* (2000) conducted a field experiment in Italy on two cultivars of broccoli with three sowing dates (August 27, October 20 and November 6).

They reported that sowing time markedly influenced the yield, yield components and time of harvest. They also observing that when sowing was delayed by 36 days, yield decreased by 36% in the first year and 66% in the second.

Sari *et al.* (2000) conducted an experiment at Turkey on two cultivars of broccoli with five sowing dates (June 15, July 1 & 15 and August 2 & 16) during 1994 and 1995 in both the years, sowing dates significantly affected the total yield and the highest yield was obtained from the June 15 sowing (1065.11 g/plant). The main head weight and diameters for the early sowing dates were higher than the others.

Trotta *et al.* (2000) reported from Italy that yield in broccoli cultivars decreased when sowing was delayed from first fortnight of August to first fortnight of September. Yield of cultivars decreased when sowing was delayed. They also reported that central head weight decreased with delayed sown.

Sari *et al*. (2000) conducted a field experiment with five different sowing times in 1994 (16 June, 1 and 15 July, 2 and 16 August) and 1995 (15 June, 3 and 18 July, 3 and 17 August) were tested using 2 broccoli cultivars (Sultan and Marathon in the first year; SG1 and Marathon in the 2nd year) grown in the South-Eastern Anatolian Project (GAP) Area, Turkey, under irrigated conditions. The plants were transplanted on 5 different dates in 1995 (3, 16 and 25 August, 28 September and 26 October). In 1994, sowing time significantly affected primary head, lateral head and total head yield of broccoli. The 16 June sowing produced the highest primary head yield (395.92 g/plant), lateral head yield (322.19 g/plant) and total head yield (648.73 g/plant). Mean head weights and diameters for the early sowing dates were higher than for the last 2 sowing dates. Harvesting took place from November to February. In 1995, primary head yields were not affected by sowing date. The first sowing date (19 June) resulted in a lateral head yield higher (893.21 g/plant) than those of other sowing dates (531.71, 304.77, 216.51 and 157.53 g/plant). Sowing dates significantly affected the total yield. The highest yield was obtained from the 15 June sowing (1065.11 g/plant). Yields from the 3 and 18 July, and 2 and 17 August sowing dates were 726.98, 455.64, 318.38 and 218.20 g/plant, respectively.

Singh (2001) conducted an experiment during the rabi seasons at Dhaulakuan, Himachal Pradesh, India to assess the plant height and head yield of broccoli planted at weekly intervals from 20 October to 22 December. The highest average values for plant height (41.75 cm) and head yield (99.05 q/ha) were recorded when the crop was transplanted on 27 October. These values were at par with those obtained from crops transplanted on 20 October and 3 November. Transplanting beyond 10 November significantly reduced both parameters.

Rekowska and Sodkowski (2002) conducted an experiment in Szczeccin, Poland to find out the effects of sowing date (10 and 25 April, 10 and 25 May, and 10 and 25 June) on the yield of broccoli cv. Lord F_1. The highest main head yield, weight, and diameter were obtained with sowing on 25 May, and 10 and 25 June. Sowing on 10 June resulted in the highest yield, weight, and diameter of secondary heads.

Wlazo and Kunicki (2003) carried out a field experiment in Poland to find out the effects of transplanting age (4, 6, 8 and 10 week old) and transplanting date (11 July and 6 August) on the yield and quality of broccoli cv. Lord F_1. The marketable yield of broccoli was highest with July planting, whereas the dry matter and ascorbic acid content in broccoli heads were highest with August planting. Ten week old, and 4 and 8 week old transplants recorded the highest marketable yield in 2000 and 2001, respectively. Dry matter and ascorbic acid content were highest in 6 and 4 week old transplants, respectively.

Uzun and Kar (2004) carried out an experiment in the research field of the Black Sea Agricultural Research Institute in Turkey from spring to winter. Cultivar Platini, which is known as sprouting broccoli, was used in the study. Seedlings were raised in module seed trays. Planting procedure was repeated for the times, viz., 25 April (first, P_1), 27 May (second, P_2) and 27 June 1999 (third, P_3). The results showed that LWR decreased with time after planting while SWR increased with time. Generally, later planting times resulted in higher SWR and LWR while early planting times had higher RWR. Earlier planted plants had higher LAR and SLA. NAR and RGR were found to be lower with earlier plantings. LA and

TPDW varied with planting times and ontogeny. Both LA and TPDW increased with time after planting and plants from earlier plantings had lower LA and TPDW values. LT was higher at later planting times and increased with time.

Yoldas and Esiyok (2004) conducted an experiment in Odemis, Turkey, to investigate the effects of plant spacing, sowing and planting dates on the growth of 3 cultivars of broccoli (Green Dome, KY-110 and Marathon). The trial was carried out in Kucuk Menderes Valley using seedlings planted between June and October. The yield tended to decrease when sowing was conducted towards autumn. When seeds were sown in autumn, the yield also tended to decrease from 5003 to 1390 kg/da.

Ahmed and Wajid (2004) carried out an experiment in Rawalakot, Pakistan to investigate the effect of sowing dates on growth and yield of broccoli cv. Green mountains. Seeds were sown in well prepared seedbeds on 20 April, 5 May, 20 May and June 2002. Seedlings were transplanted when 3-4 leaves were developed after 30 days. Sowing on 5 May produced more (18.48) and longer (47.31) leaves, taller (30.79 cm) plants, heads of greater diameter (14.97 cm) and weight (200.65 g), higher number of secondary heads (16.0) and yield per plant (15.50 kg) compared to other sowing dates. Sowing on 5 May is recommended for general cultivation of broccoli under temperate areas.

Emam (2005) conducted consequently two field experiments to study the effect of two transplanting dates i.e., 22 August and 23 September and two within plant spacing 40, 60 cm for the second transplanting dates in 2000/2001 and 2001/2002 seasons, on vegetative growth, head quality and yield of broccoli (CV. Landmark) under the conditions of Kalyobeyia governorate. The results revealed that early planting increased plant height, number of leaves/plant and main stem diameter. On the contrary, the late transplanting on 23rd September increased head weight and diameter as well as total yield significantly.

Narendra *et al*. (2007) conducted a field experiment to determine the most suitable transplanting date (30 September, 15 and 30 October, and 15 November) and planting geometry (45×30, 45×45 and 45×60 cm) for broccoli (*Brassica oleracea*) cultivation under the mid-hills conditions of Almora, Uttar Pradesh, India. Data were recorded for plant height, leaves per plant, plant diameter, curd diameter, curd weight, secondary heads per plant, yield, fodder yield and total soluble solids. Results revealed that transplanting of broccoli can be done from 30 September to 15 October at a planting geometry of 45×30 cm for higher production of broccoli under the mid-hills conditions of the Himalayas.

El-Yazied *et al*. (2007) carried out a field experiment at the experimental farm of the Faculty of Agriculture, Ain Shams University, Shoubra Elkheima, Kalubia governorate, to study the effects of three sowing dates, i.e., the first of each of September, October and November, and four pinching treatments (pinching the apical head just after appearance, pinching the main head at the marketable stage, pinching the axillary head just after appearance on broccoli plants (*Brassica olerasea* var Italica), cultivar "Emperor". Plants were grown in Kaliobia under loamy soil conditions. Plants of the second sowing date (first of October) produced the tallest plants and the highest number of leaves per plant.

Khatun *et al*. (2012) conducted an experiment at the Horticultural Research Farm, of Sher-e Bangla Agricultural University, Dhaka to study the effect of different transplanting dates (October 5, October 25, November 14 and December 4) on the growth and yield of broccoli. Different transplanting dates showed significant influence on the yield and yield contributing characters of broccoli. Weight of curd plant^{-1} (319.11g), curd yield plot^{-1} (7.83 kg) and curd yield ha^{-1} (13.04 ton) were decreased with delay in transplanting. The highest curd yield ha^{-1} was obtained from the 25th October transplanting while the lowest from the 4th December transplanting.

2.2 Effect of organic manure on the growth and yield of broccoli

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.

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 NKP_S only organic manure could not produce higher yield of curd.

Abou *et al*. (2006) conducted two field experiments at El-Kassasein, Ismailia Governorate, Egypt to study the response of vegetative growth and yield of some broccoli varieties to apply organic manures (Cattle and poultry manures) compared with mineral fertilization. The highest vegetative growth of broccoli plants was recorded by plants which were supplied with 100% cattle manure. However, the highest total yield and quality of broccoli were recorded by adding poultry manure in the two seasons.

Maurya *et al*. (2008) conducted a field experiment in Pantnagar, Uttaranchal, India to study the effects of the recommended fertilizer and farmyard manure on broccoli (cv. Fiesta): recommended fertilizers (RF; 120:60:60 kg NPK/ha), farmyard manure (FYM) at 20 t/ha, FYM at 10 t/ha + 50% FR, neem cake at 5 quintal/ha, neem cake at 2.5 quintal/ha + 50% RF, vermicompost at 5 t/ha,

vermicompost at 2.5 t/ha + 50% RF, poultry manure at 5 t/ha, and poultry manure at 2.5 t/ha + 50% RF. Poultry manure + 50% RF and FYM + 50% RF resulted in the greatest plant height in 2005-06. In 2006-07, poultry manure + 50% RF, vermicompost + 50% RF, RF and poultry manure gave the tallest plants, the number of fully opened leaves in both years was highest for poultry manure + 50% RF. Leaf length was greatest for poultry manure + 50% RF and vermicompost + 50% RF. The greatest leaf weight per plant was recorded for poultry manure + 50% RF, FYM + 50% RF and vermicompost + 50% RF in 2005-06, and for poultry manure + 50% RF, RF, FYM + 50% RF and vermicompost + 50% RF in 2006-07. Poultry manure + 50%RF, FYM + 50% RF and vermicompost + 50% RF registered the greatest head weight in 2005-06, whereas poultry manure + 50% RF was superior for this trait in 2006-07. The highest yields were obtained with poultry manure + 50% RF.

Boari *et al*. (2010) investigated the effects of fertilization and cultivar on yield and quality of broccoli in organic farming. Three levels of organic manure 0, 40 and 80 kg/ha of amino sprint, respectively indicated with F_1, F_2 and F_3 on 4 cultivars of broccoli, were compared. Any effects of fertilization levels were observed on broccoli yield and quality, because of low quantity of main nutritional elements contained in the amino sprint.

Ryan (2011) conducted a field experiments to assess the release of plant-available N to broccoli plants from five N-rich soil amendments approve for organic production. Data shows that fish meal supplied an optimal pattern of N for high broccoli yield in both years. Soil analysis in 2010 showed N availability from fish meal differed from other fertility sources, with greater initial NH_4^+ availability and consistently high NO_3 levels from early to mid-June.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted during the period from October 2011 to March 2012 to study the effect of planting time and organic manure on growth and yield of broccoli. The materials and methods that were used for conducting the experiment have been presented in this chapter. It includes a short description of the location of experimental site, soil and climate condition of the experimental plot, materials used for the experiment, design of the experiment, data collection and data analysis procedure.

3.1 Location of the experimental site

The experiment was conducted at the Horticulture Research Farm of Sher-e-Bangla Agricultural University (SAU), Dhaka. It was located in 24.09^0N latitude and 90.26^0E longitudes. The altitude of the location was 8 m from the sea level as per the Bangladesh Metrological Department, Agargaon, Dhaka-1207.

3.2 Characteristics of soil

Experimental site belongs to the Modhupur Tract (UNDP, 1988) under AEZ No. 28 and the selected plot of the land was medium high in nature with adequate irrigation facilities and remained fallow during the previous season. The soil texture of the experimental was sandy loam. The nutrient status of the farm soil under the experimental plot with in a depth 0-20 cm were collected and analyzed in the Soil Research and Development Institute Dhaka, and result have been presented in Appendix I.

3.3 Climatic condition of the experimental site

Experimental area is situated in the sub-tropical climate zone, which is characterized by heavy rainfall during the months of April to September and scanty rainfall during the rest period of the year. Details of the meteorological

data during the period of the experiment was collected from the Bangladesh Meteorological Department, Agargoan, Dhaka and presented in Appendix II.

3.4 Planting materials

The test crop used in the experiment was broccoli variety Premium and the seeds were collected from Siddique Bazar, Dhaka.

3.5 Treatment of the experiment

The experiment consisted of two factors:

Factor A: Planting time (three levels) as

i T_1: Planting at 13 November, 2011

ii. T_2: Planting at 23 November, 2011

iii. T_3: Planting at 03 December, 2011

Factor B: Organic manure (four levels) as

i. M_0: Control i.e. no manure application

ii. M_1: Cowdung @ 15 t/ha

iii. M_2: Poultry Manure @ 12 t/ha

iv. M_3: Vermicompost @ 13 t/ha

There were 12 (3 × 4) treatments combination such as T_1M_0, T_1M_1, T_1M_2, T_1M_3, T_2M_0, T_2M_1, T_2M_2, T_2M_3, T_3M_0, T_3M_1, T_3M_2 and T_3M_0.

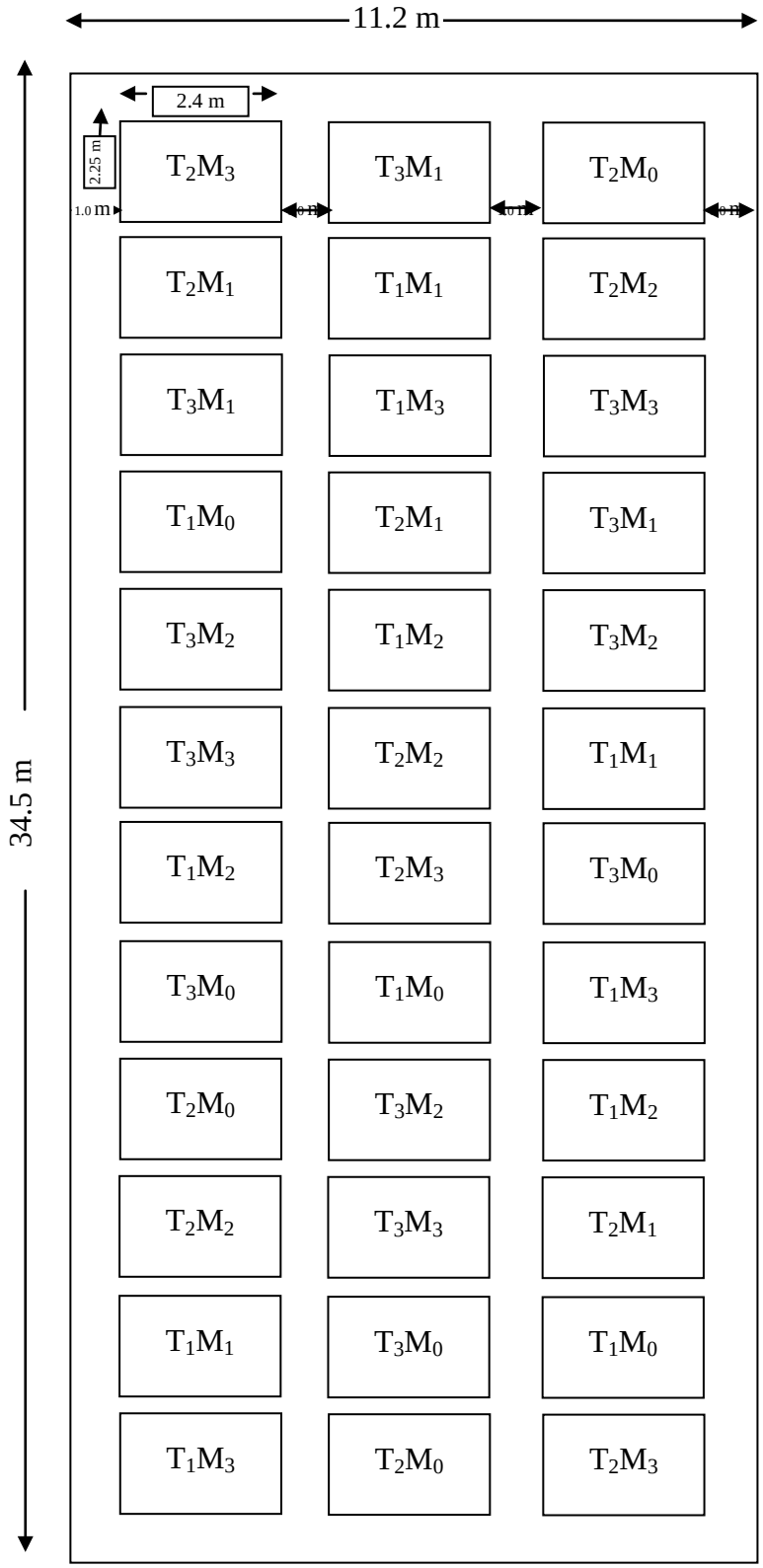
3.6 Collection of seedlings

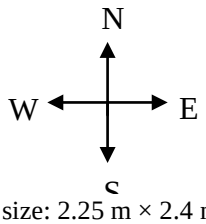
The seedlings of broccoli were collected from Horticulture Farm, of SAU, Dhaka.

3.7 Design and layout of the experiment

The two factors experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The total area of the experimental plot was 386.4 m^2 with length 34.5 m and width 11.2 m. The total area was divided into three equal blocks. Each block was divided into 12 plots where 12 treatments combination were allotted at random. There were 36 unit plots altogether in the experiment. The size of the each plot was 2.25 m × 2.4 m. The distance

maintained between two blocks and two plots were 1.0 m and 0.5 m, respectively. The layout of the experiment is shown in Figure 1.





Plot size: 2.25 m × 2.4 m
Plot spacing: 0.50 m
Between block: 1.00 m

Factor A: Planting time

T_1: Planting at 13 November, 2011

T_2: Planting at 23 November, 2011

T_3: Planting at 03 December, 2011

Factor B: Organic manure

M_0: Control i.e. No manure application

M_1: Cowdung @ 15 t/ha

M_2: Poultry Manure @ 12 t/ha

M_3: Vermicompost @ 13 t/ha

3.8 Preparation of the main field

The selected plot of the experiment was opened in the 1st week of November 2011 with a power tiller, and left exposed to the sun for a week. Subsequently cross ploughing was done five times with a country plough followed by laddering to make the land suitable for transplanting the seedlings. All weeds, stubbles and residues were eliminated from the field. Finally, a good tilth was achieved. The soil was treated with insecticides (cinocarb 3G @ 4 kg/ha) at the time of final land preparation to protect young plants from the attack of soil inhibiting insects such as cutworm and mole cricket.

3.9 Application of manure

Cowdung, poultry manure and vermicompost were applied as per treatment as a basal dose. Composition of cowdung, vermicompost and poultry manure are presented in Table 1. No inorganic fertilizers were applied in the experimental field.

Table 1. Composition of cowdung, vermicompost and poultry manure (Fertilizer Recommendation, BARC, 1997)

Manures	Amount (%)		
	N	P	K
Cowdung	0.5-1.5	0.4-0.8	0.5-0.9
Poultry Manure	1.6	1.5	0.85
Vermicompost	1.5-2.0	0.9-1.7	1.5-2.4

3.10 Raising of seedlings

The seedlings of broccoli were raised at Horticulture Farm, of Sher-e-Bangla Agricultural University (SAU), Dhaka, under special care in four seed beds each of 3 m × 1 m size. Soil of the seed bed was ploughed, prepared well and clods were broken into small pieces and converted into loose, friable to obtain good tilth. All weeds, stubbles and dead roots of the previous crops were removed carefully. Seedbeds were dried in the sun to prevent the damping of disease. Seed were sown in each seed bed on 20th October, 1st November and 10th November, 2011 to get seedlings of 23 days old at the time of transplanting. After sowing, the seeds were covered with finished light soil. Seeds were completely germinated

within 5-6 days after sowing. Shading was given by bamboo mat (chatai) over the seedbed to protect the young seedlings from scorching sunlight and rainfall. Weeding, mulching and irrigation were done from time to time to provide a favorable for good growth and raising quality seedlings.

3.11 Transplanting of seedlings

Healthy and uniform seedlings of 23 days old seedlings were transplanting in the experimental plots on 13 November, 23 November and 03 December, 2011 as per treatment of planting time. The seedlings were uprooted carefully from the seed bed to avoid damage to the root system. To minimize the damage to the roots of seedlings, the seed beds were watered on hour before uprooting the seedlings. Transplanting was done in the afternoon. The seedlings were watered immediately after transplanting. Seedlings were sown in the plot with maintaining distance between row to row and plant to plant was 60 cm and 45 cm, respectively. The young transplants were shaded by banana leaf sheath during day time to protect them from scorching sunshine up to 7 days until they were set in the soil. They (transplants) were kept open at night to allow them receiving dew. A number of seedlings were also planted in the border if the experimental plots for gap filling.

3.12 Intercultural operation

After raising seedlings, various intercultural operations such as gap filling, weeding, earthing up, irrigation pest and disease control etc. were accomplished for better growth and development of the broccoli seedlings.

3.12.1 Gap filling

The transplanted seedlings in the experimental plot were kept under careful observation. Very few seedlings were damaged after transplanting and such seedling were replaced by new seedlings from the same stock. Planted earlier on the border of the experimental plots same as planting time treatment. Those seedlings were transplanted with a big mass of soil with roots to minimize transplanting stock. Replacement was done with healthy seedling having a boll of earth which was also planted on the same date by the side of the unit plot. The

transplants were given shading and watering for 7 days for their proper establishment.

3.12.2 Weeding

The hand weeding was done at 15, 30, 45 and 60 days after transplanting (DAT) to keep the plots free from weeds.

3.12.3 Earthing up

Earthing up was done at 20 and 40 days after transplanting on both sides of rows by taking the soil from the space between the rows by a small spade.

3.12.4 Irrigation

Light watering was given by a watering cane at every morning and afternoon. Following transplanting and it was continued for a week for rapid and well establishment of the transplanted seedlings.

3.12.5 Pest and disease control

In spite of Cirocarb 3G applications during final land preparation few young plants were damaged due to attack of mole cricket and cut worm. Cut worms were controlled both mechanically and spraying Darsban 29 EC @ 3%. Birds pest such as nightingales (common Bulbuli) were seen visiting the broccoli field very frequently. The nightingale visited the fields in the morning and afternoon. The birds very found to puncture the soft levels and newly initiated curd and were controlled by striking a kerosene tin of metallic container frequently during day time.

3.13 Harvesting

Only the compact mature curds were harvested with 15 cm long fleshy stalk by using as sharp knife. To prevent the rotting of steam the cut portion were slanted, so that rain water could not stay. The curds were harvested in compact condition before the flower buds opened (Thomson and Kelly, 1985). Before harvesting of the broccoli head, compactness of the head was tested by pressing with thumbs. After harvesting the main curd, secondly the shoots were developed from the leaf

axils, which also developed into small secondary curds and were harvested over a period of time.

3.14 Data collection

Five plants were randomly selected from each unit plot except yields of curds, which was recorded plot wise. Data were collected in respect of the following parameters to assess plant growth; yield attributes and yields as affected by different treatments of the experiment. Data on plant height, number of leaves and length of large leaf were collected at 20, 40, 60 and 80 days after transplanting (DAT). All other yield contributing characters and yield parameters were recorded during harvest and after harvest.

3.14.1 Plant height

Plant height was measured from sample plants in centimeter from the ground level to the tip of the longest leaf and mean value was calculated. Plant height was also recorded at 20 days interval starting from 20 days after Transplanting (DAT) upto 80 days and at harvest to observe the growth rate of plants.

3.14.2 Number of leaves per plant

The total number of leaves per plant was counted from each selected plant with the observation of fully open leaves. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot at 20 days interval starting from 20 days after transplanting (DAT) upto 80 days and at harvest.

3.14.3 Days from transplanting to first visible curd

Each plant of the experiment plot was kept under close observation for recording the data on days from transplanting to first visible curd. Total number of days from the date of transplanting to the first visible curd was recorded.

3.14.4 Length of stem

The length of stem was taken from the ground level to base of the main curd of plant during harvesting. A meter scale used to measure the length of stem and was expressed centimeter (cm).

3.14.5 Diameter of stem

The diameter of the stem was measured at the point where the central curd was cut off. The diameter of the stem was recorded by slide calipers.

3.14.6 Fresh weight of leaves per plant

The fresh weight of leaves was recorded from the average of five (5) selected plants in gram (g) with a beam balance.

3.14.7 Length of root

The length of root was considered from the base of the tip of the root. It was measured in centimeter (cm) with a meter scale after harvesting.

3.14.8 Fresh weight of roots per plant

Fresh weight of roots was recorded in weighting the total roots and was recorded in gram.

3.14.9 Weight of primary curd

The weight of primary or central curd per plant was recorded in gram (g) by a beam balance.

3.14.10 Diameter of primary curd

The diameter of primary curd was measured in several directions with meter scale and the average of all directions was finally recorded and expressed in centimeter (cm).

3.14.11 Number of secondary curd

The number of secondary curds excluding the small shoots was counted when they reached marketable size.

3.14.12 Weight of secondary curds

The total marketable curds of an individual plant were taken and weight was recorded in gram (g) by a weighting balance.

3.14.13 Dry matter content of leaves

At first 100 gm leaves of selected plant was collected, cut into pieces and was dried under sunshine for a few days and then dried in an oven at 70^0C for 72 hours before taking dry weight till it was constant. The dry weight was recorded in gram (g) with a beam balance.

3.14.14 Dry matter content of curd

Sample of 100 g curd was taken, cut into pieces and was dried under direct sunshine for 3 days and then was dried in an oven at 70 for 72 hours before taking the dry weight till it was constant. The dry weight was recorded in gram (g) with a beam balance.

3.14.15 Yield per plot

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

3.14.16 Yield per hectare

The yield per hectare was calculated by converting from the per plot yield data to per hectare and was expressed in ton (t).

3.15 Statistical analysis

The data obtained for different characters were statistically analyzed by using MSTAT-C computer package program to find out the significance of the difference for planting time and organic manure on yield and yield contributing characters of broccoli. The mean values of all the recorded characters were evaluated and analysis of variance was performed by the 'F' (variance ratio) test. The significance of the difference among the treatment combinations of means was estimated by Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

3.16 Economic analysis

The cost of production was analyzed in order to find out the most economic combination of planting time and organic manure. 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 @ 14% in simple rate. The market price of broccoli was considered for estimating the cost and return. Analyses were done according to the procedure of Alam *et al*. (1989). The benefit cost ratio (BCR) was calculated as follows:

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

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to observe the effect of planting time and organic manure on growth and yield of broccoli under the soil and agro climatic condition of Sher-e-Bangla Agricultural University (SAU), Dhaka. Data on different growth and yield parameter were recorded. The analyses of variance (ANOVA) of the data on different growth and yield parameters are presented in Appendix III-VII. The results have been presented and discusses with the help of table and graphs and possible interpretations given under the following headings:

4.1 Plant height

Plant height varied significantly for different planting time at 20, 40, 60, 80 days after transplanting (DAT) and at harvest of broccoli under the present trial (Appendix III). From Figure 2 it is revealed that at 20, 40, 60, 80 DAT and at harvest the tallest plant (20.0 cm, 28.3 cm, 40.9 cm, 51.6 cm and 52.8 cm) was recorded from T_2 (planting at 23 November, 2011) which was statistically similar (18.3 cm, 27.1 cm, 39.7 cm, 49.8 cm and 52.5 cm) with T_1 (planting at 13 November, 2011), whereas the shortest plant (14.5 cm, 23.5 cm, 32.6 cm, 42.4 cm and 43.8 cm) was recorded from T_3 (planting at 03 December, 2011). Data revealed that the planting at 23 November produced longest plant followed by 13 November planting and delayed planting produced shortest plant. Broccoli is known as thermo sensitive crop and grown in Bangladesh in short day condition during winter season and needs cool temperature for its optimum growth and curd formation. Its growth and curd development are greatly influenced by growing environment which was governed by time of planting. The optimum planting time ensures plant to grow properly through efficient utilization of moisture, temperature, light etc. Ahmed and Abdullah (1986) reported that the earlier planting produced taller plants. Emam (2005) and Khatun *et al*. (2012) found that early planting increased plant height.

Different organic manure showed significant differences on plant height of broccoli at 20, 40, 60 and 80 DAT and at harvest (Appendix III). At 20, 40, 60 and 80 DAT and at harvest the tallest plant (20.3 cm, 30.0 cm, 41.5 cm, 51.9 cm and 54.4 cm) was found from M_2 (poultry manure @ 12 t/ha), which was statistically identical (19.7 cm, 28.4 cm, 39.8 cm, 51.1 cm and 52.8 cm) with M_3 (vermicompost @ 13 t/ha) and closely followed (17.1 cm, 26.4 cm, 38.2 cm, 47.7 cm and 53.6 cm) by M_1 (cowdung @ 15 t/ha), while the shortest plant (13.3 cm, 20.5 cm, 31.4 cm, 40.8 cm and 41.3 cm) was found from M_0 (control i.e. no manure) (Figure 3). Organic fertilizer released all type of micro and macro nutrients that improved soil physical properties for higher growth of broccoli plants.

Combined effect of different planting time and organic manure showed significant differences on plant height of broccoli at 20, 40, 60 and 80 DAT and at harvest (Appendix III). At 20, 40, 60 and 80 DAT and at harvest the tallest plant (24.4 cm, 33.8 cm, 47.3 cm, 57.8 cm and 61.3) was recorded from T_2M_2 (planting at 23 November, 2011 and poultry manure @ 12 t/ha) treatment combination, while the shortest (12.2 cm, 19.4 cm, 30.3 cm, 39.0 cm and 40.6 cm) was found from T_1M_0 (planting at 13 November, 2011 and no manure application) treatment combination (Table 2). It was revealed that in a single effect of planting at 23 November, 2011 and poultry manure @ 12 t/ha produced the tallest plant under this trial.

Table 2. Combined effect of planting time and organic manure on plant height at different days after transplanting (DAT) of broccoli

Treatment	Plant height (cm) at				
	20 DAT	**40 DAT**	**60 DAT**	**80 DAT**	**Harvest**
T_1M_0	14.2 e	19.4 e	30.3 c	39.0 d	40.6 f
T_1M_1	17.6 cd	27.7 cd	40.2 ab	49.8 bc	54.5 a-c
T_1M_2	23.0 ab	32.5 ab	45.7 a	56.2 ab	58.2 ab
T_1M_3	20.2 bc	28.9 bc	42.5 a	53.9 ab	53.4 bc
T_2M_0	15.0 de	21.6 e	32.4 c	42.4 d	43.2 ef
T_2M_1	19.5 c	28.7 bc	42.1 a	51.5 a-c	57.0 ab
T_2M_2	24.4 a	33.8 a	47.3 a	57.8 a	61.3 a
T_2M_3	21.0 bc	28.9 bc	42.0 a	54.6 ab	55.6 a-c
T_3M_0	12.2 e	20.4 e	31.5 c	39.1 d	40.7 f
T_3M_1	12.6 e	22.8 e	32.3 c	41.9 d	45.8 d
T_3M_2	13.4 e	23.7 de	31.7 c	41.9 d	43.7 de
T_3M_3	18.0 cd	27.3 cd	34.9 bc	44.8 cd	49.5 cd
$LSD_{(0.05)}$	**1.06**	**4.04**	**6.34**	**6.63**	**6.64**
Level of significance	**0.01**	**0.05**	**0.05**	**0.05**	**0.05**
CV(%)	**10.45**	**9.07**	**9.92**	**8.18**	**8.01**

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

T_1: Planting at 13 November, 2011

T_2: Planting at 23 November, 2011

T_3: Planting at 03 December, 2011

M_0: Control i.e. no manure application

M_1: Cowdung @ 15 t/ha

M_2: Poultry Manure @ 12 t/ha

M_3: Vermicompost @ 13 t/ha

4.2 Number of leaves per plant

Different planting time varied significantly for number of leaves per plant at 20, 40, 60 and 80 and at harvest of broccoli (Appendix IV). At 20, 40, 60 and 80 DAT and at harvest the maximum number of leaves per plant (5.6, 8.2, 12.8, 14.3 and 16.9) was recorded from T_2 which was statistically similar (5.32, 7.88, 11.9, 13.6 and 15.4) with T_1, again the minimum number (3.88, 6.14, 10.6, 12.1 and 13.7) was recorded from T_3 (Figure 4). Emam (2005) found that early planting increased number of leaves/plant.

Significant variation was recorded due to different organic manure for leaves per plant of broccoli at 20, 40, 60 and 80 DAT and at harvest (Appendix IV). At 20, 40, 60 and 80 DAT and at harvest the maximum number of leaves per plant (5.31, 8.09, 13.2, 14.5 and 17.6) was recorded from M_2, which was statistically identical (5.18, 7.99, 11.7, 14.3 and 17.5) with M_3 and closely followed (5.04, 7.24, 12.2, 13.4 and 15.6) by M_1, while the minimum number (4.2, 6.29, 10.1, 10.4 and 11.6) from M_0 (Figure 5). Thompson and Kelly (1988) reported that the rate of release of nitrogen from the manure is higher in poultry litter than other sources of manures which ultimately was reflected in maximum number of leaves per plant.

Planting time and organic manure showed significant differences on number of leaves per plant of broccoli due to their combined effect at 20, 40, 60 and 80 DAT and at harvest (Appendix IV). At 20, 40, 60 and 80 DAT and at harvest the maximum number of leaves per plant (6.47, 9.40, 15.1, 16.1 and 19.4) was recorded from T_2M_2 treatment combination and the minimum number (4.00, 5.87, 9.43, 10.5 and 10.9) was recorded from T_1M_0 treatment combination (Table 3).

Table 3. Combined effect of planting time and organic manure on number of leaves at different days after transplanting (DAT) of broccoli

Treatment	Number of leaves at				
	20 DAT	**40 DAT**	**60 DAT**	**80 DAT**	**Harvest**
T_1M_0	4.00 cd	5.87 d	9.43 g	10.5 g	10.9 g
T_1M_1	5.47 b	7.60 c	12.3 c-e	13.7 cd	15.6 c-e
T_1M_2	6.20 ab	9.13 a	14.1 ab	15.3 ab	18.9 ab
T_1M_3	5.60 ab	8.90 ab	11.9 c-f	14.7 bc	17.1 bc
T_2M_0	4.40 c	6.53 d	10.2 fg	11.5 fg	11.6 fg
T_2M_1	5.73 ab	7.93 bc	13.3 bc	14.5 bc	16.9 bc
T_2M_2	6.47 a	9.40 a	15.1 a	16.1 a	19.4 a
T_2M_3	5.80 ab	8.90 ab	12.7 b-d	15.1 ab	18.8 ab
T_3M_0	4.20 c	6.47 d	10.5 e-g	11.2 fg	11.6 g
T_3M_1	3.93 cd	6.20 d	11.1 d-g	12.2 ef	14.2 de
T_3M_2	3.27 d	5.73 d	10.3 fg	12.0 ef	13.5 ef
T_3M_3	4.13 cd	6.17 d	10.6 e-g	13.0 de	16.5 b-d
$LSD_{(0.05)}$	**0.80**	**1.02**	**1.67**	**1.07**	**2.45**
Level of significance	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
CV(%)	**9.57**	**8.09**	**8.36**	**5.13**	**9.46**

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

T_1: Planting at 13 November, 2011

T_2: Planting at 23 November, 2011

T_3: Planting at 03 December, 2011

M_0: Control i.e. no manure application

M_1: Cowdung @ 15 t/ha

M_2: Poultry Manure @ 12 t/ha

M_3: Vermicompost @ 13 t/ha

4.3 Days from transplanting to first visible curd

Different planting time of broccoli showed significant variation in terms of days from transplanting to first visible curd (Appendix V). The minimum days from transplanting to first visible curd (52.3) was found from T_3 which was statistically similar (53.8) with T_2. On the other hand, the maximum days (55.2) was recorded from T_1 (Table 4). Early planting took more time for curd initiation for attaining optimum temperature of curd initiation whereas delay plant produced early curd due to shortest vegetative growth period. Ahmed and Abdullah (1986) reported that the earlier planting took more number of days for flower bud initiation.

Significant variation was found for different organic manure on days from transplanting to first visible curd (Appendix V). The minimum days from transplanting to first visible curd (50.6) was found from M_2, which was statistically similar (52.4 and 53.0) with M_1 and M_3, whereas the maximum days (58.9) from M_0 (Table 4).

Planting time and organic manure showed significant differences on days from transplanting to first visible curd due to their combined effect (Appendix V). The minimum days from transplanting to first visible curd (44.7) was attained from T_2M_2 treatment combination and the maximum days (62.0) was found from T_1M_0 treatment combination (Table 5).

4.4 Length of stem

Length of stem varied significantly for different planting time of broccoli (Appendix V). The highest length of stem (24.7 cm) was recorded from T_2 which was statistically similar (23.8 cm) with T_1, while the lowest (20.7 cm) was recorded from T_3 (Table 4). Emam (2005) also reported similar findings from earlier experiment.

Table 4. Effect of planting time and organic manure on days from transplanting to first visible curd, length of stem and diameter of stem of broccoli

Treatment	Days from transplanting to first visible curd	Length of stem (cm)	Diameter of stem (cm)
Planting time			
T_1	55.2 a	23.8 a	3.27 b
T_2	53.8 ab	24.7 a	3.80 a
T_3	52.3 b	20.7 b	3.76 a
$LSD_{(0.05)}$	**2.17**	**1.60**	**0.240**
Level of significance	**0.05**	**0.01**	**0.01**
Organic manure			
M_0	58.9 a	16.4 c	3.07 c
M_1	52.4 b	23.8 b	3.43 b
M_2	50.6 b	26.2 a	4.07 a
M_3	53.0 b	25.7 a	3.87 a
$LSD_{(0.05)}$	**2.51**	**1.85**	**0.277**
Level of significance	**0.01**	**0.01**	**0.01**
CV(%)	**4.77**	**8.19**	**7.86**

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

T_1: Planting at 13 November, 2011

T_2: Planting at 23 November, 2011

T_3: Planting at 03 December, 2011

M_0: Control i.e. no manure application

M_1: Cowdung @ 15 t/ha

M_2: Poultry Manure @ 12 t/ha

M_3: Vermicompost @ 13 t/ha

Table 5. Combined effect of planting time and organic manure on days from transplanting to first visible curd, length of stem and diameter of stem of broccoli

Treatment	Days from transplanting to first visible curd	Length of stem (cm)	Diameter of stem (cm)
T_1M_0	62.0 a	14.8 e	2.57 f
T_1M_1	54.7 cd	25.3 bc	2.97 ef
T_1M_2	55.3 cd	28.6 ab	3.87 a-c
T_1M_3	56.7 bc	26.4 a-c	3.67 b-d
T_2M_0	60.7 ab	15.0 e	3.20 de
T_2M_1	53.3 c-e	27.4 a-c	3.63 b-d
T_2M_2	44.7 f	29.8 a	4.23 a
T_2M_3	49.3 e	26.6 a-c	4.13 ab
T_3M_0	54.0 c-e	19.4 d	3.43 c-e
T_3M_1	49.3 e	18.8 d	3.70 a-d
T_3M_2	51.7 de	20.3 d	4.10 ab
T_3M_3	53.0 c-e	24.2 c	3.80 a-c
$LSD_{(0.05)}$	**4.34**	**3.20**	**0.479**
Level of significance	**0.01**	**0.01**	**0.05**
CV(%)	**4.77**	**8.19**	**7.86**

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

T_1: Planting at 13 November, 2011

T_2: Planting at 23 November, 2011

T_3: Planting at 03 December, 2011

M_0: Control i.e. no manure application

M_1: Cowdung @ 15 t/ha

M_2: Poultry Manure @ 12 t/ha

M_3: Vermicompost @ 13 t/ha

Different organic manure showed significant variation on length of stem of broccoli (Appendix V). The highest length of stem (26.2 cm) was recorded from M_2, which was statistically identical (25.7 cm) with M_3 and closely followed (23.8 cm) by M_1. On the contrary, the lowest length (16.4 cm) was recorded from M_0 (Table 4). But Abou *et al*. (2006) reported that the longest stem of broccoli plants was recorded by plants which were supplied with 100% cattle manure.

Combined effect of different planting time and organic manure showed significant differences on length of stem (Appendix V). The highest length of stem (29.8 cm) was recorded from T_2M_2 treatment combination, again the lowest length (14.8 cm) was recorded from T_1M_0 treatment combination (Table 5).

4.5 Diameter of stem

Significant variation was recorded in terms of diameter of stem varied due to different planting time of broccoli (Appendix V). The highest diameter of stem (3.80 cm) was recorded from T_2 which was statistically similar (3.76 cm) with T_1, again the lowest (3.27 cm) was recorded from T_3 (Table 4). Emam (2005) found that early planting increased main stem diameter of broccoli. But the present study showed that November, 23 generated highest diameter of stem.

Diameter of stem of broccoli showed significant variation for different organic manure (Appendix V). The highest diameter of stem (4.07 cm) was recorded from M_2, which was statistically identical (3.87 cm) with M_3, while the lowest diameter (3.07 cm) from M_0 (Table 4).

Significant variation was recorded for combined effect of different planting time and organic manure in terms of diameter of stem (Appendix V). The highest diameter of stem (4.23 cm) was found from T_2M_2 treatment combination, whereas the lowest diameter (2.57 cm) was recorded from T_1M_0 treatment combination (Table 5).

4.6 Fresh weight of leaves per plant

Fresh weight of leaves per plant varied significantly for different planting time of broccoli (Appendix V). The maximum fresh weight of leaves per plant (230.9 g) was recorded from T_1 which was statistically similar (226.2 g) with T_2, while the minimum fresh weight (197.8 g) was attained from T_3 (Table 6). Emam (2005) also reported similar findings from earlier experiment.

Different organic manure showed significant variation on fresh weight of leaves per plant of broccoli (Appendix V). The maximum fresh weight of leaves per plant (246.2 g) was recorded from M_2, which was statistically identical (234.8 g) with M_3, while the minimum fresh weight (178.0 g) was found from M_0 (Table 6).

Fresh weight of leaves per plant showed significant differences due to the combined effect of different planting time and organic manure (Appendix V). The maximum fresh weight of leaves per plant (273.1 g) was recorded from T_1M_2, while the minimum (171.2 g) from T_1M_0 treatment combination (Table 7).

4.7 Length of root

Significant variation was recorded for length of root due to different planting time of broccoli (Appendix V). The highest length of root (24.8 cm) was recorded from T_2 which was statistically similar (24.0 cm) with T_1, whereas the lowest length (21.8 cm) was found from T_3 (Table 6). Khatun *et al.* (2012) also reported similar findings from earlier experiment.

Length of root of broccoli varied significantly for different organic manure under the present trial (Appendix V). The highest length of root (25.3 cm) was attained from M_2, which was statistically identical (24.7 cm) with M_3, while the lowest length (20.5 cm) was found from M_0 (Table 6).

Combined effect of different planting time and organic manure showed significant differences on length of root (Appendix V). The highest length of root (27.9 cm) was found from T_1M_2 treatment combination, while the lowest length (19.4 cm) from T_1M_0 treatment combination (Table 7).

Table 6. Effect of planting time and organic manure on fresh weight of leaves, length of root and fresh weight of roots of broccoli

Treatment	Fresh weight of leaves per plant (g)	Length of root (cm)	Fresh weight of roots per plant (g)
Planting time			
T_1	230.9 a	24.0 a	23.1 a
T_2	226.2 a	24.8 a	22.7 a
T_3	197.8 b	21.8 b	19.1 b
$LSD_{(0.05)}$	**14.12**	**1.38**	**1.48**
Level of significance	**0.01**	**0.01**	**0.01**
Organic manure			
M_0	178.0 c	20.5 c	19.4 b
M_1	214.0 b	23.6 b	21.4 a
M_2	246.2 a	25.3 a	23.0 a
M_3	234.8 a	24.7 ab	22.8 a
$LSD_{(0.05)}$	**16.30**	**1.59**	**1.71**
Level of significance	**0.01**	**0.01**	**0.01**
CV(%)	**7.64**	**6.93**	**8.07**

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

T_1: Planting at 13 November, 2011

T_2: Planting at 23 November, 2011

T_3: Planting at 03 December, 2011

M_0: Control i.e. no manure application

M_1: Cowdung @ 15 t/ha

M_2: Poultry Manure @ 12 t/ha

M_3: Vermicompost @ 13 t/ha

Table 7. Combined effect of planting time and organic manure on fresh weight of leaves, length of root and Fresh weight of roots of broccoli

Treatment	Fresh weight of leaves per plant (g)	Length of root (cm)	Fresh weight of roots per plant (g)
T_1M_0	171.2 e	19.4 e	18.3 d
T_1M_1	224.8 bc	25.5 abc	23.7 ab
T_1M_2	273.1 a	27.9 a	25.4 a
T_1M_3	254.4 ab	23.2 cd	25.2 a
T_2M_0	180.5 de	21.5 de	20.1 cd
T_2M_1	228.2 bc	24.5 bc	21.9 bc
T_2M_2	255.6 ab	27.6 ab	24.6 ab
T_2M_3	240.3 bc	25.7 abc	24.3 ab
T_3M_0	182.2 de	20.5 de	19.7 cd
T_3M_1	189.1 de	20.9 de	18.5 d
T_3M_2	210.0 cd	20.6 de	19.1 cd
T_3M_3	209.8 cd	25.2 abc	19.0 cd
$LSD_{(0.05)}$	**28.24**	**2.76**	**2.96**
Level of significance	**0.05**	**0.01**	**0.01**
CV(%)	**7.64**	**6.93**	**8.07**

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

T_1: Planting at 13 November, 2011

T_2: Planting at 23 November, 2011

T_3: Planting at 03 December, 2011

M_0: Control i.e. no manure application

M_1: Cowdung @ 15 t/ha

M_2: Poultry Manure @ 12 t/ha

M_3: Vermicompost @ 13 t/ha

4.8 Fresh weight of roots per plant

Fresh weight of roots per plant varied significantly for different planting time of broccoli (Appendix V). The maximum fresh weight of roots per plant (23.1 g) was found from T_1 which was statistically similar (22.7 g) with T_2, again the minimum fresh weight (19.1 g) was attained from T_3 (Table 6). Khatun *et al.* (2012) and Emam (2005) also reported similar findings from earlier experiment.

Different organic manure showed significant variation on fresh weight of roots per plant of broccoli (Appendix V). The maximum fresh weight of roots per plant (23.0 g) was recorded from M_2, which was statistically similar (22.8 g and 21.4 g) with M_3 and M_1, again the minimum fresh weight (19.4 g) was found from M_0 (Table 6).

Planting time and organic manure showed significant differences on fresh weight of roots per plant due to their combined effect (Appendix V). The maximum fresh weight of roots per plant (25.4 g) was found from T_1M_2, whereas the minimum fresh weight (18.3 g) was recorded from T_1M_0 (Table 7).

4.9 Weight of primary curd

Significant variation was recorded in terms of weight of primary curd for different planting time of broccoli (Appendix VI). The highest weight of primary curd (427.8 g) was recorded from T_2 which was statistically similar (411.9 g) with T_1, while the lowest weight (404.2 g) was recorded from T_3 (Table 8). Moel (1992) reported that head size of 375 g and high percentage of first class heads were obtained from the early planted trial.

Weight of primary curd broccoli varied significantly for different organic manure (Appendix VI). The highest weight of primary curd (484.7 g) was attained from M_2, which was statistically identical (466.5 g) with M_3, whereas the lowest weight (253.9 g) was found from M_0 (Table 8). Organic fertilizer released all type of micro and macro nutrients that improved soil physical properties for higher weight of primary curd.

Table 8. Effect of planting time and organic manure on yield contributing characters and yield of broccoli

Treatment	Weight of primary curd (g)	Diameter of primary curd (cm)	Weight of secondary curd per plant (g)	Dry matter content of leaves (g)	Dry matter content of curd (g)	Yield per plot (kg)
Planting time						
T_1	411.9 ab	9.21 b	63.1 ab	13.2 ab	12.3 ab	9.50 b
T_2	427.8 a	10.1 a	66.8 a	13.6 a	12.9 a	9.89 a
T_3	404.2 b	9.10 b	58.8 b	12.9 b	11.7 b	9.26 b
$LSD_{(0.05)}$	**16.47**	**0.39**	**5.01**	**0.38**	**0.70**	**0.37**
Level of significance	**0.05**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Organic manure						
M_0	253.9 c	8.56 c	47.8 d	11.8 c	11.6 b	6.03 d
M_1	453.5 b	9.43 b	58.8 c	13.4 b	12.2 b	10.3 c
M_2	484.7 a	10.0 a	76.7 a	13.9 a	13.1 a	11.2 a
M_3	466.5 ab	9.85 ab	68.4 b	13.8 ab	12.3 ab	10.7 b
$LSD_{(0.05)}$	**19.02**	**0.450**	**5.79**	**0.438**	**0.812**	**0.426**
Level of significance	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
CV(%)	**4.69**	**4.87**	**9.41**	**4.39**	**6.75**	**4.57**

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

T_1: Planting at 13 November, 2011

T_2: Planting at 23 November, 2011

T_3: Planting at 03 December, 2011

M_0: Control i.e. no manure application

M_1: Cowdung @ 15 t/ha

M_2: Poultry Manure @ 12 t/ha

M_3: Vermicompost @ 13 t/ha

Statistically significant variation was recorded due to the combined effect of different planting time and organic manure in terms of weight of primary curd (Appendix VI). The highest weight of primary curd (532.3 g) was found from T_2M_2 and the lowest weight (236.8 g) was recorded from T_1M_0 (Table 9).

4.10 Diameter of primary curd

Diameter of primary curd varied significantly for different planting time of broccoli (Appendix VI). The highest diameter of primary curd (10.1 cm) was recorded from T_2, whereas the lowest diameter (9.10 cm) was recorded from T_3 which was statistically similar (9.21 cm) with T_1 (Table 8). Sari *et al.* (2000) reported that the main head diameters for the early sowing dates were higher than the others.

Different organic manure showed significant variation on diameter of primary curd broccoli (Appendix VI). The highest diameter of primary curd (10.0 cm) was found from M_2, which was statistically identical (9.85 cm) with M_3, while the lowest diameter (8.56 cm) was attained from M_0 (Table 8).

Combined effect of different planting time and organic manure showed significant differences on diameter of primary curd (Appendix VI). The highest diameter of primary curd (10.9 cm) was recorded from T_2M_2, while the lowest diameter (8.07 cm) was found from T_3M_0 (Table 9).

Table 9. Combined effect of planting time and organic manure on yield contributing characters and yield of broccoli

Treatment	Weight of primary curd (g)	Diameter of primary curd (cm)	Weight of secondary curd per plant (g)	Dry matter content of leaves (g)	Dry matter content of curd (g)	Yield per plot (kg)
T_1M_0	236.8 f	8.50 ef	41.1 e	11.5 f	10.0 d	5.99 f
T_1M_1	447.5 de	9.44 cd	59.3 cd	13.4 cd	12.7 bc	10.1 de
T_1M_2	480.5 bcd	9.98 bc	83.7 a	14.5 ab	14.0 ab	11.3 bc
T_1M_3	461.3 cde	8.91 def	68.4 bc	13.6 bc	12.5 bc	10.6 cd
T_2M_0	266.6 f	9.10 de	43.5 e	12.1 ef	10.7 d	6.20 f
T_2M_1	486.5 bc	10.1 abc	66.0 bc	13.6 c	13.4 ab	11.1 bc
T_2M_2	532.3 a	10.9 a	86.2 a	14.6 a	14.6 a	12.4 a
T_2M_3	426.0 e	10.2 abc	71.7 b	14.0 abc	13.0 b	9.95 de
T_3M_0	258.4 f	8.07 f	58.7 cd	11.9 f	14.0 ab	6.03 f
T_3M_1	426.5 e	8.81 def	51.1 de	13.2 cd	10.6 d	9.55 e
T_3M_2	441.4 e	9.11 de	60.3 cd	12.7 de	10.7 d	10.0 de
T_3M_3	512.2 ab	10.4 ab	65.2 bc	13.8 bc	11.5 cd	11.6 b
$LSD_{(0.05)}$	**32.94**	**0.78**	**10.0**	**0.76**	**1.41**	**0.738**
Level of significance	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
CV(%)	**4.69**	**4.87**	**9.41**	**4.39**	**6.75**	**4.57**

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

T_1: Planting at 13 November, 2011

T_2: Planting at 23 November, 2011

T_3: Planting at 03 December, 2011

M_0: Control i.e. no manure application

M_1: Cowdung @ 15 t/ha

M_2: Poultry Manure @ 12 t/ha

M_3: Vermicompost @ 13 t/ha

4.11 Number of secondary curd per plant

Different planting time of broccoli varied significantly for number of secondary curd per plant (Appendix VI). The maximum number of secondary curd per plant (3.20) was recorded from T_1 which was statistically similar (3.16) with T_2, while the minimum number (2.71) was recorded from T_3 (Figur 6). Moel (1992) reported that number of secondary curd (3.22) was obtained from the early planted trial.

Significant variation was recorded for different organic manure on number of secondary curd per plant of broccoli (Appendix VI). The maximum number of secondary curd per plant (3.48) was found from M_2, which was statistically identical (3.42) with M_3, again the minimum number (2.21) was recorded from M_0 (Figure 7). Abou *et al*. (2006) reported that the highest number of secondary curd of broccoli plants supplied with 100% cattle manure.

Planting time and organic manure showed significant differences due to their combined effect number of secondary curd per plant (Appendix VI). The maximum number of secondary curd per plant (3.85) was recorded from T_1M_2, whereas the minimum number (2.12) was recorded from T_1M_0 (Figure 8).

4.12 Weight of secondary card per plant

Significant variation was recorded for weight of secondary curd per plant for different planting time of broccoli (Appendix VI). The highest weight of secondary curd per plant (66.8 g) was attained from T_2 which was statistically similar (63.1 g) with T_1 and the lowest weight (58.8 g) was found from T_3 (Table 8). Khatun *et al.* (2012) also reported similar findings from earlier experiment.

Application of different organic manure showed significant variation on weight of secondary curd per plant of broccoli (Appendix VI). The highest weight of secondary curd per plant (76.7 g) was recorded from M_2, which was closely followed (68.4 g) with M_3. On the other hand the lowest weight (47.8 g) was found from M_0 (Table 8).

Weight of secondary curd per plant varied significantly due to the combined effect of different planting time and organic manure (Appendix VI). The highest weight of secondary curd per plant (86.2 g) was attained from T_2M_2 and the lowest weight (41.1 g) was found from T_1M_0 (Table 9).

4.13 Dry matter content of leaves

Dry matter content of leaves varied significantly for different planting time of broccoli (Appendix VI). The highest dry matter content of leaves (13.6 g) was recorded from T_2 which was statistically similar (13.2 g) with T_1, while the lowest (12.9 g) was recorded from T_3 (Table 8). Diputado and Nichols (1989) reported that total dry weight production varied with sowing dates and with cultivars.

Different organic manure showed significant variation on dry matter content of leaves of broccoli (Appendix VI). The highest dry matter content of leaves (13.9 g) was recorded from M_2, which was statistically identical (13.8 g) with M_3 and closely followed (13.4 g) by M_1, again the lowest (11.8 g) was recorded from M_0 (Table 8).

Combined effect of different planting time and organic manure showed significant differences on dry matter content of leaves (Appendix VI). The highest dry matter content of leaves (14.6 g) was recorded from T_2M_2 and the lowest weight (11.5 g) was recorded from T_1M_0 (Table 9).

4.14 Dry matter content of curd

Planting time of broccoli varied significantly for dry matter content of curd (Appendix VI). The highest dry matter content of curd (12.9 g) was recorded from T_2 which was statistically similar (12.3 g) with T_1, whereas the lowest (11.7 g) was found from T_3 (Table 8). Diputado and Nichols (1989) reported that the head dry weight production varied with sowing dates and with cultivars.

Significant variation was recorded for different organic manure in terms of dry matter content of curd of broccoli (Appendix VI). The highest dry matter content of curd (13.1 g) was found from M_2, which was statistically identical (12.3 g) with M_3, while the lowest (11.6 g) was attained from M_0, which was statistically similar (12.2 g) with M_1 (Table 8).

Significant variation was recorded due to combined effect of different planting time and organic manure on dry matter content of curd (Appendix VI). The highest dry matter content of curd (14.6 g) was recorded from T_2M_2, while the lowest weight (10.0 g) was attained from T_1M_0 (Table 9).

4.15 Yield per plot

Statistically significant variation was recorded for yield per plot of broccoli due to different planting time (Appendix VI). The highest yield per plot (9.89 kg) was found from T_2, whereas the lowest (9.26 kg) was recorded from T_3 which was statistically similar (9.50 kg) with T_1 (Table 8). Khatun *et al.* (2012) also reported similar findings from earlier experiment.

Yield per plot of broccoli varied significantly for different organic manure under the present trial (Appendix VI). The highest yield per plot (11.2 kg) was recorded from M_2, while the lowest (6.03 kg) was found from M_0 (Table 8).

Different planting time and organic manure showed significant differences due to their combined effect in terms of yield per plot (Appendix VI). The highest yield per plot (12.4 kg) was attained from T_2M_2 and the lowest (5.99 kg) was found from T_1M_0 (Table 9).

4.16 Yield per hectare

Yield per hectare of broccoli varied significantly for different planting time of broccoli (Appendix VI). The highest yield per hectare (10.6 ton) was recorded from T_2, while the lowest (9.91 ton) was recorded from T_3 which was statistically similar (10.2 ton) with T_1 (Figure 9). The yield of the crop, for obvious reason, depends on the environmental conditions prevailing during the growing season in a particular place. Ahmed and Abdullah (1986) reported that highest yield was obtained from the crop planted on October 15 followed by November 1, while September 15 planting produced the lowest yield.

Significant variation was recorded for different organic manure in for yield per hectare of broccoli (Appendix VI). The highest yield per hectare (12.0 ton) was found from M_2, which was closely followed (11.4 ton) by M_3, whereas the lowest (6.45 ton) was recorded from M_0 (Figure 10). Hochmuth *et al.* (1993) reported that 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. Akter *et al*. (1996) reported that the highest curd yield of 20.70 and 16.75 tons per hectare were obtained with poultry manure and cowdung against 9.0 tons per hectare in the control treatment. Abou *et al*. (2006) reported that the highest total yield and quality of broccoli were recorded by adding poultry manure in the two seasons.

Yield per hectare of broccoli showed significant differences due to the combined effect of different planting time and organic manure (Appendix VI). The highest yield per hectare (13.2 ton) was recorded from T_2M_2, whereas the lowest (5.48 ton) was recorded from T_1M_0 (Figure 11). It was revealed that planting at 23 November, 2011 and poultry manure @ 5 t/ha ensured the highest vegetative growth as well as highest yield of broccoli under this trial.

4.17 Economic analysis

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

4.17.1 Gross return

The combination of different planting time and organic manure showed different value in terms of gross return under the trial (Table 10). The highest gross return (Tk. 396,000) was obtained from the treatment combination T_2M_2 and the second highest gross return (Tk. 363,000) was found in T_1M_2. The lowest gross return (Tk. 164,400) was obtained from T_1M_0.

4.17.2 Net return

In case of net return, different planting time and organic manure showed different levels of net return under the present trial (Table 10). The highest net return (Tk. 224,854) was found from the treatment combination T_2M_2 and the second highest net return (Tk. 191,854) was obtained from the combination T_1M_2. The lowest (Tk. 33,700) net return was obtained T_1M_0.

4.17.3 Benefit cost ratio

In the different planting time and organic manure the highest benefit cost ratio (2.31) was noted from the combination of T_2M_2 and the second highest benefit cost ratio (2.15) was estimated from the combination of T_2M_1 and the lowest benefit cost ratio (1.26) was obtained from T_1M_0 (Table 10). From economic point of view, it is apparent from the above results that the combination of T_2M_2 was more profitable treatment combination than rest of the combination.

Table 10. Cost and return of broccoli cultivation as influenced by planting time and organic manure

Treatment	Cost of production (Tk./ha)	Yield of Broccoli (t/ha)	Gross return (Tk./ha)	Net return (Tk./ha)	Benefit cost Ratio
T_1M_0	130,700	5.48	164,400	33,700	1.26
T_1M_1	164,405	10.8	324,000	159,595	1.97
T_1M_2	171,146	12.1	363,000	191,854	2.12
T_1M_3	189,122	11.3	339,000	149,878	1.79
T_2M_0	130,700	6.63	198,900	68,200	1.52
T_2M_1	164,405	11.8	354,000	189,595	2.15
T_2M_2	171,146	13.2	396,000	224,854	2.31
T_2M_3	189,122	10.7	321,000	131,878	1.70
T_3M_0	130,700	6.32	189,600	58,900	1.45
T_3M_1	164,405	10.2	306,000	141,595	1.86
T_3M_2	171,146	10.7	321,000	149,854	1.88
T_3M_3	189,122	12.4	372,000	182,878	1.97

T_1: Planting at 13 November, 2011

T_2: Planting at 23 November, 2011

T_3: Planting at 03 December, 2011

M_0: Control i.e. no manure application

M_1: Cowdung @ 15 t/ha

M_2: Poultry Manure @ 12 t/ha

M_3: Vermicompost @ 13 t/ha

Market price of broccoli @ Tk. 30,000/ton

Gross return = Total yield (t/ha) × Tk. 30,000

Net return = Gross return - Total cost of production

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

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the Horticulture Research Farm of Sher-e-Bangla Agricultural University (SAU), Dhaka during the period from October 2011 to March 2012 to observe the effect of planting time and organic manure on growth and yield of broccoli. The test crop used in the experiment was broccoli variety Premium. The experiment consisted of two factors: Factor A: Planting time (three levels) as T_1: Planting at 13 November, 2011; T_2: Planting at 23 November, 2011; T_3: Planting at 03 December, 2011 and Factor B: Organic manure (four levels) as M_0: Control i.e. no manure application; M_1: Cowdung @ 15 t/ha; M_2: Poultry Manure @ 12 t/ha and M_3: Vermicompost @ 13 t/ha. There were 12 (3 × 4) treatments combination. Data on different growth and yield parameter were recorded and significant variation was recorded for each of the parameters.

In planting time, at 20, 40, 60 and 80 DAT and at harvest the tallest plant (20.0 cm, 28.3 cm, 40.9 cm, 51.6 cm and 52.8 cm) was recorded from T_2, whereas the shortest plant (14.5 cm, 23.5 cm, 32.6 cm, 42.4 cm and 43.8 cm) was recorded from T_3. At 20, 40, 60 and 80 DAT and at harvest the maximum number of leaves per plant (5.6, 8.2, 12.8, 14.3 and 16.9) was recorded from T_2, again the minimum number (3.88, 6.14, 10.6, 12.1 and 13.7) was recorded from T_3. The minimum days from transplanting to first visible card (52.3) was found from T_3 and the maximum days (55.2) was recorded from T_1. The highest length of stem (24.7 cm) was recorded from T_2, while the lowest (20.7 cm) was recorded from T_3. The highest diameter of stem (3.80 cm) was recorded from T_2, again the lowest (3.27 cm) was recorded from T_3. The maximum fresh weight of leaves per plant (230.9 g) was recorded from T_1, while the minimum fresh weight (197.8 g) was attained from T_3. The highest length of root (24.8 cm) was recorded from T_2, whereas the lowest length (21.8 cm) was found from T_3. The maximum fresh weight of roots per plant (23.1 g) was found from T_1, again the minimum fresh weight (19.1 g) was attained

from T_3. The highest weight of primary curd per plant (427.8 g) was recorded from T_2, while the lowest weight (404.2 g) was recorded from T_3. The highest diameter of primary curd (10.1 cm) was recorded from T_2, whereas the lowest diameter (9.10 cm) was recorded from T_3. The maximum number of secondary curd per plant (3.20) was recorded from T_1, while the minimum number (2.71) was recorded from T_3. The highest weight of secondary curd per plant (66.8 g) was attained from T_2, again the lowest weight (58.8 g) was found from T_3. The highest dry matter content of leaves (13.6 g) was recorded from T_2, while the lowest (12.9 g) was recorded from T_3. The highest dry matter content of curd (12.9 g) was recorded from T_2, whereas the lowest (11.7 g) was found from T_3. The highest yield per plot (9.89 kg) was found from T_2, whereas the lowest (9.26 kg) was recorded from T_3. The highest yield per hectare (10.6 ton) was recorded from T_2, while the lowest (9.91 ton) was recorded from T_3.

For organic manure, at 20, 40, 60 and 80 DAT and harvest the tallest plant (20.3 cm, 30.0 cm, 41.5 cm, 51.9 cm and 54.4 cm) was found from M_2, while the shortest plant (13.3 cm, 20.5 cm, 31.4 cm, 40.8 cm and 41.3 cm) was obtained from M_0. At 20, 40, 60 and 80 DAT and harvest the maximum number of leaves per plant (5.31, 8.09, 13.2, 14.5 and 17.6) was recorded from M_2 and the minimum number (5.04, 7.24, 12.2, 13.4 and 15.6) was recorded from M_0. The minimum days from transplanting to first visible curd (50.6) was recorded from M_2, whereas the maximum days (58.9) was found from M_0. The highest length of stem (26.2 cm) was recorded from M_2, and the lowest length (16.4 cm) was recorded from M_0. The highest diameter of stem (4.07 cm) was recorded from M_2, while the lowest diameter (3.07 cm) from M_0. The maximum fresh weight of leaves per plant (246.2 g) was recorded from M_2 and the minimum fresh weight (178.0 g) was found from M_0. The highest length of root (25.3 cm) was attained from M_2, while the lowest length (20.5 cm) was recorded from M_0. The maximum fresh weight of roots per plant (23.0 g) was recorded from M_2, again the minimum fresh weight (19.4 g) was found from M_0. The highest weight of primary curd per plant (484.7 g) was attained from M_2, whereas the lowest weight (253.9 g) was found from M_0. The highest

diameter of primary curd (10.0 cm) was found from M_2, while the lowest diameter (8.56 cm) was attained from M_0. The maximum number of secondary curd per plant (3.48) was found from M_2, again the minimum number (2.21) was recorded from M_0. The highest weight of secondary curd per plant (76.7 g) was recorded from M_2 and the lowest weight (47.8 g) was found from M_0. The highest dry matter content of leaves (13.9 g) was recorded from M_2 and the lowest (11.8 g) was recorded from M_0. The highest dry matter content of curd (13.1 g) was found from M_2, while the lowest (11.6 g) was attained from M_0. The highest yield per plot (11.2 kg) was recorded from M_2, while the lowest (6.03 kg) was found from M_0. The highest yield per hectare (12.0 ton) was found from M_2, and the lowest (6.45 ton) was recorded from M_0.

Due to the interaction effect of planting time and organic manure, at 20, 40, 60 and 80 DAT and harvest the tallest plant (24.4 cm, 33.8 cm, 47.3 cm, 57.8 cm and 61.3 cm) was recorded from T_2M_2, while the shortest (12.2 cm, 19.4 cm, 30.3 cm, 39.0 cm and 40.6 cm) was found from T_1M_0. At 20, 40, 60 and 80 DAT and harvest the maximum number of leaves per plant (6.47, 9.40, 15.1, 16.1 and 19.4) was recorded from T_2M_2 and the minimum number (4.00, 5.87, 9.43, 10.5 and 10.9) was recorded from T_1M_0. The minimum days from transplanting to first visible curd (44.7) was attained from T_2M_2 and the maximum days (62.0) was found from T_1M_0. The highest length of stem (29.8 cm) was recorded from T_2M_2, again the lowest length (14.8 cm) was recorded from T_1M_0. The highest diameter of stem (4.23 cm) was found from T_2M_2, whereas the lowest diameter (2.57 cm) was recorded from T_1M_0. The maximum fresh weight of leaves per plant (273.1 g) was recorded from T_1M_2, while the minimum fresh weight (171.2 g) from T_1M_0. The highest length of root (27.9 cm) was found from T_1M_2, while the lowest length (19.4 cm) was recorded from T_1M_0. The maximum fresh weight of roots per plant (25.4 g) was found from T_1M_2, whereas the minimum fresh weight (18.3 g) was recorded from T_1M_0. The highest weight of primary curd per plant (532.3 g) was found from T_2M_2 and the lowest weight (236.8 g) was recorded from T_1M_0. The highest diameter of primary curd (10.9 cm) was recorded from T_2M_2, while the

lowest diameter (8.07 cm) was found from T_3M_0. The maximum number of secondary curd per plant (3.85) was recorded from T_1M_2, whereas the minimum number (2.12) was recorded from T_1M_0. The highest weight of secondary curd per plant (86.2 g) was attained from T_2M_2 and the lowest weight (41.1 g) was found from T_1M_0. The highest dry matter content of leaves (14.6 g) was recorded from T_2M_2 and the lowest weight (11.5 g) was recorded from T_1M_0. The highest dry matter content of curd (14.6 g) was recorded from T_2M_2, while the lowest weight (10.0 g) was attained from T_1M_0. The highest yield per plot (12.4 kg) was attained from T_2M_2 and the lowest (5.99 kg) was found from T_1M_0. The highest yield per hectare (13.2 ton) was recorded from T_2M_2, whereas the lowest (5.48 ton) was recorded from T_1M_0.

The highest gross return (Tk. 396,000) was obtained from the treatment combination T_2M_2 and the lowest gross return (Tk. 164,400) was obtained from T_1M_0. The highest net return (Tk. 224,854) was found from the treatment combination T_2M_2 and the lowest (Tk. 33,700) net return was obtained T_1M_0. In the different planting time and organic manure the highest benefit cost ratio (2.31) was noted from the combination of T_2M_2 and the lowest benefit cost ratio (1.26) was obtained from T_1M_0.

It was revealed that the above results that the combination of T_2M_2 was more suitable in consideration of yield contributing characters and yield and consideration value for money concept.

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

1. Another experiment may be carried out with another planting time.
2. Different level of organic manure may be used for further study.
3. Such study is needed in different agro-ecological zones (AEZ) of Bangladesh for regional compliance and other performance.

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APPENDICES

Appendix I. Characteristics of the soil of experimental field analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

A. Morphological characteristics of the soil of experimental field

Morphological features	Characteristics
Location	Horticulture Garden , 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: SRDI, 2012

Appendix II. Monthly record of air temperature, rainfall, relative humidity, rainfall and sunshine of the experimental site during the period from October, 2011 to March, 2012

Month	*Air temperature (°c)		*Relative humidity (%)	*Rainfall (mm)	*Sunshine (hr)
	Maximum	Minimum			
October, 2011	26.5	19.4	81	22	6.9
November, 2011	25.8	16.0	78	00	6.8
December, 2011	22.4	13.5	74	00	6.3
January, 2012	24.5	12.4	68	00	5.7
February, 2012	27.1	16.7	67	30	6.7
March, 2012	31.4	19.6	54	11	8.2

* Monthly average,

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

Appendix III. Analysis of variance of the data on plant height of broccoli at different days after transplanting (DAT) as influenced by planting time and organic manure

Source of variation	Degrees of freedom	Mean square				
		Plant height (cm) at				
		20 DAT	40 DAT	60 DAT	80 DAT	Harvest
Replication	2	0.909	4.911	4.009	14.717	0.626
Planting time (A)	2	95.998**	72.677**	242.491**	283.628**	557.402**
Organic manure (B)	3	92.446**	155.279**	176.820**	229.701**	604.977**
Interaction (A×B)	6	15.535**	18.203*	38.484*	41.104*	151.939**
Error	22	3.379	5.697	14.017	15.338	28.518

**: Significant at 0.01 level of significance; *: Significant at 0.05 level of significance

Appendix IV. Analysis of variance of the data on number of leaves per plant of broccoli at different days after transplanting (DAT) as influenced by planting time and organic manure

Source of variation	Degrees of freedom	Mean square				
		Number of leaves per plant at				
		20 DAT	40 DAT	60 DAT	80 DAT	Harvest
Replication	2	0.030	0.220	0.121	0.023	0.381
Planting time (A)	2	10.162**	14.620**	15.202**	7.093**	30.154**
Organic manure (B)	3	2.257**	6.244**	21.736**	49.905**	95.793**
Interaction (A×B)	6	1.577**	2.777**	2.550**	1.585**	7.014**
Error	22	0.223	0.359	0.399	0.345	2.097

**: Significant at 0.01 level of significance;

Appendix V. Analysis of variance of the data on yield contributing characters of broccoli as influenced by planting time and organic manure

Source of variation	Degrees of freedom	Mean square					
		Days from transplanting to curd Initiation	Length of stem (cm)	Diameter of stem (cm)	Fresh weight of leaves per plant (g)	Length of root (cm)	Fresh weight of roots per plant (g)
Replication	2	0.778	1.308	0.062	101.553	0.932	0.993
Planting time (A)	2	25.528*	53.383**	1.056**	3850.981**	29.864**	60.762**
Organic manure (B)	3	116.63**	186.403**	1.802**	8095.066**	41.703**	25.428**
Interaction (A×B)	6	60.380**	37.951**	0.106*	802.199*	15.720**	10.636**
Error	22	6.566	3.563	0.080	278.046	2.655	3.049

**: Significant at 0.01 level of significance; *: Significant at 0.05 level of significance

Appendix VI. Analysis of variance of the data on yield contributing characters and yield of broccoli as influenced by planting time and organic manure

Source of variation	Degrees of freedom	Mean square							
		Weight of primary curd (g)	Diameter of primary curd (cm)	Number of secondary curd	Weight of secondary curd per plant (g)	Dry matter content of leaves (g)	Dry matter content of curd (g)	Yield per plot (kg)	Yield per hectare (ton)
Replication	2	94.034	0.136	0.004	75.993	0.138	0.028	0.116	0.133
Planting time (A)	2	1742.17**	3.399**	0.880**	191.96**	1.356**	4.607**	1.223**	1.399**
Organic manure (B)	3	104814.0**	3.764**	3.075**	1402.11**	8.295**	3.593**	50.954**	58.284**
Interaction (A×B)	6	4542.98**	0.995**	0.172**	296.553**	0.810**	10.224v	2.195**	2.511**
Error	22	378.326	0.212	0.040	35.048	0.201	0.689	0.190	0.218

**: Significant at 0.01 level of significance; *: Significant at 0.05 level of significance

Appendix VIII. Per hectare production cost of broccoli as influenced by planting time and organic manure

A. Input cost

Treatment Combination	Labour Cost	Ploughing cost	Seed Cost	Insecticide/ pesticides	Irrigation	Organic Manure			Sub Total (A)
						Cowdung	Poultry Manure	Vermicompost	
T_1M_0	24,000	15,000	5,000	4,000	15,000	0	0	0	63,000
T_1M_1	24,000	15,000	5,000	4,000	15,000	30,000	0	0	93,000
T_1M_2	24,000	15,000	5,000	4,000	15,000	0	36,000	0	99,000
T_1M_3	24,000	15,000	5,000	4,000	15,000	0	0	52,000	115,000
T_2M_0	24,000	15,000	5,000	4,000	15,000	0	0	0	63,000
T_2M_1	24,000	15,000	5,000	4,000	15,000	30,000	0	0	93,000
T_2M_2	24,000	15,000	5,000	4,000	15,000	0	36,000	0	99,000
T_2M_3	24,000	15,000	5,000	4,000	15,000	0	0	52,000	115,000
T_3M_0	24,000	15,000	5,000	4,000	15,000	0	0	0	63,000
T_3M_1	24,000	15,000	5,000	4,000	15,000	30,000	0	0	93,000
T_3M_2	24,000	15,000	5,000	4,000	15,000	0	36,000	0	99,000
T_3M_3	24,000	15,000	5,000	4,000	15,000	0	0	52,000	115,000

T_1: Planting at 13 November, 2011 M_0: Control i.e. no manure application Cowdung @ Tk. 2/kk

T_2: Planting at 23 November, 2011 M_1: Cowdung @ 15 t/ha Poultry manure @ Tk. 3/ka

T_3: Planting at 03 December, 2011 M_2: Poultry Manure @ 12 t/ha Vermicompost @ Tk. 40/kg

M_3: Vermicompost @ 13 t/ha

Appendix VIII. Contd.

B. Overhead cost (Tk./ha)

Treatment Combination	Cost of lease of land for 6 months (14.0% of value of land Tk. 800,000/year	Miscellaneous cost (Tk. 5% of the input cost	Interest on running capital for 6 months (Tk. 14.0% of cost/year	Sub total (Tk) (B)	Total cost of production (Tk./ha) [Input cost (A)+ overhead cost (B)]
T_1M_0	56,000	3,150	8,551	67,701	130,701
T_1M_1	56,000	4,650	10,756	71,406	164,406
T_1M_2	56,000	4,950	11,197	72,147	171,147
T_1M_3	56,000	5,750	12,373	74,123	189,123
T_2M_0	56,000	3,150	8,551	67,701	130,701
T_2M_1	56,000	4,650	10,756	71,406	164,406
T_2M_2	56,000	4,950	11,197	72,147	171,147
T_2M_3	56,000	5,750	12,373	74,123	189,123
T_3M_0	56,000	3,150	8,551	67,701	130,701
T_3M_1	56,000	4,650	10,756	71,406	164,406
T_3M_2	56,000	4,950	11,197	72,147	171,147
T_3M_3	56,000	5,750	12,373	74,123	189,123

T_1: Planting at 13 November, 2011

T_2: Planting at 23 November, 2011

T_3: Planting at 03 December, 2011

M_0: Control i.e. no manure application

M_1: Cowdung @ 15 t/ha

M_2: Poultry Manure @ 12 t/ha

M_3: Vermicompost @ 13 t/ha