EFFECT OF ORGANIC MANURES AND MULCHING ON GROWTH AND YIELD OF BROCCOLI

MD. MEFTAUL ISLAM

.

DEPARTMENT OF HORTICULTURE
SHER-E-BANGLA AGRICULTURAL UNIVERSITY
DHAKA- 1207

JUNE, 2013

EFFECT OF ORGANIC MANURES AND MULCHING ON GROWTH AND YIELD OF BROCCOLI

BY

MD. MEFTAUL ISLAM
REGISTRATION NO. 06-02081

A Thesis

Submitted to the Dept. of Horticulture, Faculty of Agriculture,
Sher-e-Bangla Agricultural University, Dhaka-1207
in partial fulfillment of the requirements
for the degree
of

MASTER OF SCIENCE (MS)
IN
HORTICULTURE

SEMESTER: JANUARY-JUNE 2013

Approved by:

Prof. Dr. Md. Nazrul Islam	**Prof. Md. Hasanuzzaman Akand**
Department of Horticulture	Department of Horticulture
Sher-e-Bangla Agricultural University	Sher-e-Bangla Agricultural University
Supervisor	**Co-Supervisor**

Prof. Md. Hasanuzzaman Akand
Chairman
Examination Committee

DEPARTMENT OF HORTICULTURE
Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka-1207
Bangladesh

PABX: +88029144270-9
Ext. 309 (Off.)
Fax: +88029112649
e-mail:
bioc_sau@ymail.com

Ref :
Date:

CERTIFICATE

This is to certify that the thesis entitled, "**EFFECT OF ORGANIC MANURES AND MULCHING ON GROWTH AND YIELD OF BROCCOLI**" submitted to the Faculty of Agriculture, 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 **MD. MEFTAUL ISLAM**, Registration No. **06-02081** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.

Dated: June, 2013
Place: Dhaka, Bangladesh

……..……..……
Prof. Dr. Md. Nazrul Islam
Department of Horticulture
Sher-e-Bangla Agricultural University
Supervisor


DEDICATED
TO MY
BELOVED
PARENTS

EFFECT OF ORGANIC MANURES AND MULCHING ON GROWTH AND YIELD OF BROCCOLI

BY

MD. MEFTAUL ISLAM

ABSTRACT

An experiment was conducted at the Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka, during October 2011 to March 2012. The experiment consisted of two factors, Factor A: Three levels of organic manures, viz. O_0 = Control; O_1 = Cowdung (25 t ha^{-1}) and O_2 = Spent Mushroom compost (17 t ha^{-1}), and Factor B: Four types of mulching, viz. M_0 = Control, M_1 = Black polythene, M_2 = Water hyacinth and M_3 = Rice straw. The experiment was laid out in randomized complete block design with three replications. The highest stem length of curd, crown length, diameter and weight of primary curd $plant^{-1}$, number and weight of secondary curds $plant^{-1}$ and yield (16.99 t/ha) were obtained from O_2 while the lowest from O_0. The highest stem length of curd, crown length, diameter and weight of primary curd $plant^{-1}$, number and weight of secondary curds $plant^{-1}$ and yield (14.58 t/ha) were obtained from M_2 while the lowest from M_0. For combined effect, the highest curd yield (18.28 t/ha) was obtained from O_2M_2 and lowest from O_0M_0. So, it can be concluded that 17 t/ha spent mushroom compost with water hyacinth mulch is suitable for broccoli cultivation.

ACKNOWLEDGEMENTS

*All praises are devoted to **Almighty Allah**, the most gracious, the most merciful, the beneficent, the lord of the Day of Judgment and the supreme ruler of the universe, Who enabled the author to complete the thesis successfully for the degree of Master of Science (MS) in Horticulture.*

*The author expresses his deepest sense of gratitude, immense indebtedness and profound appreciation to his research supervisor **Dr. Md. Nazrul Islam**, Professor, Department of Horticulture, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka for planning the research work, vigilant supervision, constructive suggestions, sympathetic encouragement to conduct the research work as well as preparation and for going through the manuscript of the thesis.*

*He also expresses his grateful appreciation and deep sense of respect to his research co-supervisor **Prof Md. Hasanuzzaman Akand,** Chairman, Department of Horticulture, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka for proper guidance, continuous advice, painstaking suggestions, kind help and worthfull encouragement during the course of research work and preparation of this manuscript.*

The author also express his heartfelt thanks to Professor Md. Ruhul Amin, Assistant Professor Arfan Ali, and Shormin Chowdhuri, Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka for their inspiration, valuable suggestions and constant encouragement during the period of study and preparing the manuscript.

The author extremely indebted Dr. Noor Jahan Begum, Professor, Department of Agricultural Chemistry, Sher-e-Bangla Agricultural University, Dhaka for her co-operation and generous help in preparing the manuscript. It is worthwhile to mention Md. Harun-Ur-Rashid, Assistant Professor, Department of Genetics and Plant Breeding, Sher-e-Bangla Agricultural University, Dhaka for his cordial co-operation.

Grateful thanks are expressed to all of his friends especially Md. Dulal Sarkar, Md. Hafizur Rahman, Sharmin sultana, Syfullah shahriar, Md. Javed Azad and Ruhul Amin for their active encouragement, inspiration, direct and indirect help in the endeavor to complete this thesis.

At last but not the least, the author wishes to express his profound gratitude and deepest appreciation to his parents and all other maternal and paternal relatives for their ever ending prayer, encouragement, sacrifice and dedicated efforts to educate his to this level.

The Author

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ACRONYMS

ABBREVIATIONS	ELABORATIONS
%	Percent
@	At the rate
°C	Degree centigrade
AEZ	Agro-Ecological Zone
BARI	Bangladesh Agricultural Research Institute
BAU	Bangladesh Agricultural University
BBS	Bangladesh Bureau of Statistics
CGR	Crop Growth Rate
CV	Coefficient of Variation
DAT	Days After Transplanting
et al.	And others
etc.	Etcetera
FAO	Food and Agriculture Organization
LAI	Leaf Area Index
LSD	Least Significant Difference
MOA	Ministry of Agriculture
MSTAT	Michigan State University Statistical Package for Data Analysis
NAR	Net Assimilation Rate
pH	Hydrogen ion concentration
RGR	Relative Growth Rate
RCBD	Randomized Complete Block Design
SMC	Spent Mushroom Compost
UNDP	United Nations Development Program

CHAPTER-I

INTRODUCTION

Broccoli (*Brassica oleracia* var. *botrytis* L) is an important cole crops belongs to the family Brassicacae. There are three classes of broccoli, i.e. green, white and purple, among them green type broccoli is the most popular (Shoemaker, 1962). It is a minor vegetable in Bangladesh and commercial cultivation of broccoli has increased especially in the area of Dhaka and Gazipur districts.

Broccoli contains a high amount of vitamin A, ascorbic acid and appreciable amounts of thiamin, riboflavin, niacin, calcium and iron (Thompson and Kelly, 1957; Lincolin, 1987). Analytical data presented by Nonnecke (1989) showed that sprouting broccoli contains more vitamins and minerals than those of other cole crops. Therefore, it can be met up some degree of vitamin A and vitamin C requirement and can contribute to solve malnutrition problem in Bangladesh. 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 per capita consumption is only about 30g but it is 70 g with potato and sweet potato. It is an alarming situation for vegetable consumption in Bangladesh. So, a large-scale production of broccoli can help to increase vegetable consumption.

Broccoli is environmentally better adapted than cauliflower and is reported to withstand comparatively at higher temperature than cauliflower (Rashid, 1976). Broccoli can be grown on a wide range of soil types, ranging from light sand to heavy loam or, even clay that are well supplied with organic matter (Katayal, 1994). Successful production of broccoli depends on various factors. Fertilizer and moisture management are the most important factors, which assured crop production.

Organic manure is a source of food for the innumerable number of micro organisms and creatures like earthworm who breaks down these to micronutrients, which are easily absorbed by the plants.

Organic manures play major role in plant growth as a source of all necessary macro and micronutrients in available forms during mineralization and improving physical and chemical properties of soils (Chaterjee *et al.,* 2005). Organic manures such as cowdung, poultry manure, vermicompost and spent mushroom compost (SMC) improves the soil structure, aeration, slow release nutrient which support root development leading to higher growth and yield of broccoli (Abou *et al*., 2006).

Broccoli is cultivated in Bangladesh during the winter season when rainfall is scanty. It requires 250-300 mm water during transplanting, growing period and curd formation stage (Rashid, 1976). In most of the time irrigation increase the cost of production resulting in unprofitable production of broccoli and make growers frustrated. Mulching can minimize the requirement of water and helps in retaining moisture (Amal *et al.* 1990). Mulches also reduce the water loss from the soil by evaporation and reduce the irrigation requirements (Prihar *et al.* 1986; Amal *et al.* 1990 and Vanderwerken *et al.* 1988). Therefore, mulching may be helpful in conserving soil moisture of the preceding season and may be exploited to produce broccoli successfully particularly where rainfall and irrigation facilities are scarce. The aim of the investigation was to evaluate the growth and yield performance of broccoli influenced by organic manures and mulching.

Considering above factors, the present study was undertaken with the following objectives:

i) To find out the effect of different organic manures on growth and yield of broccoli
ii) To study the effect of different mulching materials on growth and yield of broccoli
iii) To find out the suitable combination of organic manure and mulching material on growth and yield of broccoli

CHAPTER-II

REVIEW OF LITERATURE

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

2.1 Fertilizer requirement:

Ahlawat *et al*. (2006) conducted a field experiment to study the effects of spent mushroom substrate (SMS) recomposed by different methods and mixed with arable soil on the vegetative growth, yield and quality attributes of cauliflower (*Brassica oleracea* var. *botrytis* cv. *Pusa Snowball*-1) were studied. Mixing of anaerobically recomposed SMS at 2.5 kg/m + chemical fertilizers (N, P and K at 12.5, 7.5 and 6.5 g/m2, respectively) significantly enhanced vegetative growth during curd harvesting, gross and net yields, and quality attributes, and reduced the incidence of black rot disease and larval infestation. The mortality of plants during seedling transplanting was also lower under anaerobic SMS treatments. Thus, the use of anaerobically recomposed SMS with chemical fertilizers for cauliflower cultivation was found to be a better option of SMS disposal and raising high quality vegetable crops.

An experiment was conducted in BARI to investigate the effect of chemical fertilizer and manure on the yield of cabbage, with the findings that the application of NPKS and cow dung increased the yield component and head yield significantly, whereas the effect of Zn and Mo was beneficial. The highest head yield of 75t/ha was recorded in treatment N_{120} P_{100} S_{30} Zn_5 M_{O1} kg/ha along with cow dung 5 t/ha (Anonymous. 1988).

Babik *et al*. (2005) conducted a field experiment to study the effects of compost of plant materials as substrate and soil amendment on the growth and yield of greenhouse lettuce and field broccoli. Addition of compost at 10% of peat substrate as growing media for greenhouse lettuce significantly increased the yield and head size of lettuce compared to mineral fertilizer application

only. Higher amount of compost added to substrate did not result in higher yield of lettuce. Compost rich in phosphorus and potassium secured luxury uptake of these nutrients and nitrogen as well, but nitrate content in lettuce heads was much lower. Compost application rates of 20-40 t/ha in field production of broccoli was not sufficient for high yield, mainly due to too low content of easy available nitrogen and simultaneously high level of potassium and phosphorus. In field production of vegetables, application of compost is recommended every second year and nitrogen should be supplemented with mineral fertilizers.

Boari *et al*. (2010) conducted a field experiment to study the effects of fertilization and cultivar on yield and quality of broccoli in organic farming, are reported. The research was carried out during 2004-05. Three levels of organic fertilization (0-40 and 80 kg ha-1 of Aminosprint, respectively indicated with F1-F2 and F3) on 4 cultivar of broccoli, were compared. Any effect of fertilization levels was observed on broccoli yield and quality, probably because of low quantity of main nutritional elements contained in the Aminosprint. The most productive cultivar was 'Chevalier'. The nitrate content was low mainly in 'Lord', 'Marathon' and 'Chevalier', and a good ascorbic acid content was observed in 'Chevalier' and 'Switch'.

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

Campaneili *et al*. (2010) conducted an interdisciplinary study about a horticultural crop rotation managed by the organic agriculture method of cultivation and by the conventional method has been started at CRA Horticulture Research Unit of Monsampolo del Tronto (AP).

This work reports some results about agronomic trials of varietal adaptation, soil arthropods monitoring and qualitative characteristics of different cauliflower typologies. The agronomic trials of adaptation show very good production results in organic agriculture for fresh market tomato, muskmelon, fennel and lettuce. Qualitative analyses performed on cauliflower for 6 years point out a greater content of vitamin C in samples produced by the organic agriculture method. The results of 4 years of experimentation show how the organic cultivation of tomato increases the arthropod biodiversity, used as indicator of the soil sustainability.

Ewees, *et al*. (2008). conducted a field experiment on a clayey soil at Sinnuris district, El-Fayoum Governorate, Egypt during the two successive seasons of 2006-2007 and 2007-2008 to evaluate the response of vegetative growth, nutritional status and yield of broccoli (*Brassica oleracea* L. var. *Italica*) as well as head quality to a partial substitution of 25% N-mineral by N-organic source (chicken manure at the rates of 8, 12 and 16 ton/fed) as compared with applying 100% recommended dose of N-mineral fertilizer in the form of ammonium nitrate (33.5% N), hopping an alleviation of the possible fears of chemical pollution for such a vegetable crop and environmental risks. According to the field studies and analytical data of soil initial state, the obtained results show that the studied soil is mainly encompassing the Nile alluvium deposits as a parent material and it belongs to a taxonomic unit at a family level of "Typic haplotorrerts. fine clay, smectitic, hyperthermic" as well as it could be evaluated as moderately suitable for irrigated agriculture land, with a slight intensity degree for each of soil limitations of texture (s1), CaCO3 (s3) and gypsum (s4) as well as it was suffering from zinc deficient. From the economical point of view, data of the studied plant characters indicate that the greatest vegetative growth parameters of broccoli (i.e., leaf area plant-1, number of leaves plant-1, dry weight of leaves plant-1, dry weight of stem plant-1, leaf sugar and leaf nutritional status) were achieved by plants supplied with the combined treatment of 12 ton chicken manure/fed +75% recommended dose of N-mineral fertilizer as ammonium nitrate.

Such favorable conditions were positively reflected on the followed growth stages and gave the greatest total yield/fed (i.e., central head weight and lateral head weight), with relative increase percentages reached 13.8 and 13.9% for both seasons, respectively, as well as better quality parameters of broccoli (i.e., central head weight, lateral head weight, number of lateral heads plant-1 and sugar head) during both two studied seasons. Such beneficial conditions were more attributed with the optimum soil case of the current experiment, which was achieved by ameliorated values of soil physico-chemical properties and the nutrients status. Superiority of the applied N-mineral in combination with chicken manure was mainly attributed to the later due to it plays a direct role for improving (1) Soil hydrophysical properties (i.e., soil aggregation, bulk density, total porosity, aeration, hydraulic conductivity and available water range), (2) Soil chemical characteristics (i.e., soil pH, released organic constituents of active groups such as fulvic and humic acids which have the ability to retain the essential plant nutrients in complex and available chelate forms), (3) Soil biological conditions (i.e., a source of energy for the microorganism activities which enhance in releasing necessary nutrients in available forms throughout their mineralization) and (4) Soil fertility status (i.e., slow release for nutrients which support root development among the different growth stages), that finally leading to improve vegetative growth, chemical constituents and higher yield of broccoli with better quality heads. Moreover, the periodical application of such natural organic manure is considered the best option not only for reducing the harmful effects of using chemical fertilizers, but also for sustaining soil fertility status and help to alleviate the possible risks of environmental pollution on human health.

Jin-Yan *et al*. (2002) were carried out a pot and plot experiments in which head lettuce (*Lactuca sativa* var. *capitata*), cauliflower (*Brassica oleracea* var. *botrytis*) and lettuce (*Lactuca angustana*) were supplied with sewage sludge compound fertilizer, NPK fertilizer and sewage sludge compost. Sewage sludge compound fertilizer significantly improved vegetable yield (303%) as compared with the unfertilized control.

The contents of Cu, Zn and Cd in the esculent parts of vegetables were below the threshold stipulated in the relevant National Standards of China. Pb content was higher than the permissible level.

Kumar *et al.* (2002) conducted an experiment of the effects of molybdenum (0.5 and 1 kg sodium molybdate/ha) and boron (10 and 20 kg borax/ha), applied alone or in combination with 25 t farmyard manure (FYM)/ha, on the yield and yield components of cauliflower cv. Pusa Snowball-1 were determined in a field experiment conducted in Kullu, Himachal Pradesh, India from October to March of 1995-97. Molybdenum and boron application significantly increased curd diameter, weight and yield in the absence of FYM. Boron at 10 kg/ha and molybdenum at 0.5 kg/ha increased the yield by 32 and 14%, respectively. Application of FYM in addition to 100% recommended NPK enhanced the yield of cauliflower by about 27% compared to application of NPK alone.

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

Magro *et al.* (2010) A field experiment was conducted to study the fertilization effect in vegetable seed yield and quality, mainly in the species that have an increase in cycle due to reproductive stage, it is necessary to evaluate the nutrient level to aid in recommending fertilization that provides best productivity from high physiological potential seeds. Although there are studies about nutrition and recommendation of fertilization to broccoli (*Brassica oleracea* L. var. *italica Plenk*), rarely it finds out works that approach the nutrients effects in seed yield and quality. The objective of this work was to evaluate the organic compost influence in broccoli seed quality and yield. The experiment was lead at Sao Manuel Experimental Farm and the evaluations at Horticulture Sector in Agronomic Science School (FCA/UNESP) in Botucatu. The treatments were four organic compost levels (30, 60, 90 and 120 t ha-1), and control without organic compost. The experimental design was randomized blocks with four replications. The characteristics evaluated were seed yield and number of seed per plant further the characteristics related with seed quality: one thousand seed mass, germination test, first germination counting, index of germination speed and electrical conductivity. The regression showed a linear response in function of organic compost levels, where larger levels resulted higher yield despite the seed quality is not affected.

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

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

Munro *et al.* (1978) conducted an experiment on broccoli and Brussels sprouts and analyzed the leaf tissue of broccoli (*Brassica oleracea* spp.*italica*) cv. Waltham 29 and Brussels sprouts, cv. Jode Cross during the growing season. Plants were fertilized with 4 levels of N, P and K in factorial combination with and without FYM. Growth responses to applied N and P tended to lower tissue K levels. FYM had little effect on tissue N and only small effects on tissue P and K. Concentrations of all three nutrients declined during the growing season. Critical N, P and K levels for plants growth were within the ranges of 5.2-6.0% N, 0.35-0.60 P and 1.7-2.2% K.

Murlee *et al*. (2007) conducted a field experiment in Allahabad, Uttar Pradesh, India, during the 2003 and 2004 kharif seasons, to determine the influence of organic and inorganic fertilizers on growth and yield of cauliflower. Treatment T< sub>3</ sub> (150 kg Gromor + 96 kg urea + 32 kg MOP/acre) showed significantly higher curd length (17.00 cm), curd weight (560 g), yield per plot (7.89 kg), yield (392 q/ha) and cost benefit ratio (1:2.88), whereas maximum plant height (53.33 cm) was recorded in treatment T< sub>1</ sub> (104 kg urea + 32 kg DAP + 32 kg MOP/acre).

Parmar *et al*. (2006). A field experiment was conducted at the experimental farm of the Himachal Pradesh Agricultural University in Kullu-Manali, India, over two years in a Western Himalayan Entisol to demonstrate the effects of synthetic fertilizers and organic manure on the productivity of a commonly used tomato (*Lycopersicon esculentum* Mill.)-tomato-Cauliflower (*Brassica oleracea* var *botrytis*) rotation.

The region's farmers currently fertilize with farmyard manure (FYM) supplemented with synthetic N, resulting in P and K deficiencies relative to N. Three fertilizer regimes reflecting a range of current farmer practices were compared with four regimes in which FYM applications were supplemented with synthetic NPK to better meet plant nutrient needs. Balanced nutrient applications increased soil organic C and available P and K content relative to farmer practice treatments, and increased overall profitability of system by 2-20%.

Peksen *et al*. (2008) conducted a field experiment to study the effect of chemical composition of seedling media prepared by spent mushroom compost on seedling growth and development of kale and broccoli. Spent mushroom compost (SMC), which was kept for 18 months in open field, conventional seedling medium (CSM) consisting of a mixture of decomposed farmyard manure, sand and garden soil at a rate of 2:1:1, commercial peat (P), SMC+CSM (1:1, v/v) and SMC+P (1:1, v/v) were used. Seeds of broccoli (*Brassica oleracea* L. var. *italica* L. cv. Greenpeace F1) and kale (*Brassica oleraceae* L. var. *acephale* D.C. cv. *Temel*) were used. Some chemical and physical properties of different seedling media prepared by SMC were compared and their effects on days to emergence (DE), emergence percentage (EP), seedling height (SH), mean leaf area per seedling (LA) and total dry weight of seedling (DW) were determined. Correlation analyses were carried out to determine the relationships between chemical constituents of the seedling media and DE, EP, SH, LA and DW. The results revealed that SMC+P or SMC could be used as seedling media for both kale and broccoli.

Perez-Murcia *et al.* (2006). In this study, the use of composted sewage sludge (CSS) as a binary component with peat (P) in growth media for a horticultural crop, broccoli (*Brassica oleracea* var. *Botrytis* cv. *Marathon*), was evaluated. Four treatments were established, based on the addition of increasing quantities of composted sewage sludge to peat (0%, 15%, 30% and 50%, v/v). Physical, physico-chemical and chemical analyses of the different mixtures of CSS and P were made.

Plant growth, biomass production and macronutrient (N, P, K, Ca, Mg), micronutrient (Fe, Cu, Mn, Zn) and heavy metal (Pb, Ni, Cd, Cr) contents of plants were determined. The addition of CSS to P increased plant nutrient and heavy metal contents of plants and electrical conductivity (EC) and bulk density values of the substrates. The use of CSS did not affect the germination rate, even at 50% compost. For broccoli growth, the highest yield was obtained with the medium prepared by mixing the peat with 30% of compost; however, the mixture with the most sewage sludge compost (50%) had the greatest contents of macro and micronutrients.

Roe and Cornforth. (2000). conducted an experiment on government regulations and public pressure have resulted in the use of composting as an alternative waste handling system for dairies. Utilization of locally-produced manures by vegetable production operations may increase crop yields with less conventional fertilizer. Despite its ability to stabilize nutrients and lower manure volume, composting has costs in time and equipment, so some growers prefer using uncomposted manure. Dairy manure compost at 22 (LC), 45 (MC), or 90 (HC) Mg.ha-1 or uncomposted dairy lot scrapings at 45 Mg.ha-1 (DL) were tilled into soil before seeding a dryland muskmelon (*Cucumis melo* L.) crop. All plots, including an unamended control (UC), were fertilized with a total of 23N-14P-0K (kg.ha-1). After removal of the cantaloupe in late summer, a drip-irrigated broccoli (*Brassica oleracea* var.*botrytis* Mill.) crop was planted into the identical plots, and sidedressed with 112 kg.ha-1 N. Muskmelon yields from DL, LC, MC, HC, and UC plots were 9.6, 6.9, 4.1, 9.0, and 2.9 Mg.ha-1, respectively. Broccoli yields from DL, LC, MC, HC, and UC plots were 4.2, 3.6, 4.4, 4.1, and 2.2 Mg.ha-1, respectively. All rates of compost or manure increased yields of cantaloupe, and the subsequent broccoli crop. Use of the manure resulted in highest increase in potential net income from sales of muskmelon and broccoli.

Sanwal *et al*. (2005) conducted a field experiment in Meghalaya, India during 2003-04 and 2004-05 to investigate the effects of organic manures and natural growth regulators on the chemical composition of flowers and stems of

broccoli cv. Hybrid Fiesta. The treatments included: farmyard manure (FYM) at 20 t/ha; poultry manure 10 t/ha; pig manure at 11 t/ha; rabbit manure at 11 t/ha; neem shield 4.5 t/ha; FYM at 16 t/ha + 4 sprays of panchakavya; FYM at 16 t/ha + 4 sprays of amritpani; poultry manure at 8 t/ha + 4 sprays of panchakavya; poultry manure at 8 t/ha + 4 sprays of amritpani; and NPK. Foliar spray of panchavkaya and amritpani at 10% was made at 15, 30, 45 and 60 days after planting. Floral parts showed higher values for dry matter, carotenoid, total soluble solids, acidity, ascorbic acid, carotenoid and protein; but lower values for pH. fibre content, reducing sugars, total sugars and nitrate than the stem. Integrated use of organic manures and natural growth promoters resulted in higher dry matter content, pH, ascorbic acid content, total soluble solids, reducing sugars and total sugars, but lower fibre contents in stems and flowers than NPK treatment.

Sharma, K. C. (2000) was undertaken a study at Lari (Spiti Valley, Himachal Pradesh, India) during summer 1995-97 to find out the influence of integrated nutrient management in broccoli using 'Green Head' variety. The results revealed that integration of organic and inorganic fertilizers application significantly increased the head yield over inorganic fertilizers alone and also over control. The treatment N< sub>175</ sub> P< sub>75</ sub> K< sub>60</ sub> + FYM 12.5 t/ha recorded the maximum yield (63.12 q/ha) which was at par with N< sub>150</ sub> P< sub>75</ sub> K< sub>60</ sub> + FYM 12.5 t/ha (57.59 q/ha) but significantly superior over rest of the treatments in terms of yield and net profit.

Shen *et al*. (2010) conducted a field experiment to study the effects of different farming patterns (organic farming, special farming and conventional farming) on the yield and quality of celery, lettuce, radish and broccoli were evaluated under field conditions. Data of the second year showed that four kinds of vegetables had the highest yields in organic farming system and the lowest yields in conventional farming system. Compared with conventional farming system, the increased rate of yield in organic farming system reached 57.13%-377.46%.

There were significant differences between organic farming and conventional farming for the yields of four kinds of vegetables. In conclusion, the yield and quality of four kinds of vegetables in organic farming system were better than that in conventional farming system, with higher VC, dry matter and soluble sugar, and lower soluble protein and nitrate.

Simoes *et al.* (1993) investigated the effect of container size and substrate on growth and yield of broccoli in nursery and in field. It was found that containers of 21-31 mm wide and 71-75 mm deep, in combination with rich substrates (180-210 mg N, 120-240 mg P_2O_5 and 220-270 mg K_2O litre) produced the best result.

Singh *et al.* (2000) reported a linear increased in plant height was observed with increasing N and K rates. K improved the development of roots and the utilization of N. Delay in marketable plant maturity was observed when N and K rates exceeded 150 and 50 kg/ha, respectively. The highest net head weight and yield were obtained when N at 150 kg/ha and K at 50 kg/ha were applied. Results indicate that these concentrations of N and K fertilizers are optimum for broccoli growth in Himachal Pradesh, and further increase in concentration may have negative effects on growth and yield.

Sorensen, *et al*. (2011) stated that to ensure high yield and quality in organic vegetable production, crops often require additional fertilizer applied during the season. Due to the risk of contamination of edible plant products from slurry, plant-based fertilizers may be used as an alternative. The purpose of our work was to develop mobile green manures with specific high nutrient concentrations (e.g., nitrogen [N], sulfur [S], and phosphorus [P]) that are released quickly after soil incorporation and that are easy to handle during storage and application. To distinguish from traditional green manures that are grown to improve soil fertility, the term "mobile green manures" is used for green-manure crops that are harvested in one field and then moved as a whole and used as fertilizer in other fields. To further investigate mobile-green-manure crops for use as efficient fertilizers, pot and field experiments were

conducted with cauliflower (*Brassica oleracea botrytis*) and kale (*Brassica oleracea sabellica*) supplied with organic matter consisting of a wide range of plant species with varying nutrient concentrations. Further, field experiments were conducted with leek (*Allium porrum*) and celery (*Apium graveolens dulce*) supplied with increasing amounts of organic matter consisting of fresh, ensiled, or dried green manures. Results show that garden sorrel (*Rumex acetosa*), dyer's woad (*Isatis tinctoria*), and fodder radish (*Raphanus sativus*) harvested with a high leaf-to-stem ratio resulted in high P concentration, and cruciferous crops in high S concentration. Dyer's woad, salad burnet (*Sanguisorba minor*), and stinging nettle (*Urtica dioica)* showed high boron (B) concentration, whereas species such as dandelion (*Taraxacum officinale*), chicory (*Cichorium intybus*), and garden sorrel showed high potassium (K) concentration. Green manures with high P and S concentrations increased the nutrient uptake and yield of pot-grown cauliflower and kale. Field experiments showed that the production of cauliflower and kale decreased when the carbon-to-nitrogen (C:N) ratio of applied green manure increased. In kale, for example, application of 160 kg N ha-1 in early harvested lucerne (*Medicago sativa*) with a C:N ratio of 10 resulted in the highest kale production whereas application of an equal amount of N in late harvested lucerne with a C:N ratio of 20 produced 34% less. Differences in vegetable production were not due to the amount of N applied, but to the N availability. Field experiments with fresh, ensiled, or dry green manure applied to leek and celery showed that the C:N ratio has to be low to get a fast response. Further, these field experiments demonstrate the importance of green manures, which can be stored and are easy to handle during transport, crop application, and soil incorporation. It is concluded that it is possible to produce green manures with high concentrations of S, P, K, and B, and low C:N ratios and that these properties have a great impact on the value of the green manure for vegetable production.

Steffen *et al*.(1994) observed the effect organic matter (spent mushroom compost at 64 mt/ha+rotten cattle manure at 57 mt/ha) applied in spring 1990 on growth and yield of broccoli.

No fertilizer or other amendments were added to previously amended treatments, but 100% recommended NPK be added to all control treatments. Broccoli yield and head diameter were greater in the amended treatment.

Sumiati (1998) stated that seedlings of broccoli cultivars Green King and Mikado were transplanted into Jiffy pots or into a mixture of stable manure and soil supplemented or not supplemented with NPK compound fertilizer (15:15:15) and/or Metalik. There were differences between cultivars in plant height, root length, LAI, NAR and RGR at 2, 3 or 4 weeks after transplanting. These factors were all highest at all stages in plants grown in manures + soil supplement with NPK+ Metallic and were generally lowest in plants grown in jiffy pots. t/ha cow dung as organic manure. The application of chemical fertilizer had a significant effect on growth and yield of cabbage. The highest cabbage yield (110.98 ton/ha) was obtained from the treatment N_{180} P_{120} K_{120} S_{30} Zn_5 MO_1 and the lowest (50.76 t/ha) from the absolute control treatment (Anonymous, 1982).

Thakur *et al*. (2001). Conducted an experiment on cauliflower cv. Pusa Snowball K-1 plants were supplied with 0 (T0), 600 (T1), 800 (T2) and 1000 (T3) kg recycled commercial organic manure (ORGO)/ha in a field experiment conducted in Himachal Pradesh, India during 1998-99 to determine the effects of ORGO on the seed yield of cauliflower. Plant mortality was highest with T2 (11%) and lowest with T3 application (6%). Seed yield per plot and total yield were highest in plants supplied with T2 (839.90 g/plot and 8.20 q/ha, respectively) and lowest in those supplied with T3 (540.15 g/plot and 5.27 q/ha, respectively). No significant differences among the treatments in terms of the number of outer leaves of cauliflower were observed.

Thilagam *et al*. (2011) reported that cauliflower (*Brassica oleracea* var *botrytis* L) is a heavy feeder of nutrients and it responds very well to all bulky nutrient addition through Farm Yard Manure (FYM), bio fertilizers, green manures and chemical fertilizers.

Therefore efficient management of Integrated Plant Nutrient supply System (IPNS) is a prerequisite for achieving higher productivity of cauliflower. Application of N from 120 to 225 kg ha-1 increased the curd yield and quality depending on soil fertility. Besides, N cauliflower also responds well to phosphorus ranging between from 90-200 kg ha-1 and K up to 75 kg ha-1 and it also increases the quality of produce and yield. Application of Mo increases the curd yield and decreases the incidence of whiptail. Application of B reduces browning of curd that ultimately causes the brown rot of cauliflower. Judicious combination of chemical fertilizers along with organic manures based on soil available nutrients will increase the cauliflower yield at the same time it will sustain the soil fertility.

Wani *et al*. (2010) conducted an experiment during rabi of 2004-2005 to find out the optimum dose and best combination of organic and inorganic sources of nutrients for maximizing yield and improving quality of cauliflower cv Snowball-16. Combined application of 50% recommended dose of NPK and poultry manure at 3 t/ha recorded significantly higher curd yield (325.1 q/ha), followed by combined application of 50% recommended dose of NPK and mixture of FYM, poultry manure, sheep manure and pea straw. Highest net returns (Rs 178,096/ha) and benefit cost ratio (3.59) were also recorded for the treatment including combined use of 50% recommended dose of NPK and poultry manure at 3 t/ha. Application of 50% recommended dose of NPK+mixture of half dose of FYM, poultry manure, sheep manure and pea straw remained second in order.

Warman (2005) conducted a study of compost- versus conventionally-fertilized vegetable plots was conducted for 12 years in a sandy loam soil near Truro, Nova Scotia. The fertility treatments have been applied annually to six rotation plots planted with six to eight different vegetable crops. The composts consist of animal manure, food waste, yard waste and straw or racetrack manure bedding. This paper investigated the last year of the study (2001), which examined levels of nutrients in soil, leaf tissue and the edible portion of the plant, and crop yields.

The fresh weight yields from the six plots showed that the compost treatment resulted in numerically, but not significantly, higher yields for the carrots, peppers, onions and tomatoes, and significantly higher yields for green and yellow beans. Cauliflower and broccoli yields, however, were higher in the fertilizer-amended plot. Soils with compost had higher pH, CEC, C, N and Mehlich-3 extractable levels of P, Ca, Mg, Mn, Zn and B compared with the fertilized plots. However, the increased nutrients in the compost-amended soil did not increase the nutrients in the leaf tissue or the edible portion of the plant. Of the 16 elements tested, only P and K were higher in the fertilizer-amended plant leaf tissue, while levels of P were significantly higher in the edible portion of the plant. This study demonstrated that the long-term use of compost can produce similar yields and elemental analysis for most crops in compost-amended and conventionally-fertilized soils.

Ying *et al*. (1997) conducted a pot experiment to determine the effect of N P and K on yield and quality of broccoli. They observed K was the most important element for yield and dry weight. Additive effects were observed on yield and vitamin C (ascorbic acid) content when K was applied together with N or N + P. Application of N + P gave 110.8% higher yields than N alone. Nitrogen application advanced the harvesting date. Significant positive correlations were found between yield and dry weight of leaves and plant size. They also suggested that N, P and K application should be balanced to obtain high yields and quality of broccoli.

2.2 Effect of mulching on the growth and yield of broccoli

Different growth stages and yield characters of broccoli and other cole crops are greatly influenced by the use of mulches. It had a profound influence on the measure of LAI, net assimilation rate; receptive growth rate since these measures were affected by environmental factors especially temperature.

Acharya (1968) conducted an experiment on the effect of mulching on the yield of cabbage. It was reported that mulches significantly increased the yield of cabbage. Similar results were also noted by Oyabu *et al.* (1988) and Subhan (1989).

Ali (2004) carried out an experiment on effects of mulching and different levels of nitrogen on growth and yield of broccoli in BAU Mymensing and observed that the maximum average yield (16.4 t/ha) was obtained from 220 kg N/ha with black polythene mulch.

Benoit and Ceustermans (1990) studied the influence of mulch on cabbage growth. It was found that double layer of paper mulch had better temperature condition for growth of the first 20 outer leaves (loose leaves) than single layer. Crop yield was also better which double layer than that of single.

Gattorman (1992) studied the effects of plastic film mulch on the yield of cabbage and found that the single layer of polythene and propylene resulted either in an earlier or higher yield than that of double layer in chinese cabbage.

Brakeboer (1990) conducted a trial with broccoli, cv. Corvet, seed raised in soil blocks or modules. The seedlings were planted out on 18, April and the effects were compared to direct covering with perforated expanding plastic film (Agryl P17) until 13 May, 30 May or 13 June, and without covering. The cultivar Emperor was also included as root-ball (module-raised) plants, covered by plastic until 30 May. With soil-block plants the plastic cover did not advance harvest, compared with non-covered plants, but the harvest period was shortened by about 9 days. Covering until 30 May gave the highest yield, amounting to 10.6 t/ha, compared with 6.8 t/ha for non-covered plants. Soil-block plants were harvested about 13 days earlier than root-ball plants. With root-ball plants, covering did not enhance yield but about 3 or 4 days advanced harvest. The harvest period was also longer with covering. Emperor yielded 2 t/ha more than comparable plants of Corvet. SGI and Emperor were planted out on 10 April and either direct covered until 23 or 30 May, or not covered. Emperor performed best, yielding about 6.5 t/ha with all three treatments

Burnette *et al.* (1993) stated that N fertilizer increased the broccoli yield and black plastic mulch treatments tended to produce greater broccoli than unmulched treatments; soil nitrate concentrations were higher throughout the growing season in the mulched plots.

Cai and Chen (1983) conducted an experiment to find out the effect of mulching on cabbage. They showed that mulching accelerated the mineralization of soil organic matter and release of nutrient and increased the content of hydrolytic nitrogen in soil. When mulching was used in irrigated field it ensured the efficient use of applied nitrogen fertilizer as nitrate-nitrogen as has been stated by Cook and Sandres (1990).

Campigila *et al.* (2000) studied the effect of mulches and observed that mulching with polythene increased the soil temperature at all depths compared with unmulched soil. They also reported that mulch significantly reduced weed density (70%) but not the weed biomass compared with the control. In case of cauliflower, yield was improved by 47% over black polythene mulch compared with the control.

Faruque (2004) carried out an experiment on effects of different sources of nutrients and mulching on growth and yield of broccoli in BAU Mymensing and observed that the maximum average yield (18.2 t/ha) was obtained from organic + inorganic fertilizer with black polythene mulch while minimum yield was given by (no fertilizer + no mulch +irrigation) treatment.

Halappa and Sreenivas (1973) harvested 75% of the yield of cauliflower over black polythene mulched plots in first 3 weeks, while they collected only 32% yield in the control during the same period. The yield increase observed in the case of 100, 200 and 300 gauge film mulches over the control were 39.5%, 41.01% and 44.9%, respectively.

Halappa and Sreenivas (1975) reported that black polythene mulch results in the retention of soil moisture, prevent the deterioration of soil structure, control weed and reduce the differences between maximum and minimum soil temperature, and increase cauliflower yield by about 40%.

Hashem (2005) carried out an experiment on effects of manuring and mulching on growth and yield of broccoli in BAU Mymensing and observed that the maximum average yield (17.6 t/ha) was obtained from organic and inorganic fertilizers with black polythene mulch.

Hopen and Oebker (1975) observed higher carbon dioxide levels under polythene, paper-polythene and paper-aluminium foil mulches then over bare soil. They obtained higher yield with mulches in broccoli, lettuce and cucumber due to higher soil temperature.

Kashyap *et al*. (2005) A field experiment was conducted in Jorhat, Assam, India during 2000-01 to study the growth, yield and water use of broccoli cv. KTS-1 as affected by drip irrigation at different levels of evaporation replenishment (EPR; 60, 80, 100 and 120% of USWB class A pan evaporation), with or without black plastic mulch. A furrow irrigation at fortnightly intervals on the basis of available soil moisture depletion was included. There was improved growth, yield and increased water use efficiency under drip irrigation compared to furrow irrigation. The highest broccoli yield of 25.14 t/ha was found under drip irrigation at 120% EPR with black plastic mulch, while the lowest yield of 9.22 t/ha was recorded in the furrow-irrigated plants. The WUE was considerably higher under drip irrigation than under furrow irrigation. Drip irrigation at 60% EPR with black plastic mulch recorded the highest WUE (4.11 t/ha-cm), while the lowest WUE (0.59 t/ha-cm) was observed under furrow irrigation.

Mulching has miscellaneous effects on pest management, prevention of bolting, and increased quality of produce as well as yield. Eichin and Deiser (1990) studied the effect of mulch on cabbage, lettuce production and reported that polythene mulching reduced the incidence of rot in the outer leaves of

cabbage lettuce and the final product was clear. Weed control was good. It is possible that increase in temperature in the prevailing microclimate discouraged the incidence of attacks of pest and disease.

Mulching increased the marketable head yield in cabbage (Ashworth and Harrison, 1983). While working with mulch on cabbage yield Bragagnolo and Miclniezuk (1990) found similar results.

Mulching influences the nutrient retention of soil. In an experiment with mulching on cabbage Chen and Katen (1980) found that NO_3, NH_4, K^+, Ca^{++}, Mg^{++}, Cl^- and $NaHCO_3$ extractable P were found to be increased by mulch application. Similar results have been described by Blane *et al.* (1987).

Oh *et al.* (1984) in their experiment found no significant difference in yield between mulched and unmulched plots. Mulching has influence on dry matter content of cauliflower seedlings. The effect of mulch on cauliflower and reported that mulching increased leaf chlorophyll content resulting in increasing dry matter content of these seedlings showing better result when mat aluminium was used as mulch in comparison to white, transparent, black polythene and control (Duffek, 1984).

Over seeded legume living mulch did not affect broccoli yield in many site compared to the control plots and suppressed weeds as well as the oxyfluorofen in three of the four sites. Thus, the NT (no tillage) systems used in this experiment could suppress weeds and produce high broccoli yield. Over seeded legume, living mulches could be established effectively after transplanting to suppress weeds without reducing broccoli yield (Infante and Morse, 1996).

Petroleum mulch and clear polythene films at bandwidths of 6 inches or more increase soil temperature during the day light hours to a depth of 6 inches and retain some soil heat during the night. Increase in soil temperature with black polythene film are smaller than with either petroleum mulch or clear polythene film during day, but the black polythene film retain more soil heat during the night.

For that the initial emergence of all vegetable species tested was beneficial in the establishment of early stands and in the hastening of maturity of many crops (Takatori *et al.*, 1964).

Poll and Geven (1996) studied the effect of mulches (black paper, black polythene and 11 t old straw/ha) on iceberg and butter head lettuces, leeks, *Cichorium intybus*, Chinese cabbage and paksoi crops in the Netherlands. They reported that mulches significantly reduced the incidence of *Phytophthora porri* in leeks and increased yield of iceberg and butter head lettuces and winter leeks. Mulch application was economic for leeks, but not for lettuces. Nitrogen leaching to ground water was decreased with mulches.

Rahman *et al.* (1989) conducted an experiment at Khagrachhari, Bangladesh to test different soil moisture management practices including mulch and stated that all the parameters like plant height, fresh and dry weights of root, fresh weight of shoot, diameter of head, marketable head weight were significantly increased with increasing irrigation rate, However, in the presence of mulch the maximum growth was obtained with irrigation at 161.72 mm/ha.

Roy *et al.* (1990) investigated the effects of mulching for the production of cabbage. In their experiment water hyacinth, straw and sawdust mulch were used. They reported that mulches increased crop growth rate (CGR). Net assimilation rate (NAR), leaf area index (LAI), but relative growth rate (RGR) was significant. Water hyacinth significantly increased chlorophyll b and was found to be the best in increasing the growth of cabbage and also of potato.

Runham *et al.* (2000) reported that paper mulch increased soil moisture levels in non-irrigated courgettes but not in irrigated celery compared to non-covered soil. They also found that both paper and plastic mulches gave similar or higher mean head weight in broccoli. From another experiment they concluded that soil temperature beneath the paper mulch was lower than both the non-mulched and black polythene-covered plots.

Santos *et al.* (2003) carried out an experiment with broccoli cultivars Baron, Shigimori and pinacco and found that the fresh mass of broccoli heads due to cultivation were not significant except for Shigimori which recorded higher fresh mass when cultivated in open fields. The number of leaves per plant was higher under open field cultivation of Shigimori and pinacco and under non-woven propylene cultivation of boron. The longitudinal diameters of all the 3 cultivars were higher under open field cultivation compared to cultivation under non-woven propylene. The transverse diameters of broccoli were higher under open field cultivation for boron and Shigimori and under non-woven propylene cultivation of pinacco.

Singh and Misra (1975) compared hay, pine needles, mango leaves, paddy straw and black polythene mulch on the growth and yield of cauliflower. The best results in terms of growth and yields were obtained from black polythene, differences between the other treatments being slight. They obtained maximum net returns from mango leaves, followed by pine needle and hay mulches.

The growth of broccoli is greatly influenced by the use of mulching. Mulches has profound influence on the measures of plant growth viz., leaf area index (LAI), net assimilation rate (NAR), crop growth rate (CGR), relative growth rate (RGR), since these measure were affected by environmental factors especially temperature, moisture (Miedema 1982; Awal and Khan 1999).

The influence of mulches on yield of cabbage were investigated by Yoon (1984) and observed that mulch like black polythene, clear polythene and straw gave higher yield of cabbage than that of non-mulched. Similar results have also been reported by either worker (Tumuhairwe and Gumbs, 1983; Hill *et al.*, 1982). But

While working with different mulches on cabbage, Hossain (1999) observed that maximum gross and marketable yields (116.67 t/ha and 97.53 t/ha) were obtained from black polythene mulch and the lowest from the control treatment.

CHAPTER-III

MATERIALS AND METHODS

This chapter describes the materials and methods which were used in the field to conduct the experiment during the period from 15 November 2011 to 15 March 2012. It comprises a short description of experimental site, soil and climate, variety, growing of the crops, experimental design and treatments and collection of data presented under the following headings:

3.1 Experimental site

The study was conducted at the Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh. Geographically the experimental area is located at $23^0$41 N latitude and $90^0$22 E longitudes at the elevation of 8.6 m above the sea level (FAO, 1988). The map showing the experimental site under study in Appendix III.

3.2 Characteristics of soil

Soil of the experimental field was silty loam in texture. The soil of the experimental area belongs to the Modhupur Tract (UNDP, 1988) under the AEZ No. 28. Soil sample of the experimental plot was collected from a depth of 0-30 cm before conducting the experiment and analyzed in the Soil Resources Development Institute (SRDI), Soil Testing Laboratory, Khamarbari, Dhaka and have been presented in Appendix I.

3.3 Climate and weather

The climate of the experimental site was under the subtropical climate, characterized by three distinct seasons, winter season from November to February and the pre-monsoon or hot season from March to April and the monsoon period from May to October (Edris *et al*., 1979). 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 Plating material

The hybrid variety of “Early green” broccoli was used in the experiment. The seeds of the hybrid variety was produced by Japan and was collected from Masud Seed Company, 174, Siddique Bazar, Dhaka-1000.

3.5 Seedbed preparation

Seedbed was prepared on 15 October 2011 for raising seedlings of broccoli and the size of the seedbed was 3m×1m. For making seedbed, the soil was well ploughed to loose friable and dried masses to obtained good tilth. Weeds, stubbles and dead roots were removed from the seedbed. Cow dung was applied to prepared seedbed. The soil was treated by Sevin 50WP @ 5kg/ha to protect the young plants from the attack of mole crickets, ants and cutworm.

3.6 Seed treatment

Seeds were treated by Provax 200WP @ 3g/1kg seeds to protect some seed borne diseases.

3.7 Seed sowing

Seeds were sown on 30 October 2011 in the seedbed. Sowing was done thinly in lines spaced at 5cm distance. Seeds were sown at a depth of 2cm and covered with a fine layer of soil followed by light watering by water can. Thereafter the beds were covered with dry straw to maintain required temperature and moisture. The cover of dry straw was removed immediately after emergence of seed sprout. When the seeds were germinated, shade by white polythene was provided to protect the young seedlings from scorching sunshine and rain.

3.8 Raising of seedlings

Light watering and weeding were done several times. No chemical fertilizers were applied for rising of seedlings. Seedlings were not attacked by any kind of insect or disease. Healthy and 25 days old seedlings were transplanted into the experimental field on 24 November 2011.

3.9 Treatment of the experiment

The experiment consisted of two factors *viz*., Organic manures and mulching.

Factor A: Three levels of organic manure

i) O_0 = Control (No organic manure)
ii) O_1 = Cowdung (25 t/ha or, 15 kg/plot)
iii) O_2 = Spent mushroom compost (17 t/ha or, 10.2 kg /plot)

Factor B: Four levels of mulching

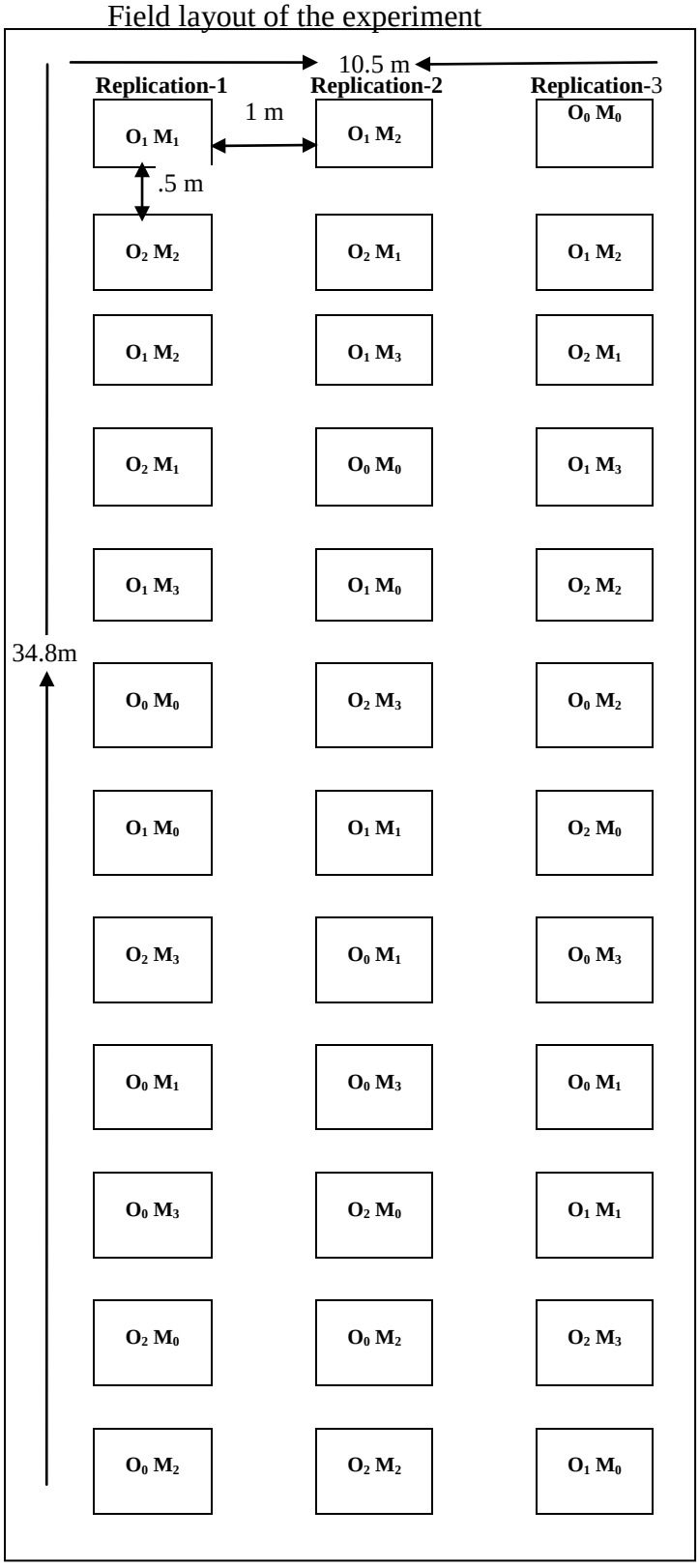
i) M_0 = Control (No mulch material)
ii) M_1 = Black polythene
iii) M_2 = Water hyacinth
iv) M_3 = Rice straw

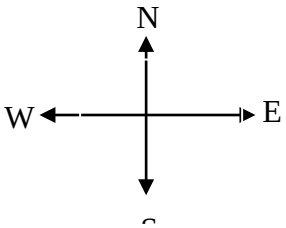
There were 12 (3 × 4) treatments combination such as O_0M_0, O_0M_1, O_0M_2, O_0M_3, O_1M_0, O_1M_1, O_1M_2, O_1M_3, O_2M_0, O_2M_1, O_2M_2 and O_2M_3.

3.10 Design and layout of the experiment

The two factorial experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The total area of the experimental plot was 365.40 m^2 with length 34.8 m and width 10.5 m. The total area was divided into three equal blocks. Each block was divided into 12 plots where 12 treatments combination were distributed randomly. There were 36 unit plots altogether in the experiment. The size of the each plot was 2.5m × 2.4m. The distance maintained between two blocks and two plots were 1 m and 0.5 m, respectively. The plots were raised up to 10 cm. In the plot with maintaining distance between row to row and plant to plant were 60 cm and 50 cm, respectively. The layout of the experiment is given below:

Field layout of the experiment





Plot size: 2.5 m x 2.4 m

Spacing: 60 cm x 50 cm

Spacing between replication: 1 m

Spacing between plot: 0.5 m

Factor A:
Three levels of organic manure

i) O_0 = Control
ii) O_1 = Cowdung (25 t/ha)
iii) O_2 = Spent mushroom compost (17 t/ha)

Factor B:
Four levels of mulching

i) M_0 = Control
ii) M_1 = Black polythene
iii) M_2 = Water hyacinth
iv) M_3 = Rice straw

Figure 1. Field layout of the two factors experiment in the Randomized complete Block Design

3.11 Land preparation

The plot selected for conducting the experiment was opened in the 3nd week of November 2011 with a power tiller and left exposed to the sun for a week. After one week the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain good tilth. Weeds and stubbles were removed and finally obtained a desirable tilth of soil was obtained for transplanting of seedling. In order to avoid water logging due to rainfall during the study period, drainage channels were made around the land. The soil was treated with Furadan 5G @ 15 kg ha^{-1} when the plot was finally ploughed to protect the young seedlings from the attack of cut worm.

3.11.1 Application of organic manure

Only organic manure was used as the source of nitrogen, phosphorus and potassium. Total amount of organic manure was applied during final land preparation as per treatment. Different organic manure with available amount of nutrient were given below:

Name of organic manures	Available amount of nutrient (%)		
	N	P_2O_5	K_2O
Cowdung	1.0-1.1	0.3-0.33	0.46-0.51
Spent mushroom compost	1.7-1.86	0.85-0.93	1.9-2.07

source: Fertilizer recommendation guide, 2012

3.11.2 Application of mulching materials

Three types of mulching material; viz., black polythene, water hyacinth and rice straw mulch were used. The fresh water hyacinth and rice straw were chopped into small pieces (5 cm) and sun dried for three days before placing and black polythene sheet with small opening which was made for maintaining proper plant to plant and row to row distance before placing over the plots. The thickness of water hyacinth and rice straw mulch materials were maintained at 5 cm approximately.

3.11.3 Transplanting

The seedbed was watered before uprooting the seedlings to minimize the damage of roots. Twenty five days old healthy seedlings were transplanted at the spacing of 60 cm × 50 cm in the experimental plots on 24 November 2011. Thus the 20 plants were accommodated in each unit plot. Planting was done in the afternoon. Light irrigation was given immediately after transplanting around each seedling for their better establishment. The transplanting seedlings were shaded for five days with the help of banana leaf sheath to protect them from scorching sunlight, watering was done up to five days until they became capable of establishing on their own root system.

3.12 Intercultural operations

3.12.1 Gap filling

Very few seedlings were damaged after transplanting and new seedlings from the same stock were replaced these.

3.12.2 Weeding

The plants were kept under careful observation. Weeding was done at two times. First weeding was done two weeks after transplanting. Another weeding was done after 30 days of first weeding. No weed was found in the plots covered by black polythene, while a few weeds were noticed in plots covered by water hyacinth and rice straw.

3.12.3 Irrigation

Light irrigation was given immediately after transplanting around each seedling for their better establishment. Watering was done up to five days until they become capable of establishing on their own root system. Irrigation was given by observing the soil moisture condition. Four times irrigation were done during crop period.

3.12.4 Ear thing up

Earthing up was done only on unmulched plots by taking the soil from the space between the rows at 15days after transplanting. Earthing up was not necessary in mulched plots.

3.12.5 Insects and diseases management

Precautionary measures against Fusarium rot were taken by spraying Dithane M-45 @ 2 g /liter water. The crop was attacked by cutworms, mole cricket and field cricket during the early stage of growth of seedlings in the month of February. This insect was controlled initially by beating and hooking afterwards by spraying Dieldrin 20 EC @ 0.1%.

3.12.6 General observation

The field was frequently observed to notice any changes in plants, pest and disease attack and necessary action was taken for normal plant growth.

3.12.7 Harvesting

Main curds and secondary curds were harvested at different dates according to maturity indices. Main curds were harvested when the plants formed compact curd. After harvesting the main curd, secondary curds were developed from the leaf axils, which also developed into small secondary curds and were harvested over a period. Harvesting was started on 18 January 2012 and was completed on 2 March 2012. The curds were harvested with 10 cm of stem attached with the sprouts.

3.13 Collection of data

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

3.13.1 Plant height

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

3.13.2 Number of leaves per plant

Total number of leaves produced by each plant was counted at 20, 40 and 60 DAT and the time of main curd harvesting excluding the small leaves which produced auxiliary shoots.

3.13.3 Leaf length

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

3.13.4 Leaf breadth

The breadth of leaf was measured at 20, 40 and 60 DAT taking the widest part of the lamina. A meter scale was used to measure the length of the leaves and expressed in centimeter (cm).

3.13.5 Days required for curd initiation

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

3.13.6 Stem length of curd

Stem length of curd was measured from the base of the curd to the tip after harvest. A meter scale was used to measure the stem length of curd and expressed in centimeter (cm).

3.13.7 Crown length

Crown length was measured from one side of the curd to another side after harvest. A meter scale was used to measure the crown length and expressed in centimeter (cm).

3.13.8 Diameter of primary curd

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

3.13.9 Weight of primary curd

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

3.13.10 Number of secondary curd per plant

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

3.13.11 Average weight of secondary curd

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

3.13.12 Yield per plant

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

3.13.13 Yield per plot

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

3.13.14 Yield per hectare

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

3.14 Statistical analysis

The data collected on various parameters were statistically analyzed to find out the statistical significance of the treatment effect. The mean values of all the treatments were calculated and analyses of variance for all the characters were performed by the F-test (variance ratio). The significance of the difference among the treatment combinations of means was estimated by least significance difference (LSD) at 5% level of probability.

CHAPTER IV

RESULTS AND DISCUSSION

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

4.1 Plant height

Application of organic manure exhibited a significant influence on plant height of broccoli at 20, 40 and 60 days after transplanting (DAT) (Figure 1, Appendix V). At 20 DAT, the tallest plant (34.5 cm) was measured from O_2 which was statistically similar to that of O_1 and the shortest (23.3 cm) was recorded from control treatment (O_0).

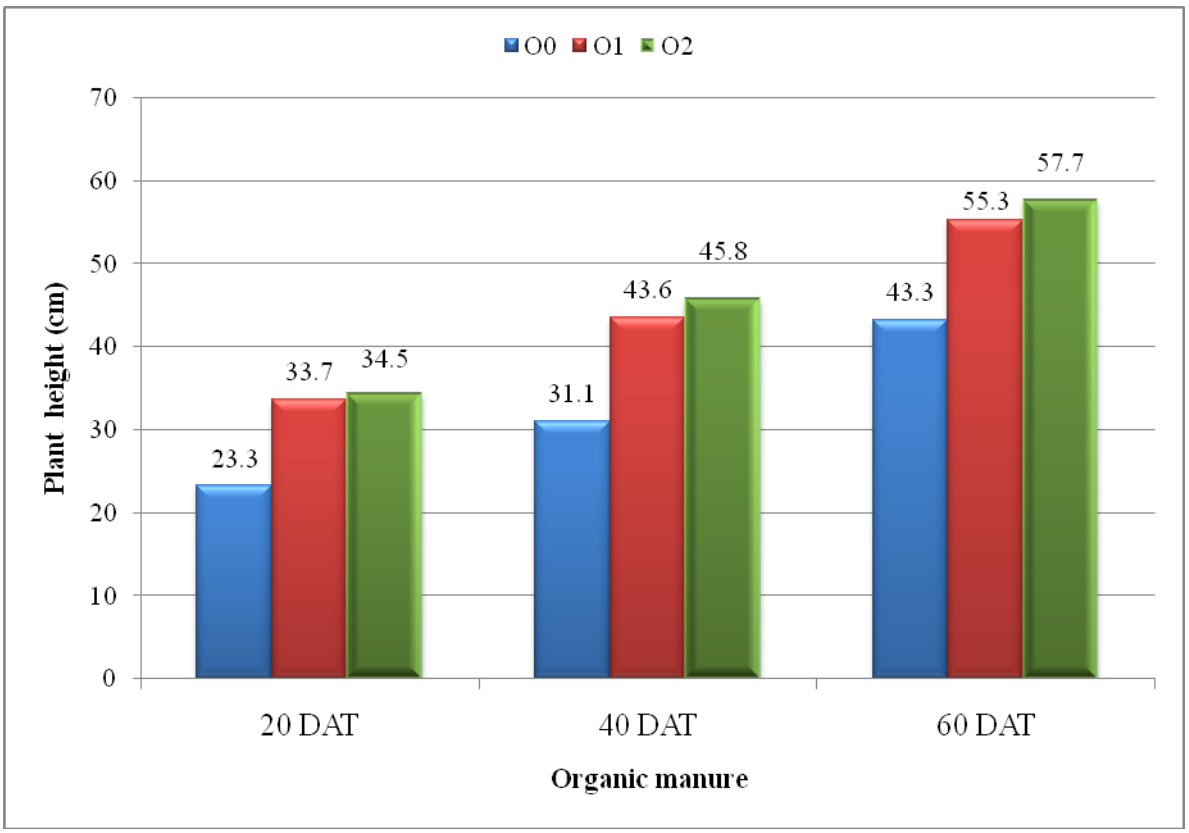


Figure 1. Effect of organic manures on plant height of broccoli
O_0 = Control, O_1 = Cowdung, O_2 = Spent mushroom compost.

At 40 DAT, the tallest plant height (45.8 cm) was recorded from O_2 which was statistically similar to that of O_1 and the shortest (31.1 cm) was measured from O_0. At 60 DAT, the highest plant height (57.7 cm) was measured from O_2 which was statistically similar to that of O_1 and the lowest (43.3 cm) was recorded from O_0 treatment. It was revealed that the plant height increased with the increase in days after transplanting (DAT) i.e., 20, 40 and 60 DAT and also revealed that the plant height increased with different organic manure application as well. Spent mushroom compost (SMC) and cowdung provided more or less similar result. This might be due to organic manure improve soil fertility, productivity and continuous nutrient supply thoughout the growing period.

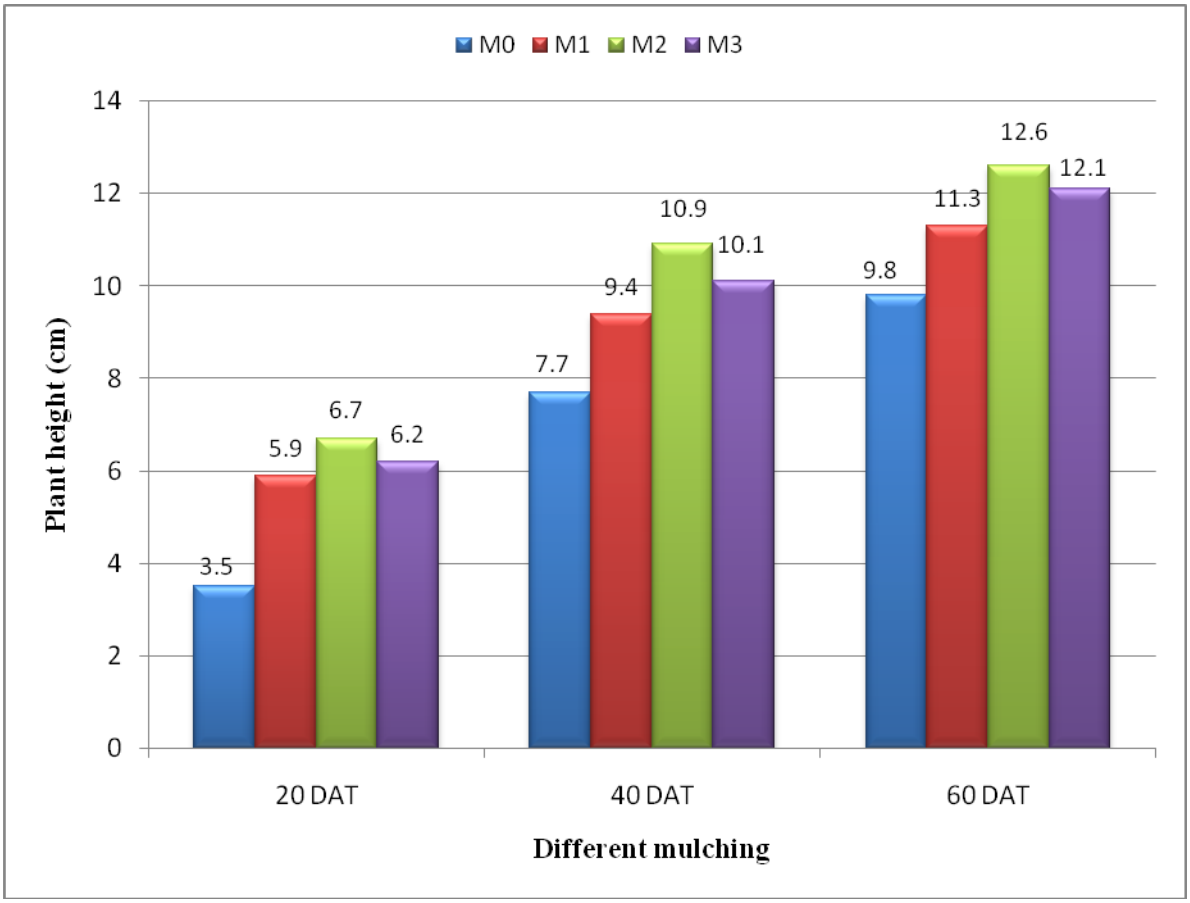


Figure 2. Effect of different mulching on plant height of broccoli

M_0 = Control, M_1 = Black polythene, M_2 = Water hyacinth, M_3 = Rice straw.

Application of mulching showed significant influence on the height of broccoli plants at 20, 40 and 60 DAT (Figure 2, Appendix V). At 20 DAT, the tallest

plant (6.7 cm) was measured from M_2 which was statistically similar to that of M_3 and the shortest (3.5 cm) was recorded from M_0. At 40 DAT, the tallest plant height (10.9 cm) was recorded from M_2 which was statistically similar to that of M_3 and the shortest (7.7 cm) was recorded from M_0.

Table 1. Combined effect of organic manures and mulching on plant height of broccoli

Treatments	Plant height at 20 DAT (cm)	Plant height at 40DAT (cm)	Plant height at 60DAT (cm)
O_0M_0	29.5 g	38.3 g	49.8 h
O_0 M_1	30.5 f	38.8 fg	50.0 h
O_0M_2	30.9 f	39.8 f	50.8 gh
O_0M_3	30.4 f	39.5 f	50.3 gh
O_1M_0	32.9 e	41.7 e	52.3 fg
O_1M_1	33.5 de	43.0 d	55.2 de
O_1M_2	34.7 b	45.2 c	57.7 bc
O_1M_3	33.9 cd	44.5 c	55.9 cd
O_2M_0	33.4 de	43.2 d	53.5 ef
O_2M_1	34.5 bc	45.3 c	57.8 bc
O_2M_2	35.7 a	48.0 a	60.7 a
O_2M_3	34.5 bc	46.8 b	58.7 ab
LSD	0.68	1.06	2.29
Level of significance	*	*	*
CV (%)	1.22	1.46	2.49

* = Significant at 5% probability

At 60 DAT, the highest plant height (12.6 cm) was measured from M_2 which was statistically similar to that of M_3 and the lowest height (9.8 cm) was recorded from M_0 treatment. It was revealed that the plot covered by mulching gave better plant height then control. This might be due to mulching increased crop growth rate (CGR), net assimilation rate (NAR), leaf area index (LAI) and

relative growth rate (RGR). Similar result was found by Roy *et al.* (1990) on growth of cabbage.

The plant height was significantly influenced by the interaction effect of organic manure and mulching at 20, 40 and 60 DAT (Table 1, Appendix V). At 20 DAT, the highest plant height (35.7 cm) was measured from the combination of O_2M_2 and the lowest (29.5 cm) was recorded from O_0M_0. At 40 DAT, the highest plant height (48.0 cm) was measured from O_2M_2 and the lowest (38.3 cm) from O_0M_0. At 60 DAT, the tallest plant height (60.7 cm) was measured from O_2M_2 and the shortest (49.8 cm) was recorded from O_0M_0. From the results, it is obvious that organic manure and mulching are helpful for increasing plant height of broccoli.

4.2 Number of leaves per plant

Application of organic manure exhibited a significant influence on number of leaves per plants of broccoli at 20, 40 and 60 DAT (Figure 3, Appendix V). The minimum numbers of leaves (4.3) were found with control treatment (O_0) and maximum numbers of leaves per plant (6.8) were observed from O_2 at 20 DAT. At 40 DAT, minimum numbers of leaves (8.8) were observed from O_0 and maximum numbers of leaves (10.5) were observed from O_2 that was statistically similar to that of O_1. At 60 DAT, minimum numbers of leaves (10.3) were found with control treatment (O_0) and maximum numbers of leaves (12.7) were observed from O_2 that was statistically similar to O_1.

Application of mulching was significantly influenced on the number of leaves of broccoli plants at 20, 40 and 60 DAT (Figure 4). At 20 DAT, the maximum numbers of leaves (6.8) were found in M_2 that was statistically similar to that of M_3 while the minimum (4.5) were found in M_0.

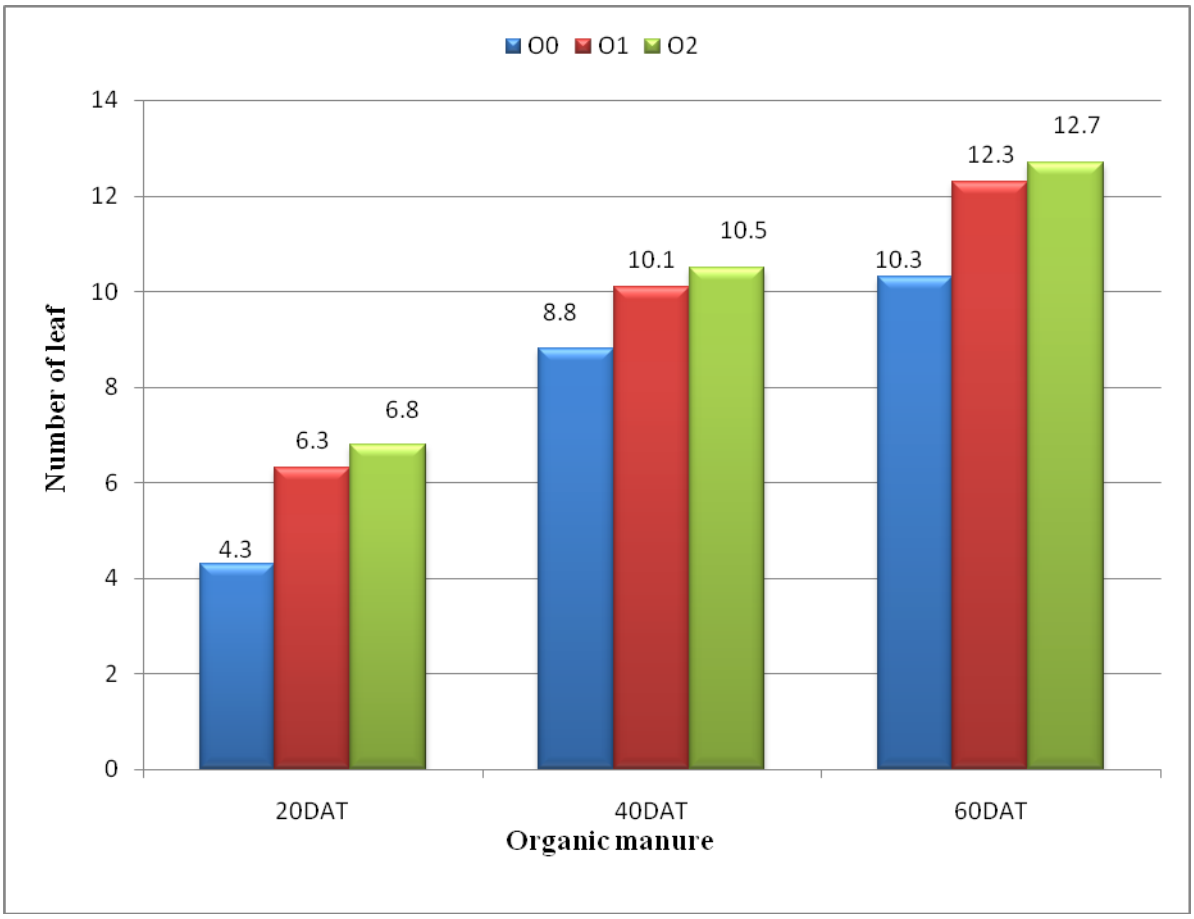


Figure 3. Effect of organic manures on number of leaves of broccoli
O_0 = Control, O_1 = Cowdung, O_2 = Spent mushroom compost.

Water hyacinth and rice straw mulching showed more or less similar result in number of leaves per plant of broccoli. At 40 DAT the maximum numbers of leaves (10.9) were observed from M_2 that was statistically similar to that of M_3 while the minimum (7.8) were found in M_0. At 60 DAT, the maximum numbers of leaves (12.8) were observed from M_2 which was statistically similar to that of M_3 while the minimum (9.8) were found in M_0. The number of leaves per plant increased with the increase in water hyacinth mulching application. Similar result was obtained by other investigators such as Roy *et al.* (1990) and Hossain (1999).

The number of leaves was significantly influenced by the interaction effect of organic manure and mulching at 20, 40 and 60 DAT (Table 2). At 20 DAT, the maximum numbers of leaves (7.0) were observed in O_2M_2

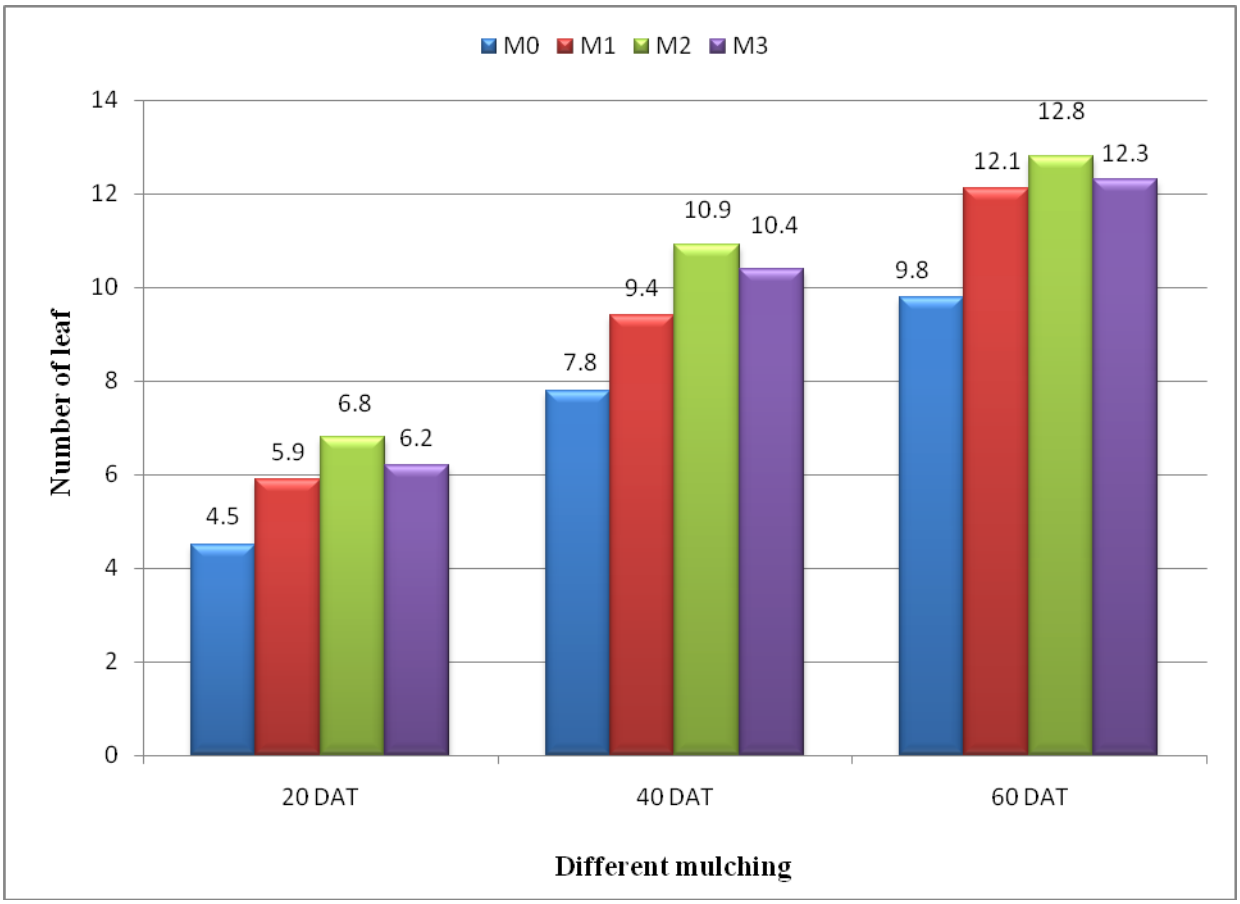


Figure 4. Effect of different mulching on number of leaves of broccoli

M_0 = Control, M_1 = Black polythene, M_2 = Water hyacinth, M_3 = Rice straw.

which was statistically similar to that of O_2M_1, O_1M_3, O_1M_2 and O_2M_3 while the minimum (5.0) were observed from O_0M_0. At 40 DAT, the maximum numbers of leaves (11.0) were observed in O_2M_2 and the minimum (9.3) were observed from O_0M_0. At 60 DAT, the maximum numbers of leaves (13.0) were observed in O_2M_2 and the minimum (11.0) were found from O_0M_0. It was appeared that number of leaves differ significantly due to the combined effect of organic manure and mulching.

Table 2. Combind effect of organic manures and mulching on number of leaves of
broccoli

Treatments	Number of leaf at 20 DAT	Number of leaf at 40 DAT	Number of leaf at 60 DAT
O_0M_0	5.0 d	9.3 c	11.0 d
O_0 M_1	5.2 d	9.9 bc	11.2 d
O_0M_2	5.3 cd	10.1 abc	11.5 cd
O_0M_3	5.5 cd	10.4 ab	11.3 cd
O_1M_0	5.7 cd	9.9 bc	12.3 ab
O_1M_1	6.0 bc	9.7 bc	12.5 ab
O_1M_2	6.7 ab	9.3 c	12.3 ab
O_1M_3	6.7 ab	9.3 c	12.3 ab
O_2M_0	5.7 cd	9.8 bc	12.0 bc
O_2M_1	6.7 ab	10.3 ab	12.7 ab
O_2M_2	7.0 a	11.0 a	13.0 a
O_2M_3	6.5 ab	10.3 ab	12.7 ab
LSD	0.67	0.91	0.82
Level of significance	*	*	*
CV (%)	6.88	5.37	4.01

* = Significant at 5% probability

4.3 Leaf length

Organic manure had a significant influence on the length of leaves of broccoli plants at 20, 40 and 60 DAT (Figure 5, Appendix VI). At 20 DAT, O_2 produced the longest leaf (20.7 cm) and the shortest (13.4 cm) was measured from O_0. At 40 DAT, the longest leaf (43.5 cm) was recorded from O_2 while the shortest leaf (35.3 cm) was recorded from O_0. At 60 DAT, the longest leaf (53.9 cm) was measured from O_2 while the shortest (43.0 cm) was recorded from O_0. Organic manures have slow release nutrients all over the growth season. Spent mushroom compost is rich in nutrient content and especially in nitrogen.

This may helped in better nutrient absorption and thus favoured the vegetative growth. Consequently highest leaf length was found by spent mushroom compost.

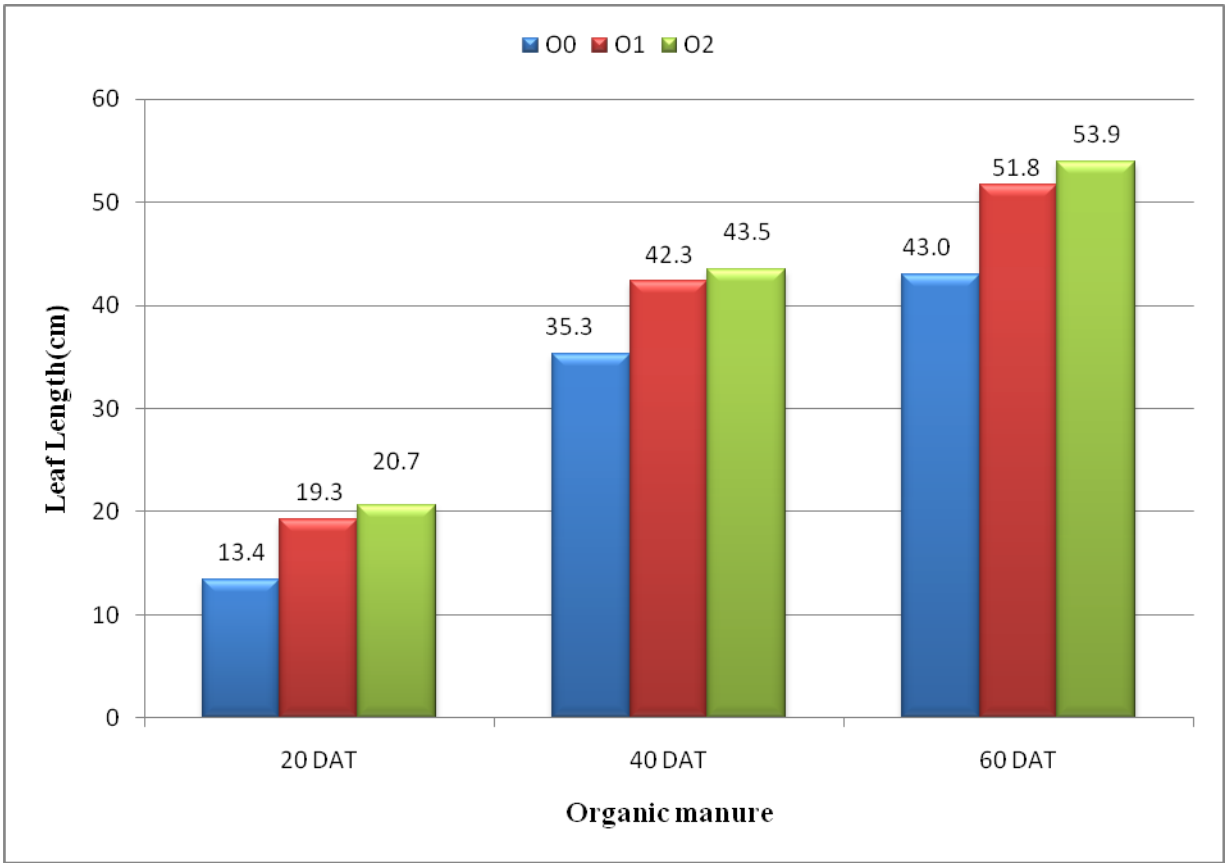


Figure 5. Effect of organic manures on leaf length of broccoli
O_0 = Control, O_1 = Cowdung, O_2 = Spent mushroom compost.

Mulching had a significant influence on leaf length of broccoli plants at 20, 40 and 60 DAT (Figure 6). At 20 DAT, M_2 produced the longest leaf (19.9 cm) which was statistically similar to that of M_1 and M_3 where as M_0 produced the shortest leaf (15.2 cm). Similar trend of result was found at 40 DAT and 60 DAT. At 40 DAT, M_2 produced the longest leaf (42.4 cm) whereas M_0 produced the shortest leaf (35.4 cm). At 60 DAT, the longest leaf (52.8 cm) was recorded from M_2 and the shortest leaf (43.4 cm) was measured in M_0. This might be due to mulching has profound influence on plant growth viz., leaf area index (LAI), net assimilation rate (NAR), crop growth rate (CGR), relative growth rate (RGR), also influence on soil temperature and moisture.

Miedema (1982); Awal and Khan (1999) found the same results in their investigations.

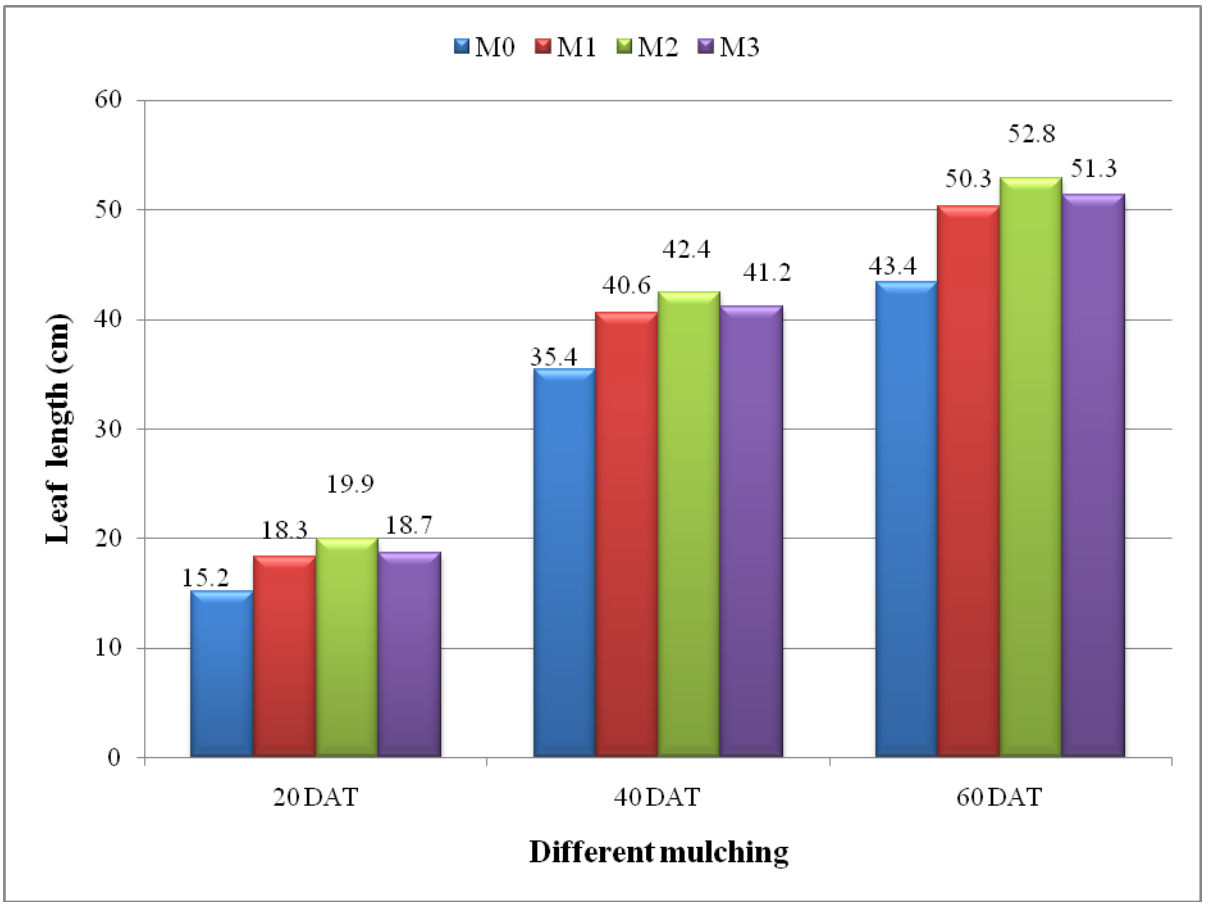


Figure 6. Effect of different mulching on leaf length of broccoli
M_0 = Control, M_1 = Black polythene, M_2 = Water hyacinth, M_3 = Rice straw.

The leaf length was significantly influenced by the interaction effect of organic manure and mulching at 20, 40 and 60 DAT (Table 3, Appendix VI). At 20 DAT, the longest leaf (21.7 cm) was measured from O_2M_2 which was statistically similar to that of O_2M_3 while the shortest (14.5 cm) was recorded from O_0M_0. At 40 DAT, the longest leaf (44.5 cm) was recorded from O_2M_2 which was statistically similar to that of O_2M_3 while the shortest (36.3 cm) was recorded from O_0M_0. At 60 DAT, the longest leaf (56.7 cm) was measured from O_2M_2 while the shortest (45.7 cm) was recorded from O_0M_0.

Table 3. Combined effect of organic manures and mulching on leaf length of broccoli

Treatments	Leaf length at 20DAT	Leaf length at 40DAT	Leaf length at 60DAT
O_0M_0	14.5 f	36.3 f	45.7 f
O_0 M_1	15.3 ef	37.3 ef	46.3 f
O_0M_2	16.5 e	37.7 ef	45.8 f
O_0M_3	15.3 ef	38.0 e	46.3 f
O_1M_0	18.3 d	41.0 d	49.3 e
O_1M_1	19.0 cd	42.2 cd	51.0 de
O_1M_2	20.2 abc	43.0 bc	53.0 bcd
O_1M_3	19.7 bcd	43.2 abc	53.7 bc
O_2M_0	19.3 cd	42.3 cd	51.3 cde
O_2M_1	20.5 abc	43.3 abc	53.7 bc
O_2M_2	21.7 a	44.5 a	56.7 a
O_2M_3	21.2 ab	43.8 ab	54.0 b
LSD	1.58	1.47	2.41
Level of significance	*	**	*
CV (%)	5.06	2.12	2.82

** = Significant at 1% probability
* = Significant at 5% probability

4.4 Leaf breadth

Organic manure had a significant influence on leaf breadth of broccoli plants at 20, 40 and 60 DAT (Figure 7, Appendix VI). At 20 DAT, O_2 produced the highest leaf breadth (10.2 cm) which was statistically similar to O_1 and the lowest result (7.3 cm) was measured in O_0. At 40 DAT, the largest leaf breadth (16.7cm) was measured from O_2 which was statistically similar to O_1 while the smallest result (13.3 cm) was recorded from O_0. At 60 DAT, the highest leaf breadth (21.5 cm) was measured from O_2 which was statistically similar to O_1 while the lowest (18.2 cm) was recorded from O_0.

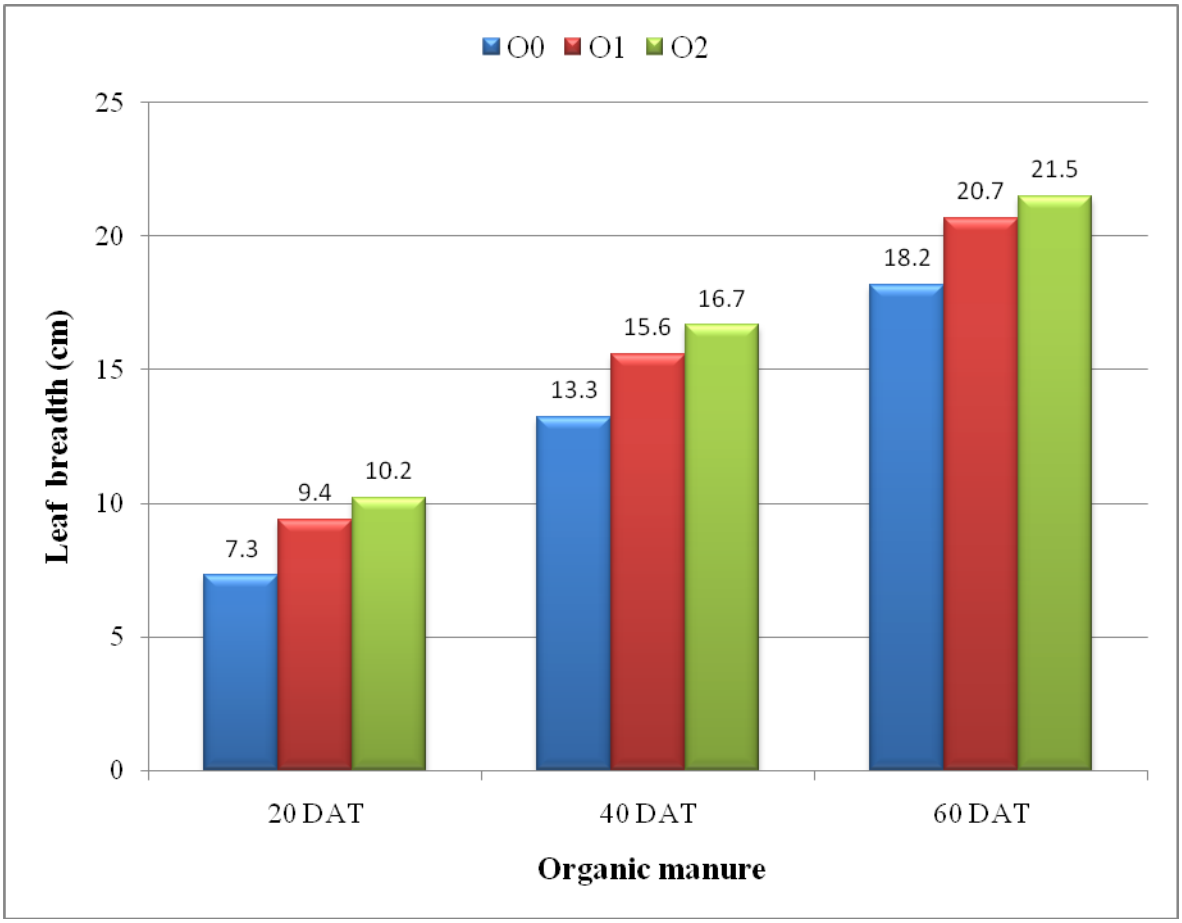


Figure 7. Effect of organic manures on leaf breadth of broccoli
O_0 = Control, O_1 = Cowdung, O_2 = Spent mushroom compost.

Mulching had a significant influence on leaf breadth of broccoli plants at 20, 40 and 60 DAT (Figure 8). At 20 DAT, O_2 produced the highest leaf breadth (9.8 cm) which was statistically similar to M_3 and the lowest (6.6 cm) was recorded in M_0. At 40 DAT, the highest leaf breadth (16.6 cm) was measured from M_2 while the lowest leaf breadth (13.1 cm) was recorded from M_0. At 60 DAT, the highest leaf breadth (20.7 cm) was measured from M_2 which was statistically similar to M_3 while the lowest (17.4 cm) was recorded from M_0. This might be due to mulching has profound influence on plant growth viz., leaf area index (LAI), net assimilation rate (NAR), crop growth rate (CGR), relative growth rate (RGR), also influence on soil temperature and moisture. Miedema (1982); Awal and Khan (1999) were found the same results in their investigations.

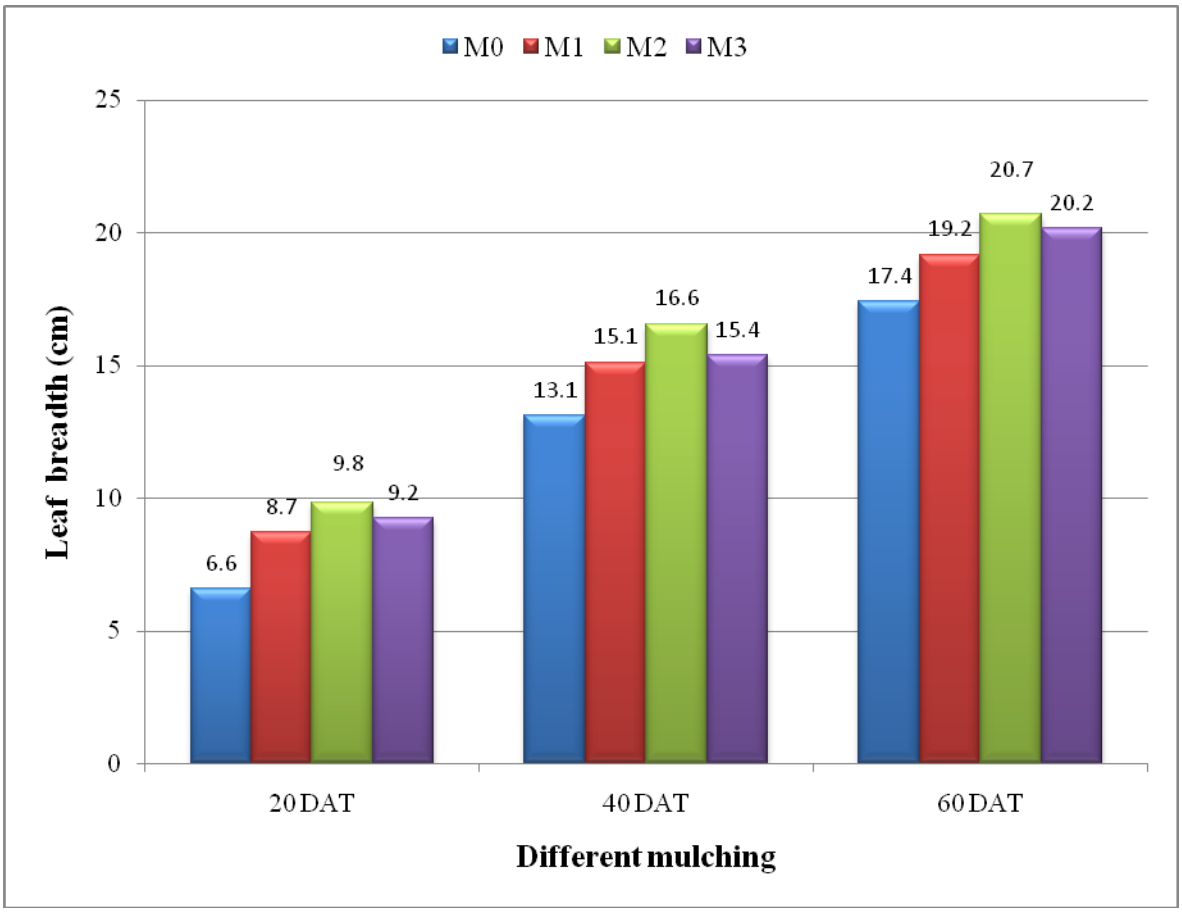


Figure 8. Effect of different mulching on leaf breadth of broccoli
M_0 = Control, M_1 = Black polythene, M_2 = Water hyacinth, M_3 = Rice straw.

The leaf breadth was significantly influenced by the interaction effect of organic manure and mulching at 20, 40 and 60 DAT (Table 4). At 20 DAT, the highest leaf breadth (10.7 cm) was recorded in O_2M_2 which was statistically similar to that of O_2M_3 and O_2M_1 while the lowest (7.1 cm) was recorded from O_0M_0.

Table 4. Combined effect of organic manures and mulching on Leaf breadth of broccoli

Treatments	Leaf breadth at 20DAT (cm)	Leaf breadth at 40DAT (cm)	Leaf breadth at 60DAT (cm)
O_0M_0	7.1 f	13.0 f	17.7 f
O_0 M_1	7.2 ef	13.1 ef	18.3 ef
O_0M_2	7.5 ef	13.3 ef	18.5 e
O_0M_3	7.2 ef	13.2 ef	18.2 ef
O_1M_0	8.7 d	14.3 d	19.7 d
O_1M_1	9.2 bc	15.7 c	20.7 c
O_1M_2	9.7 bc	16.0 ab	21.5 ab
O_1M_3	10.0 b	15.3 bc	20.8 bc
O_2M_0	9.5 bc	15.7 bc	20.8 bc
O_2M_1	10.3 ab	16.7 ab	21.5 ab
O_2M_2	10.7 a	17.3 a	22.2 a
O_2M_3	10.4 ab	17.0 ab	21.5 ab
LSD	1.81	1.64	0.80
Level of significance	**	**	**
CV (%)	3.27	1.92	2.36

** = Significant at 1% probability

At 40 DAT, the highest leaf breadth (17.3 cm) was measured from O_2M_2 which was statistically similar to that of O_2M_3 and O_2M_1 while the lowest (13.0 cm) was recorded from O_0M_0. At 60 DAT, the highest leaf breadth (22.2 cm) was measured from O_2M_2 which was statistically similar to that of O_2M_3 and O_2M_1 while the lowest (17.7 cm) was recorded from O_0M_0.

4.5 Days required for curd initiation

The number of days required for curd initiation was significantly influenced by organic manure application (Figure 9, Appendix VIII). The minimum days (45.2) required for 80% curd initiation were showed by O_2 while the maximum days (57.5) were required by O_0. Mitra *et al.* (1990) reported that application of organic manure hastened the crop to reach reproductive stage which was agreed with the present findings.

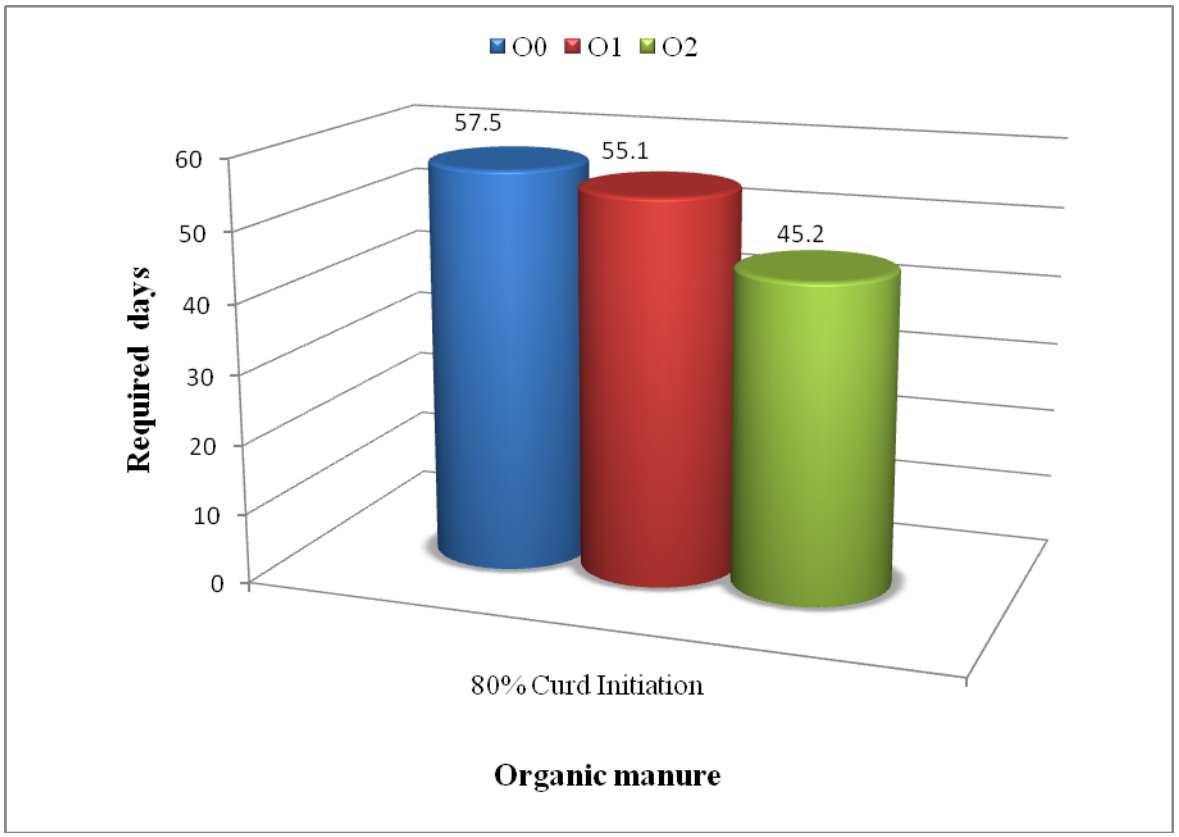


Figure 9. Effect of organic manures on days required for curd initiation of broccoli

O_0 = Control, O_1 = Cowdung, O_2 = Spent mushroom compost.

The application of mulching significantly influenced the number of days required for curd initiation (Figure 10). The minimum days (55.0) required for 80% curd initiation were observed from M_2 which was statistically similar to that of M_3 and the maximum (58.6) days were required by M_0.

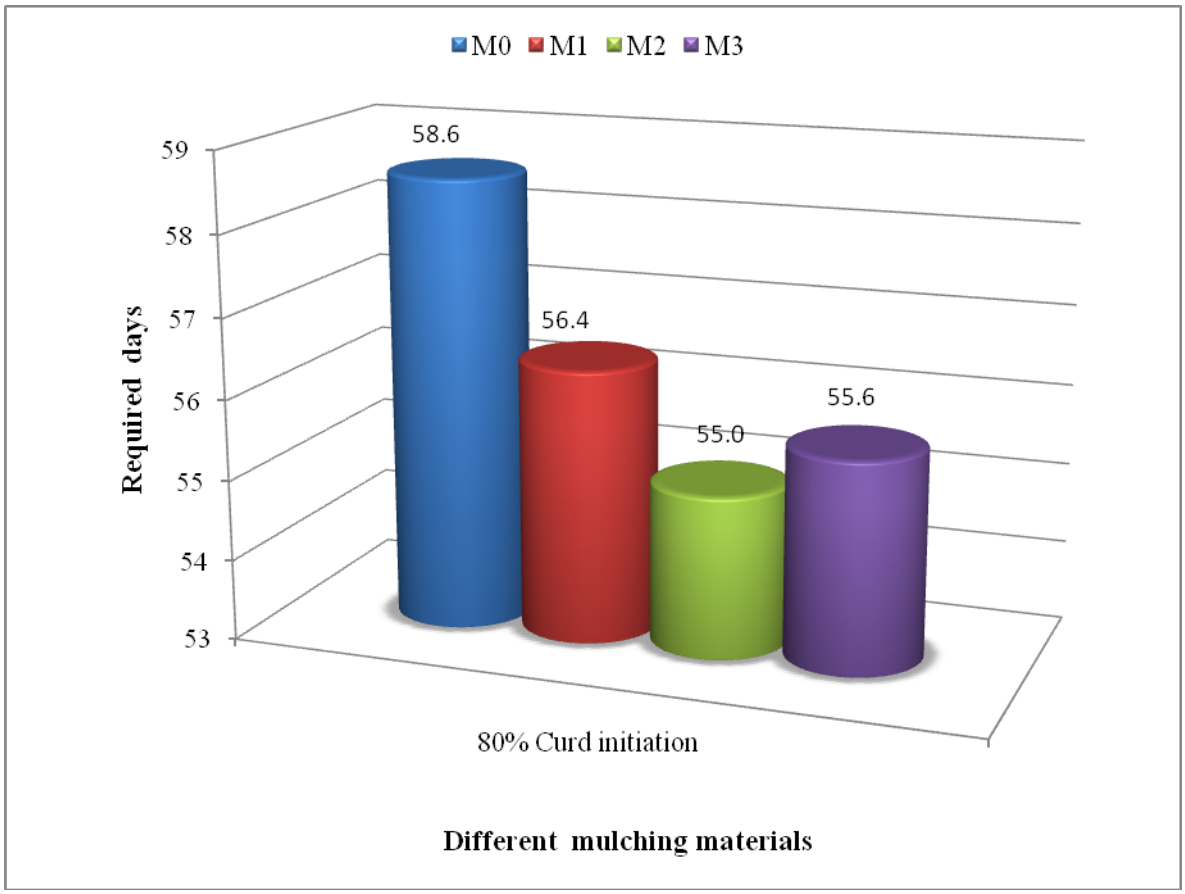


Figure 10. Effect of different mulching materials on days required for curd initiation of broccoli

M_0 = Control, M_1 = Black polythene, M_2 = Water hyacinth, M_3 = Rice straw.

Days required for curd initiation was significantly varied among the treatment combinations (Table 5). The maximum days (57.7) were required in the O_0M_0 treatment while the minimum days (54.0) were required for 80% curd initiation in O_2M_2 treatment followed by O_2M_1.

Table 5. Combined effect of organic manures and mulching on days required for curd initiation of broccoli

Treatments	Days required for 80% curd initiation
O_0M_0	57.7 a
O_0 M_1	55.3 abc
O_0M_2	57.0 ab
O_0M_3	56.0 abc
O_1M_0	55.3 abc
O_1M_1	55.3 abc
O_1M_2	54.7 c
O_1M_3	55.0 bc
O_2M_0	55.7 abc
O_2M_1	54.0 c
O_2M_2	54.0 c
O_2M_3	55.0 bc
LSD	2.09
Level of significance	*
CV (%)	2.23

* = Significant at 5% probability

4.6 Stem length of curd

Application of organic manure exhibited a significant influence on stem length of curd of broccoli plants (Table 6, Appendix VII). The highest stem length of curd (11.3 cm) was measured from O_2 which was statistically similar to that of O_1 while the lowest (9.8 cm) was recorded in O_0. It was revealed that the stem length of curd increased with organic manure application.

Application of mulching significantly influenced the stem length of curd of broccoli plants (Table 7). The maximum stem length of curd (12.8 cm) was measured from M_2 which was statistically similar to that of M_3 while the minimum (10.3 cm) was recorded from M_0.

Stem length of curd significantly influenced by the interaction effect of organic manure and mulching (Table 8). The maximum stem length of curd (11.8 cm) was measured from O_2M_2 which was statistically similar to that of O_2M_3 while the minimum (9.8 cm) was recorded from O_0M_0 which was statistically similar to that of O_0M_1 and O_0M_3. Stem length of curd is important for curd yield. Stem length of curd was significantly influenced by organic manure application.

4.7 Crown length

Application of organic manure exhibited a significant influence on crown length of broccoli plants (Table 6, Appendix VII). The maximum crown length **(**13.8 cm) was recorded from O_2 which was statistically similar to that of O_1 while the minimum (11.3 cm) was measured from O_0. It was revealed that the crown length increased with organic manure application. This might be due to slow and continuous nutrient supply. It helps to store energy, cell division and cell enlargement.

Application of mulching significantly influenced the crown length of broccoli plants (Table 7). The maximum crown length **(**13.1 cm) was measured from M_2 which was statistically similar to that of M_3, while the minimum (12.0 cm) was recorded from M_0. This results revealed that the crown length increase with mulching application.

Crown length was significantly influenced by the interaction effect of organic manure and mulching (Table 8). The maximum crown length **(**14.6 cm) was measured from O_2M_2 which was statistically similar to that of O_2M_3 while the minimum (11.0 cm) was recorded from O_0M_0. Crown length is important for curd yield. Crown length was significantly influenced by organic manure and mulching application.

4.8 Diameter of primary curd

Application of organic manure exhibited a significant influence on diameter of primary curd of broccoli plants (Table 6, Appendix VII). The maximum curd diameter (17.5 cm) was measured from O_2 which was statistically similar to that of O_1 while the minimum (12.5 cm) was measured from O_0. It was revealed that the curd diameter increased with organic manure application. This might be due to slow and continuous nutrient supply. That helps in uniform curd formation. During curd formation continuous nutrient supply is very much essential.

Application of mulching had a significant influence on diameter of primary curd of broccoli plants (Table 7). The maximum curd diameter (16.0 cm) was measured from M_2 which was statistically similar to that of M_3 while the minimum (13.8 cm) was recorded from M_0. This result was revealed that the curd diameter increased with mulching application. This might be caused that mulching increase soil moisture that helps in water uptake by the plants. Similar trend of the result was found by Rahman *et al.* (1989).

Primary curd diameter was significantly influenced by the interaction effect of organic manure and mulching (Table 8). The maximum primary curd diameter (18.9 cm) was measured from O_2M_2 which was statistically similar to that of O_2M_3 while the minimum (11.9 cm) was recorded from O_0M_0. Primary curd diameter is important for curd yield of broccoli. Diameter of the primary curd was significantly influenced by organic manure and mulching application.

4.9 Weight of primary curd

Organic manure exhibited a significant influence on weight of primary curd of broccoli plants (Table 6, Appendix VII). The maximum primary curd weight (0.41 kg) was measured from O_2 which was statistically similar to that of O_1 while the minimum primary curd weight (0.21 kg) was recorded from O_0. It was revealed that the primary curd weight increased with organic manure application. Spent mushroom compost and cowdung provided more or less similar yield.

This might be caused that organic manures such as cowdung and spent mushroom compost improves the soil structure, aeration, slow release nutrient which support root development leading to higher growth and yield of broccoli.

Mulching showed a significant influence on weight of primary curd of broccoli plants (Table 7). The maximum primary curd weight (0.35 kg) was measured from M_2 which was statistically similar to that of M_3 and M_1 while the minimum weight of primary curd (0.29 kg) was recorded from M_0. It was revealed that the primary curd weight increased with mulching application. Mulching retain soil moisture that helps to increase primary curd weight of broccoli. Runham *et al.* (2000) also found that mulches gave higher curd weight in broccoli then non-mulched plots.

Weight of primary curd was significantly influenced by the interaction effect of organic manure and mulching (Table 8). The maximum primary curd weight (0.46 kg) was measured from O_2M_2 which was statistically similar to that of O_2M_3 while the minimum (0.20 kg) was recorded from O_0M_0. Weight of primary curd is important for increasing total production of broccoli.

4.10 Number of secondary curd per plant

The secondary curds were those, which develop after harvest of the primary curd.

Number of secondary curd of broccoli plant is important for increasing total production. Application of organic manure exhibited a significant influence on number of secondary curd of broccoli plants (Table 6, Appendix VII). The maximum numbers of secondary curds (2.9) were observed from O_2 which was statistically similar to that of O_1 and while the minimum (1.6) were observed from O_0. It was revealed that the number of secondary curd increased with organic manure application.

Mulching exhibited a significant influence on number of secondary curd of broccoli plants (Table 7). The maximum numbers of secondary curds (2.6) were observed from M_3 which was statistically similar to that of M_1 and M_2 while the minimum numbers of secondary curds (2.0) were observed in M_0. It

was revealed that the number of secondary curd increased with mulching application.

Number of secondary curd was significantly influenced by the interaction effect of organic manure and mulching (Table 8). The maximum numbers of secondary curds (3.7) were observed from O_2M_2 that was statistically similar to that of O_1M_2 and O_1M_3 while the minimum (1.4) were recorded from O_0M_0.

4.11 Weight of secondary curd

Weight of secondary curd of broccoli plant is important for increasing total yield. Organic manure had a significant influence on secondary curd weight of broccoli plants (Table 6, Appendix VII). The maximum secondary curd weight (107.3 g) was measured from O_2 which was statistically similar to that of O_1 and the minimum (73.6 g) was recorded from O_0.

Table 6. Effect of organic manures on stem length of curd, crown length, diameter of primary curd, weight of primary curd, number of secondary curd and weight of secondary curd of broccoli

Treatments	Stem length of curd (cm)	Crown length (cm)	Diameter of primary curd (cm)	Weight of primary curd (kg)	Number of secondary curd	Weight of secondary curd (g)
O_0	9.8 c	11.3 c	12.5 c	0.2c	1.6 b	73.6 c
O_1	10.8 b	13.0 b	15.5 b	0.3 b	2.8 a	98.4 b
O_2	11.3 a	13.8 a	17.5 a	0.4 a	2.9 a	107.3 a
$LSD_{(0.05)}$	0.13	0.25	0.39	0.03	0.34	0.93
Significance level	**	**	**	**	**	**
CV%	1.41	2.32	3.04	6.25	6.52	4.26

** = Significant at 1% probability

Application of mulching exhibited a significant influence on weight of secondary curd of broccoli plants (Table 7). The maximum secondary curd weight (103.0 g) was recorded from M_2 which was statistically similar to that of M_3 while the minimum (76.3 g) was recorded from M_0. It was revealed that the plot covered by mulching gave higher yield than non-mulched plot.

Table 7. Effect of different mulching on stem length of curd, crown length, diameter of primary curd , weight of primary curd, number of secondary curd and weight of secondary curd of broccoli

Treatments	Stem length of curd (cm)	Crown length (cm)	Diameter of primary curd (cm)	Weight of primary curd (kg)	Number of secondary curd	Weight of secondary curd (g)
M_0	10.3 c	12.0 c	13.8 c	0.3 c	2.0 b	76.3 d
M_1	11.6 b	12.6 b	15.2 b	0.3 bc	2.5 a	97.0 c
M_2	12.8 a	13.1 a	16.0 a	0.4 a	2.5 a	103.0 a
M_3	12.3 a	12.9 a	15.6 ab	0.3 ab	2.6 a	99.8 b
$LSD_{(0.05)}$	0.15	0.29	0.45	0.03	0.39	0.03
Significance Level	**	**	**	**	*	*
CV%	1.41	2.32	3.04	6.25	6.52	4.26

** = Significant at 1% probability
* = Significant at 5% probability

Weight of secondary curd was significantly influenced by the interaction effect of organic manure and mulching (Table 8). The maximum secondary curd weight (121.0 g) was measured in O_2M_2 which was statistically similar to that of O_2M_1, O_1M_2, O_2M_3 and O_1M_3 while the minimum (60.3 g) was recorded from O_0M_0.

4.12 Yield per plant

Yield per plant is important for increasing total yield. Application of organic manure exhibited a significant influence on yield per plant of broccoli (Table 9, Appendix IX). The maximum yield (0.51 kg) was recorded from O_2 while the minimum (0.27 kg) was measured in O_0. It was revealed that yield per plant increased with organic manure application. Spent mushroom compost and cowdung provided more or less similar yield. Broccoli yield and head diameter were greater in organic manure treatment. Steffen *et al*. (1994) observed the effect of organic matter (spent mushroom compost + rotten cattle manure) on growth and yield of broccoli and found that broccoli yield and head diameter were greater in the amended treatment.

Table 8. Combined effect of organic manures and Mulching on stem length of curd, crown length, diameter of primary curd, weight of primary curd, number of secondary curd and weight of secondary curd of broccoli

Treatments	Stem length of curd (cm)	Crown length (cm)	Diameter of primary curd (cm)	Weight of primary curd (kg)	Number of secondary curd	Weight of secondary curd (g)
O_0M_0	9.8 e	11.0 g	11.9 g	0.20 e	1.4 e	60.3 c
O_0M_1	9.8 e	11.5 f	12.4 fg	0.21 e	1.4 e	61.0 b
O_0M_2	9.9 e	11.5 fg	12.8 f	0.22 e	1.7 de	70.0 bc
O_0M_3	9.8 e	11.2 fg	12.7 f	0.21 e	1.8 de	65.0 bc
O_1M_0	10.5 d	12.2 e	14.6 e	0.30 d	2.2 cd	80.0 b
O_1M_1	10.8 c	12.8 d	15.4 de	0.35 cd	2.50 bc	93.0 ab
O_1M_2	10.9 c	13.3 bc	16.4 c	0.3 c	3.17 ab	110.0 a
O_1M_3	11.0 bc	13.5 b	15.5 d	0.36 c	3.15 ab	117.0 a
O_2M_0	10.8 c	12.9 cd	14.8 de	0.37 c	2.58 bc	90.0 ab
O_2M_1	11.2 b	13.6 b	17.7 b	0.39 bc	2.53 bc	110.0 a
O_2M_2	11.8 a	14.6 a	18.9 a	0.46 a	3.67 a	121.0 a
O_2M_3	11.6 a	14.2 a	18.5 a	0.43 ab	2.88 b	116.0 a
$LSD_{(0.05)}$	0.26	0.49	0.78	0.05	0.67	0.054
Significance Level	**	*	**	*	*	*
CV (%)	1.41	2.32	3.04	6.25	6.52	4.26

** = Significant at 1% probability
* = Significant at 5% probability

Application of mulching exhibited a significant influence on total yield per plant (Table 10). The maximum yield (0.44 kg) was recorded from M_2 that was statistically similar to that of M_3 and M_1 while the minimum (0.37 kg) was measured in M_0. This might be caused that mulching suppressed weeds, retain soil moisture, prevent the deterioration of soil structure also influences the nutrient retention of soil and produce high broccoli yield. Similar trend of the results on caulifiower were found by Halappa and Sreenivas (1975).

Table 9. Effect of organic manures on yield of broccoli

Treatments	Yield / plant (kg)	Yield / plot (kg)	Yield/ha (t)
O_0	0.27 c	5.49 c	9.14 c
O_1	0.44 b	8.85 b	14.75 b
O_2	0.51 a	10.19 a	16.99 a
LSD $_{(0.05)}$	0.03	0.34	0.56
Level of significance	**	**	**
CV%	4.85	4.85	4.84

** = Significant at 1% probability

Yield per plant was significantly influenced by the interaction effect of organic manure and mulching (Table 11, Appendix IX). The maximum yield (0.55 kg) was measured in O_2M_2 which was statistically identical with those of O_2M_3 while the minimum (0.26 kg) was recorded from O_0M_0.

Table 10. Effect of different mulching on yield of broccoli

Treatments	Yield / plant (kg)	Yield / plot (kg)	Yield/ha (t)
M_0	0.37 c	7.34 c	12.23 c
M_1	0.41 b	8.10 b	13.51 b
M_2	0.44 a	8.75 a	14.58 a
M_3	0.43 ab	8.51 a	14.18 a
LSD $_{(0.05)}$	0.03	0.39	0.65
Level of significance	**	**	**
CV%	4.85%	4.85%	4.84%

** = Significant at 1% probability

4.13 Yield per plot

The yield per plot of broccoli consists of the main curd and the secondary curd those develop after the removal of the main one. Application of organic manure exhibited a significant influence on yield per plot of broccoli plants (Table 9, Appendix IX). The maximum yield (10.19 kg) was recorded from O_2 which was statistically similar to that of O_1 while the minimum (5.49 kg) was measured in O_0. Spent mushroom compost and cowdung provided more or less similar yield. Broccoli yield and head diameter were greater in organic manure treatment. Steffen *et al*. (1994) observed the effect of organic matter (spent mushroom compost +rotten cattle manure) on growth and yield of broccoli and found that broccoli yield and head diameter were greater in the amended treatment.

Application of mulching exhibited a significant influence on total yield per plot of broccoli plants (Table 10). The maximum yield (8.75 kg) was recorded in M_2 which was statistically similar to that of M_1 and M_3 while the minimum (7.34 kg) was measured in control treatment (M_0). This might be caused that mulching suppressed weeds, retain soil moisture, prevent the deterioration of soil structure also influences the nutrient retention of soil and produce high broccoli yield. Similar trend of the results on caulifiower were found by Halappa and Sreenivas (1975).

Total yield per plot was significantly influenced by the interaction effect of organic manure and mulching (Table 11). The maximum yield per plot (10.97 kg) was measured in O_2M_2 which was statistically identical with those of O_2M_3 while the minimum (5.20 kg) was recorded from O_0M_0.

4.14 Yield per hectare

Application of organic manure significantly influenced the yield per hectare of broccoli plants (Table 9, Appendix IX). The maximum yield (16.99 t ha^{-1}) was measured from O_2 which was statistically similar to that of O_1 while the minimum yield (9.14 t ha^{-1}) was recorded in O_0. It was revealed that yield per hectare increased with organic manure application. Spent mushroom compost and cowdung provided more or less similar yield. Broccoli yield and head diameter were greater in organic manure treatment. Steffen *et al*. (1994) observed the effect of organic matter (spent mushroom compost +rotten cattle manure) on growth and yield of broccoli and found that broccoli yield and head diameter were greater in the amended treatment.

Table 11. Combined effect of organic manures and mulching on yield of broccoli

Treatments	Yield / plant (kg)	Yield / plot (kg)	Yield/ha (t)
O_0M_0	0.26 e	5.20 f	8.67 f
O_0 M_1	0.27 e	5.47 f	9.11 f
O_0M_2	0.29 e	5.75 f	9.59 f
O_0M_3	0.28 e	5.52 f	9.20 f
O_1M_0	0.39 d	7.71 e	12.84 e
O_1M_1	0.44 c	8.85 d	14.76 d
O_1M_2	0.48 bc	9.53 bc	15.89 bc
O_1M_3	0.47 bc	9.31 cd	15.52 cd
O_2M_0	0.46 bc	9.11 cd	15.19 cd
O_2M_1	0.51 ab	9.99 b	16.65 b
O_2M_2	0.55 a	10.97 a	18.28 a
O_2M_3	0.54 a	10.69 a	17.82 a
$LSD_{(0.05)}$	0.05	0.67	1.12
Level of significance	*	*	*
CV (%)	4.85	4.85	4.84

* = Significant at 5% probability

Application of mulching exhibited a significant influence on total yield per hectare of broccoli plants (Table 10). The maximum yield (14.58 t ha^{-1}) was recorded from M_2 which was statistically identical with M_1 and M_3 while the minimum yield (12.23 t ha^{-1}) was measured in M_0.

It was revealed that the yield per hectare increased with mulching application. This might be caused that mulching suppressed weeds, retain soil moisture, prevent the deterioration of soil structure also influences the nutrient retention of soil and produce high broccoli yield. Similar trend of the results on caulifiower were found by Halappa and Sreenivas (1975).

Yield per hectare was significantly influenced by the interaction effect of organic manure and mulching (Table 11, Appendix IX). The maximum yield (18.28 t ha^{-1}) was measured in O_2M_2 which was statistically identical with those of O_2M_3 while the minimum (8.67 t ha^{-1}) was recorded from O_0M_0.

CHAPTER V

SUMMARY AND CONCLUSION

A field experiment was conducted at the Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh, during the period from October 2011 to March 2012 to study the "Effect of organic manures and mulching on growth and yield of broccoli." The experiment comprised of three levels of organic manure viz., O_0 (control), O_1 (25 ton cowdung) and O_2 (17 ton spent mushroom compost) and four levels of mulching *viz*., M_0 (control), M_1 (black polythene), M_2 (water hyacinth) and M_3 (rice straw). Thus there were twelve treatments and the experiment was laid out in randomized complete block design with three replications.

All the growth characters like plant height, number of leaves, leaf length, leaf breadth, days required for curd initiation, stem length of curd, crown length, diameter of primary curd, weight of primary curd, number of secondary curd per plant, weight of secondary curd, yield per plant, yield per plot and yield per hectare varied significantly due to organic manures and mulching.

Application of organic manure exhibited a significant influence on the plant height, number of leaf, leaf length, leaf breadth, days required for curd initiation, stem length of curd, crown length, diameter of primary curd, weight of primary curd, number of secondary curd per plant, weight of secondary curd of broccoli plants at 20, 40 and 60 days after transplanting (DAT).

Application of mulching exhibited a significant influence on the plant height, number of leaf, leaf length, leaf breadth, days required for curd initiation, stem length of curd, crown length, diameter of primary curd, weight of primary curd, number of secondary curd per plant, weight of secondary curd of broccoli plants at 20, 40 and 60 days after transplanting (DAT).

By the treatment combinations at 20, 40 and 60 DAT the plant height, number of leaf, leaf length, leaf breadth, days required for curd initiation, stem length of curd, crown length, diameter of primary curd, weight of primary curd, number of secondary curd per plant, weight of secondary curd of broccoli plants was significantly influenced. In all the cases combination of O_2M_2 were gave better results.

Yield parameters like yield per plant, yield per plot and yield per hectare varied significantly due to organic manures, mulching and treatment combinations of organic manure and mulching. Yield per plant is important for increasing total yield. Application of organic manure exhibited a significant influence on yield per plant. The maximum yield (16.99 t/ha) was recorded from O_2 (spent mushroom compost). Mulching exhibited a significant influence on total yield per plant. The maximum yield (14.58 t/ha) was recorded from M_2 (water hyacinth). Yield per plant was significantly influenced by the treatment combinations of organic manure and mulching of broccoli. The maximum yield (18.28 t/ha) was recorded from the treatment combination of O_2M_2.

Considering the findings of the experiment, it can be concluded that;

- Use of spent mushroom compost (SMC) showed best vegetative growth and yield of broccoli, which may also improve the soil health and save the use of costly chemical fertilizers.
- Water hyacinth mulching (M_2) gave best results for both vegetative growth and yield of broccoli.
- So, it can be concluded that combination of spent mushroom compost and water hyacinth is suitable for broccoli cultivation.

Recommendation:

- ❖ Such study is needed in different Agro Ecological zones (AEZ) of the country for regional adaptability and performance before commercial application.

REFERENCES

Abou El- Magd, M. M.; Hoda, A.; Mohamed and Fawzy, Z. F. 2006. Effect of organic manure with or without chemical fertilizers on growth, yield and quality of some varieties of broccoli plants. *J. Appl. Sci. Res.*,**2**(10): 791-798.

Acharya, B. C. 1968. Effect of mulching on vegetables. Proc. Res. Found., Bihar Agril. Coll., Sabour, 10-49.

Agarwal, S. K. and De, R. 1977. Effect of application of nitrogen, mulching and antitranspirants on the growth and yield of barley.*Indian j. Agril. Sci.*, **47**(4): 191-194.

Ahlawat, O. P.; Dev,Raj; Sagar, M. P.; Pardeep, Gupta and Vijay, B. 2006. Effect of recomposted button mushroom spent substrate on yield, quality and disease-pest management of cauliflower. *Mushroom Research.* **15**(2): 149-152.

Alam, M.S.; Iqbal, M. T.; Amin, M. S. and Gaffer, M. A. 1989. Krishitattik Fasaler Utpadan & Unnayan. Jubair Bin Iqbal, T. M. Vills. Manikpotal, Meghai, Sirajgonj. pp. 231-239.

Ali, R. M. 2004. Effect of mulching and different levels of N fertilizers on the growth and yield of broccoli. M. S. Thesis, Department of Horticulture, Bangladesh Agricultural University, Mymensingh, Bangladesh. pp. 79-83.

Amal, K. A.; Muslin, A. A. and Khan, A. H. 1990. Effect of different mulches on the growth of potato (*Solanum tuberosum* L.). *Bangladesh J. Bot.*, **19**(1): 56-60.

Anonymous. 1982. Annual report, Bangladesh Agricultural Research Institute, Joydepur, Gazipur. p. 452.

Anonymous. 1988. Annual report, Bangladesh Agricultural Research Institute, Joydepur, Gazipur. p. 452.

Ashworth, S. and Harrison, H. 1983. Evaluation of mulches for use in the home garden. *Hort. Science.,***18**(2): 180-182.

Awal, M. A. and khan, M. A. H. 1999. Alteration of soil temperature and moisture through mulching on the morphophysiological differentiation in maize. *Pakistan J. Biol. Sci*., **2**(4): 1164-1167.

Babik, I.; Kowalczyk, W. 2005. The use of organic fertilizer obtained from composting of plant materials in vegetables cultivation. Instytut Warzywnictwa (Research Institute of Vegetable Crops RIVC). Skierniewice, Poland. **39:** 49-54.

Balyan, D. S.; Dhakar, B. S.; Ruhal, D. S. and Singh, K. P. 1988. Growth and yield of cauliflower variety snowball-16 as influenced by nitrogen, phosphorus and zinc. *Haryana J. Hort. Sci.*,**17(**3-4**)**: 247-254.

Balanged fertilization, 2005.International potash Institute coordination India.

Benoit, F. and Ceustermans, N. 1990. Hastening a crop of chinese cabbage susceptible to bolting by means of a direct temporary single or double plastic cover. *Revue del' Agriculture*, **39**(5): 1111-1117.

Blane, D.; Gilly, G. and Gras, R. 1987. Effects of straw mulch on soil under Mediterranean climate. II. Major nutrients status. *Components Rendus des Seances de I' Academic d' Agriculture de France*, **73**(2): 11-19.

Boari, F.; Bianco, V. V.; Cefola, M.; Pace, B.; Vanadia, S. and Cantoren, V. 2010. Characteristics of broccoli in organic farming related to cultivar and biofertilizer amount. *Italus-Hortus*. **17**(2): 39-41.

Braganolo, N. and J. Mielniczuk. 1990. Soil mulching by rice straw and its relation to soil temperature and moisture. Revista Brasilerira de Ciencia do solo, **14**(3): 369-373.

Brakeboer, T. 1990. Broccoli perforated plastic cover over soil-block plants. Not for advancing harvest, but rather for the kilos. *Groenten-en-Fruit*. **45**(37): 80-81.

Burnette, R. R.; Coffey, L. D. and Brooker, J. R. 1993. Economic implications of nitrogen fertilization, drip irrigation and plastic culture on cole crops

and tomatoes grown sequentially. *Tennessee Farm Home Sci*., **168**: 5-13.

Cai, S. Z. and Chen, J.M. 1983. Studies on the dry matter accumulation, absorption and distribution of nutrients in tomato with polythene film mulches. *J. Soil Sci*., **26**(5): 33-36.

Cai, Y. P.; Liu, M.Y. and Liu, Z.M. 1999. A study on N K application amount on broccoli raised in compound media. *J. Hunan Agric. Univ.*,**25(**2**):** 99-102.

Campaneili, G.; Ferrari, V.; Bertone, A.; Leteo, F.; Mancinelli, G.; Scalzo, R.; Cesare-di, L. F.; Sgolastra, F.; Ramilli, F. and Burgio, G. 2010. Comparison between organic and conventional agricultural ecosystems. *Italus-Hortus.***17**(2): 36-38.

Campiglia, E. O.; Temperini, R.; Mancinelli and Saccardo, F. 2000. Effects of soil solarization on the weed control vegetable crops on the cauliflower and fennel production in the open field. *Acta. Hort*., **533**: 249-255.

Chaterjee, B.; P. Ghanti; U. Thapa and Tripathy, P. 2005. Effect of organic nutrition in sprouting broccoli *(Brassica aleraceae* var. *italicaplenck), Vegetable Science*, **33**(1): 51-54.

Chen, Y. and Katen, J. 1980. Effect of solar heating of soils by transparent polythene mulching on their chemical properties, *Soil Sci*,**130**(5):271-277.

Cook, W. P. and Sanders, D. C. 1990. Fertilizer placement effect on soil nitrogen and use by drip irrigated and plastic mulched tomatoes. *Hort. Science*, **25**(7): 767-769.

Demchak, K. T. and Smith, C. B. 1990. Yield responses and nutrient uptake of broccoli as affected by time type and fertilizer. *Amer. soc. Hort. Sci*., **115 (**5**)**: 737-740.

Duffek, J. 1984. Increasing the utilization of solar radiation by mulching the substrate for vegetable seedling in glasshouse. Fukulta Agronomika. **40**:271-288.

Edris, K. M.; Islam, A. T. M.; Chowdhury, M. S. and Haque, A. K. M. 1979. Detailed Soil Survey of Bangladesh. Department Soil Survey, Govt. of the People's Republic of Bangladesh. p. 118.

Eichin, R. and E. Deiser. 1990. Paper mulch in cabbage, lettuce. Gemuse-Munchen, **26**(5):164-167.

Ewees, M. S. A.; Osman, A. S.; El-Sowfy, D. M. 2008. Significance of applied organic manure combined with N-mineral fertilizer to alleviate the possible risks of chemical pollution for broccoli. *Egyptian-Journal-of-Soil-Science*; **48**(3): 343-366.

Faruque, A. C. 2004. Effect of different sources of nutrients and mulching on the growth and yield of broccoli. M.S. thesis, Department of Horticulture, Bangladesh Agricultural University, Mymensingh, Bangladesh. pp. 80-83.

Fertilizer recommendation guide-2012, BARC, Dhaka. p. 248-249.

Gattorman, G. W. 1992. Effect of various types of plastic film on temperature and vegetable yield. Norsk-Land Bruksforsking. *Hort. Abst.*, **76** (1): 51-60.

Halappa, G. and Sreenivas, L. 1973. Effect of black polythene film mulch on soil conditions and yield of cauliflower. *Mysore J. Agril. Sci.*, **7**(4): 510-519.

Halappa, G. and Sreenivas, L. 1975. Effect of black polythene film mulch on the growth, earliness and yield of cauliflower. *Mysore J. Agril. Sci*., **9**(3): 400-460.

Hashem, M. A. 2005. Effects of manuring and mulching on the growth and yield of broccoli. M.S. thesis.Department of Horticulture, Bangladesh Agricultural University, Mymensingh, Bangladesh. pp. 64-65.

Hatano, Y. and Araki, H. 2002. Weed control and broccoli growth in no-tilled field with organic mulch of summer cover. *Bulletin-of-the-Faculty-of-Agriculture,-Niigata-University*. **54**(2): 197-205.

Hill, E. E.; Hankin, L. and Stephens, G. R. 1982. Mulches: their effect on fruit timing and yield of vegetables. *Bull. Con. Agric. Expt. Sta.*, New Haven. pp. 805.

Hopen, H. J. and Oebker, N. F. 1975. Mulch effects of ambient carbon dioxide levels and growth of several vegetables. *Hort. Science*, **10**(2): 159-161.

Hossain, M. E. 1999. Effect of different sources of nutrients and mulching on the growth and yield of cabbage.M.S. Thesis, Departement of Horticulture, Bangladesh Agricultural University, Mymensingh, Bangladesh.pp. 29-68.

Infante, M. L. and Morse, R. D. 1996. Integration of no tillage and over seeded legume living mulches for transplanted broccoli production. *Hort. Science*, **31**(3): 376-380.

Jin-Yan; Li-Yan, Xia; Chen-Tong, Bin and Liu-Shu, Qin. 2002. Effects of sewage sludge compost and compound fertilizer on the yield of vegetables and heavy metal accumulation in them. *Plant-Nutrition-and-Fertilizer-Science*. **8**(3): 288-291.

Karim, M. A.; Hossain, M. M. and Hoque, M. M. 1987. Response of cauliflower to NPK fertilizers at different levels of irrigation. *Bangladesh Hort.*,**15(**2**):** 23-29.

Kashyap, S.; Borboraphookan, D. and Barua, P. 2005. Effect of drip irrigation and black plastic mulch on growth, yield and water use of broccoli [*Brassica oleracea* (L.) var.*italica*]. *Research-on-Crops*. **6**(3): 555-559.

Katyal, S. L. 1994.Vegetable growing in India.Mohan primiani, Oxford and IBH publishing. : 66, Janapath; New Delhi-110001; P 45.

Kumar, R., Ahalawat, V. P. and Daulata, B. S. 2002. Growth, Yield and quality attributes of keno as affected by nitrogen and phosphorus application. *Haryana J. Hort. Sci.*, **22:** 8-13.

Lincolin, C. P. 1987. Vegetable characteristics, production and marketing.John Wiley and sons.Inc. New York. p. 217.

Magnani, G.; Botrini, L. and Graifenberg, A. 2003. Growth rate and quality of the seedlings of broccoli (*Brassica oleracia* var. *botrytis* L.) and cabbage (*Brassica oleracea* L.) for the organic horticulture. *Italus-Hortus.***10**(4, Supplemento): 80-87.

Magro, F.O.; Arruda, N.; Casa, J.; Salata, A.; da, C.; Cardoso, A. I. I. and Fernandes, D. M. 2010. Organic compost in broccoli seed yield and quality. *Ciencia-e-Agrotecnologia.* **34**(3): 596-602.

Mal, K. S. and Shandu, B. S. 1955. The nitrogen requirements of cabbage. *Indian J. Hort.,***12:** 188-195.

Mann, J. S. and Chakor, I. S. 1989. Effect of trash mulch and weed control on rainfed sugarcane ratoon. *Indian J. Agron.,* **34**(3): 279-282.

Maurya, A. K.; Singh, M. P.; Srivastava, B. K.; Singh, Y. V.; Singh, D. K.; Singh, S. and Singh, P. K. 2008. Effect of organic manures and inorganic fertilizers on growth characters, yield and economics of sprouting broccoli cv. Fiesta. *Indian-Journal-of-Horticulture*. **65**(1): 116-118.

Miedema, P. 1982. The effects of low temperature on *Zea mays*. *Adv. Agron*., **35**: 93-128.

Mishra, G. U. and Indulkarl, B. S 1993. Effect of phosphorus and boron on cauliflower. *veg. Sci***., 49:** 83-86.

Mital, R. K.; Singh, T.; Bhagat, M. and Maheshwari, K. P. 1975. Response of broccoli to nitrogen and row spacing. *Indian J. Agron.,***20(**3**):** 278-279.

Mitra, S.K.; M.K. Sadhu and T.K. Bose. 1990. Nutrition of Vegetable Crops. Naya Prokash, Calcutta 700006, India. pp. 157-160.

Munro, D., Mackay, C. and Cutcliffe, J. 1978. Relation of nutrient of broccoli and brussels sprouts leaves to maturity and fertilization with N, P and K fertilizer. *Candian J. Plant sci.,* **58(**2**):** 385-394.

Murlee, Yadav; Rashmi,Chaudhary and Singh, D. B. 2007. Performance of organic and inorganic fertilisers on growth and yield of cauliflower. *Plant-Archives*. **7**(1): 245-246.

Nonnecke, I. L. 1989. Vegetable production. Van Nostrand Reinhold, NewYork. pp. 394-399.

Oh, D. G.; Yoon, J. Y.; Lee, S. S. and Woo, J. G. 1984. The effect of some mulch materials on Chinese cabbage growing different seasons. *J. Korean Soc. Hort. Sci*., **25**(4): 263-269.

Oyabu, T.; Suzuki, I. and Aoyagi, M. 1988. Effects of shading materials and mulching film on the yield and quality of summer Chinese crops. Res. Bull. Acichi-ken Agril Res. Cent., **1146**:(1029-1034).

Parmar, D. K.; Verma, T. S.; Deor, B. S.; Mishra, Arun; and Vermani, Ankur 2006. Enhancing yield and profitability of a Western Himalayan vegetable production system by balancing nutrient inputs through farmyard manure and synthetic fertilizer applications. *Journal-of-Sustainable-Agriculture*; **29**(3): 89-99.

Peksen, A. and Uzun, S. 2008. Effect of chemical compositions of seedling media prepared by spent mushroom compost. *Asian-Journal-of-Chemistry*. **20**(4): 3002-3008.

Perez-Murcia, M. D.; Moral, R.; Moreno-Caselles, J.; Perez-Espinosa, A. and Paredes, C. 2006. Use of composted sewage sludge in growth media for broccoli. *Bioresource-Technology*; **97**(1): 123-130.

Pieters, J. H. 1976. Effect of supplementary nitrogen manuring of sprouting broccoli for multiple harvesting. Bedrijsont wikkeling. **7**(2): 111-115.

Poll, J. T. K. and Geven, C. G. M. 1996. Effect of mulches on the yield and quality of green vegetables. Profestationvor de Akkerbouw en de Groenteteelt in de Vollegrond Verslag, **212**: 87.

Prihar, S. S.; Sandhu, K. S. and Khera, K. L. 1996. Potentialities of increasing maize and sugarcane yields with straw mulching in Punjab. *Indian J. Ecol.,* **4**(2):167-176.

Rahman, M. A.; Guha, D.; Golder, P. C. and Satter, M. A. 1989. Effect of irrigation and mulch on the growth and yield of cabbage in the hilly region. *Bangladesh Hort.,* **17**(1): 37-39.

Ram, K. and Sharma, R. K. 1969. Effect of nitrogen supplies on growth, yield and ascorbic acid content of cabbage. *Poona Agril. Co. J.,***59(**1-2**):** 25-29.

Ramphal and Gill, H. S. 1990. Demand and supply of vegetables and pulses in south Asia. P. 159-165. In: S. Shanmugasundaram (ed.) Vegetables Research and Development in south Asia. Proc. Of a workshop held at Islamabad, Pakistan, September 24-29. AVRDC publications N. 90-331.AVRDC, Tainan, Taiwan.

Rashid, M. M. 1976. Bangladesher sabji (In Bengali). First edition, Bangla Academy, Dhaka.P. 283.

Raut, K. R. and Keder, V. P. 1980-1981. Effect of fertilizer levels and plant growth regulators on growth and yield of cauliflower *.coll. Agric. Nagpur, Mag*. **53:** 73-75.

Roe, N. E. and Cornforth, G. C. 2000. Effects of dairy lot scrapings and composted dairy manure on growth, yield, and profit potential of double cropped vegetables. *Compost-Science-and-Utilization*. **8**(4): 320-327.

Roy, A. K.; Muhsi, A. A. A. and Khan, A. H. 1990. Effect of different mulches on the growth of potato. *Bangladesh J. Bot*., **19**(1): 41-46.

Ruan, R.; Gilkes, J.; Scott, B. J.; xie, L. C. and Hu, X. Z. 1991. Potassium response of Brassica chinensis Baily in the Guangzhou area, southern china. *Fertilizers Research,* **29:** 159-162.

Runham, S. R.; Town, S. J.; Fitzpatrick, J. C. and Verhoyen, M. N. J. 2000. Evaluation over four seasons of a paper mulch used for weed control in vegetables. *Acta Hort.,* **513**: 193-201.

Saimbhi, M. S.; Singh, K. and Padda, D. S. 1969. Influence of nitrogen and phosphorus fertilization on the yield and curd size of cauliflower. *Punjab. Hort. J.,* **9:** 188-202.

Sanjay-Kumar and Chaudhary, D. R.. 2002. Effect of FYM, molybdenum and boron application on yield attributes and yield of cauliflower. *Crop-Research-Hisar*. **24**(3): 494-496.

Santos, G. M.; Braz, L. T.; Grilli, G. V. G.; Costa, C. C.; Cantliffe, D. J.; Stoffela, P. J. and Nascimeto, W. M. 2003. Effect of protecting broccoli plant with non polypropylene, *Acta Hort.,* **607**: 175-178.

Sanwal, S. K.; Rai, N.; Yadav, D. S. and Yadav, R. K. 2005. Compositional differences of stem and floral portions of broccoli under different organic manures and natural growth promoters. *Vegetable-Science*. **32**(1): 73-75.

Schoningh, E. 1985. The effect of mulch on yield and factors of soil Fertility in eastern region of Brazil Giessener Beitage Zur Entwick lungs forshung, **11**:6.

Sharma, K. C. 2000. Influence of integrated nutrient management on yield and economics in broccoli (*Brassica oleracea* L. var *Italica*) plenck under cold temperate conditions. *Vegetable-Science*.**27**(1): 62-63.

Shekour, G. M.; Brathwaite, R. A. I. and Mc. David, C. R. 1997. Dry season sweet corn response to mulching and antitranspirants. *Agron. J.,* **79**(4): 629-631.

Shen, Mao-Hua; Wen-Long, He.; Yan, Shao-Hua; Cheng, Hui-Lin. 2010. Effects of organic farming and special farming on the yield and quality of four kinds of vegetables. *Jiangsu-Journal-of-Agricultural-Sciences*. **26**(4): 729-734.

Shoemaker, J. S.; Benjamin, J. E. and Teskey. 1962. Practical Horticulture. John wiley & sons. Inc. New York. p. 219.

Simoes, A. M.; Calouro, F.; Abrantes, E.; Sousa, E.; Fragoso, M. A. C. and Beusichem, M. L. 1993. Influences of container size and substrate mineral composition on transplant growlth and yield of broccoli cv. Green Duke. Optim. *plantnutr. Lisbon. Portugal.* pp. 87-92.

Singh, S. B. and Misra, R. S. 1975. Effect of various mulches on the growth and yield of cauliflower. *Prog. Hort.,* **7**(2): 65-71.

Singh, A. K; Akhilesh-Singh; Singh, A. 2000. Influence of nitrogen and potassium on growth and head yield of broccoli (*Brassica oliraceae* L. var. *italica*) under low hills sub-tropical condition of Himachal Pradesh. *Veg. Sci.*, **27(**1**):**99-100; 2 ref.

Sorensen, J. N. and Thorup-Kristensen, K. 2011. Plant based fertilizers for organic vegetable production. *Journal-of-Plant-Nutrition-and-Soil-Science*; **174**(2): 321-332.

Steffen, K. L.; Dann, M. S.; Fager, K.; Fleischer, S. J. and Harper, J. K. 1994. Short term and long term impact of an initial large scale SMS soils amendment on vegetable crop productivity and resource use efficiency. *Compost Sci. Util.,* **2(**4**):** 75-83.

Subhan. 1989. Effect of NPK fertilizer and mulch on the growth and yield of the Chinese cabbage cultivar Naga Oka. *Bulletin-Penelitian-Horticultura*, **17**(4): 57-65.

Sumiati, H. 1998. The effect of cultivar and growing medium on the growth and development of broccoli seedlings in the nursery. *Bulletin-Penelitian Horticultura*, **16(**4**):** 14-23.

Takatori, F. H.; Lippert, L. F. and Whiting, F. L. 1964. The effect of petroleum mulch and polythene films on soil temperature and growth. *Proc. Amer. Soc*., **85**: 532-539.

Thakur, P. C. and Singh, V. P. 2001. Effect of organic manure on seed yield of late cauliflower. *Haryana-Journal-of-Horticultural-Sciences*. **30**(3/4): 282-283.

Thilagam, V. K.; Lalitha, M.; Natesan, R. 2011. Integrated nutrient management for sustaining cauliflower productivity. *Agricultural-Reviews*; **32**(1): 26-31.

Thompson, H. C. and Kally, W. C. 1957. Vegetable crops, fifth edition. Mcgrow Hill Book Co. 6 New York, Tornoto, London. P**.** 307.

Tindall, H. D. 1983. Vegetables in the Tropics. Macmillan Education Ltd. Basingstoke Hampshire , London.

Tumuhairwe, J. K. and Gumbs, F. A. 1983. Effect of mulches and irrigation on the production of cabbage in the dry season. *Trop. Agric*., **60**(2): 122-127.

Vanderwerken, J. E. and Wilcox -Lee, D. 1988. Influence of plastic mulch and type and frequency of irrigation on growth and yield of bell pepper. *Hort. Science*, **23**(61): 985-988.

Wani, A. J.; Mubarak, T. and Rather, G. H. 2010. Effect of organic and inorganic nutrient sources on growth and curd yield of cauliflower. *Environment-and-Ecology*. **28**(3): 1660-1662.

Warman, P. R. 2005. Soil fertility, yield and nutrient contents of vegetable crops after 12 years of compost or fertilizer amendments. *Biological Agri. Hort.*, **23**(1): 85-96.

Watt, B. K. 1983. Nutritive value of fruits and vegetables. USAID, Handbook No. 8.

Wyatt, J. E; Mullins, J. A.; CA- Mullins, 1989. Potassium fertilization of broccoli transplants. *Ferti-Res*., **21:** 1, 13-18; 9 ref.

Ying, W. G., Z. C. Zheng and Z. Fushan. 1997. Effect of nitrogen, phosphorus and potassium fertilizer on the yield and physiology target of broccoli. *China Veg.* **1**: 14-17.

Yoon, J. Y., D. G. Oh, J. G. Woo and S. S. Lee. 1984. Effect of some mulch materials on Chiness Cabbage growng in different sesaons. *J. Korean Soc. Hort. Sci.*, **25**(4): 270-276.

APPENDICES

Appendix I. Analytical data of soil sample of the experimental plot

D. Morphological Characteristics

Morphological features	characteristics
Location	Horticulture Garden, SAU, Dhaka
AEZ	Modhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land Type	Medium high land
Soil Series	Tejgaon
Topography	Fairly leveled
Flood Level	Above flood level
Drainage	Well drained

A. Mechanical analysis

Constituents	Percent
Sand	27
Silt	43
Clay	30

B. Chemical analysis

Soil properties	Amount
Soil pH	5.8
Organic carbon (%)	0.45
Total nitrogen (%)	0.03
Available P (ppm)	20
Exchangeable K (%)	0.1
Available S (ppm)	45

Source: Soil Resource Development Institute (SRDI)

Appendix II. Monthly records of air temperature, relative humidity, rainfall and sunshine

during the period from November 2011 to February 2012

Year	Month	** Air temperature (^{0}C)			**Relative humidity (%)	*Rainfall (mm)	**Sunshine (Hours)
		Maximum	Minimum	Mean			
2011	November	28.79	18.54	23.76	82.53	83.1	235.0
	December	25.32	14.40	19.86	84.06	0.00	196.4
2012	January	21.77	10.17	15.97	83.65	Trace	165.6
	February	26.77	15.49	21.13	75.21	27.10	229.2

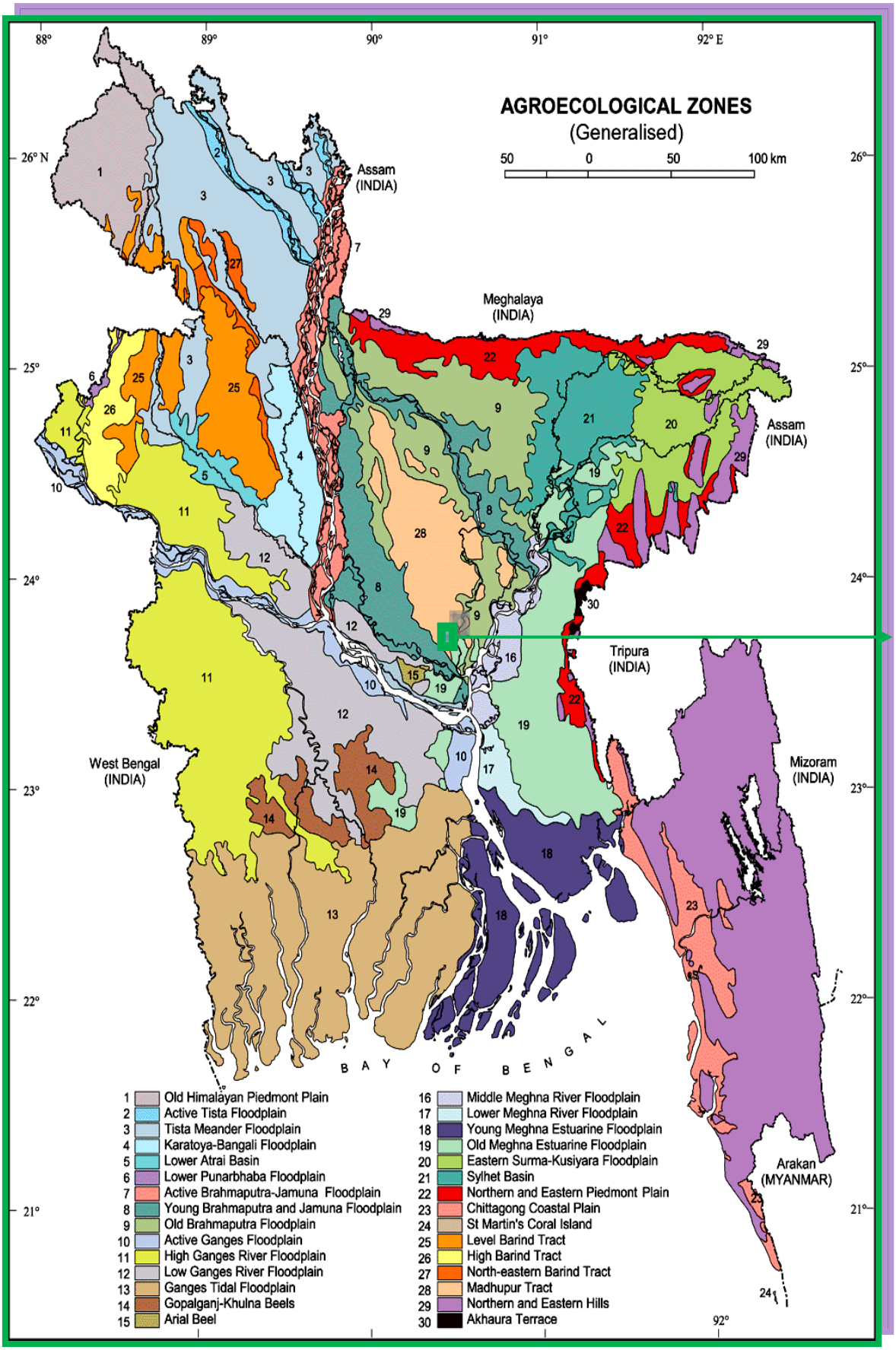
Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan,

Dhaka, Bangladesh

**** Monthly average**

***Monthly total**

Appendix III. Map showing the experimental site



The experimental site

Appendix IV. Nutritive value of 1 lb of selected Cole crops for comparison

Kind of product	Broccoli	Cauliflower	Cabbage
Refuse percent	39.00	55.00	27.00
Food energy (cal.)	103.00	63.00	49.00
Protein (g)	9.10	4.90	4.60
Fat (g)	0.60	0.40	0.70
Carbohydrate (g)	15.20	10.00	17.50
Calcium (mg)	360.00	45.00	152.00
Phosphorus (mg)	211.00	147.00	103.00
Iron (mg)	3.60	2.20	1.70
Vitamin (i.u)	9700.00	200.00	270.00
Ascorbic acid (mg)	327.00	141.00	173.00
Riboflavin (mg)	0.59	0.22	0.21
Thiamin	0.26	0.21	0.23
Niacin	2.50	1.20	0.90

Source: Thomson and Kelly, (1985)

Appendix V. Analysis of variance of the data on Plant height and Number of leaves of broccoli

Source of variation	Degrees of freedom	Plant height (cm)			Number of leaf		
		20 DAT	40 DAT	60 DAT	20 DAT	40 DAT	60 DAT
Replication	2	0.27	1.09	0.61	0.22	0.69	1.51
Factor A	2	59.87**	139.88**	171.91**	5.01**	4.36**	6.17**
Factor B	3	5.04**	18.64**	31.78**	1.27**	0.51*	0.39*
Ax B	6	0.17*	1.57*	5.49*	0.29*	0.58*	0.15*
Error	22	0.16	0.39	1.83	0.17	0.29	0.23

** = Significant at 1% probability
* = Significant at 5% probability

Appendix VI. Analysis of variance of the data on leaf length and Leaf breadth of broccoli

Source of variation	Degrees of freedom	Leaf length (cm)			Lleaf breadth (cm)		
		20 DAT	40 DAT	60 DAT	20 DAT	40DAT	60 DAT
Replication	2	0.08	0.34	3.38	0.10	1.01	1.19
Factor A	2	88.94**	128.78**	198.59**	24.23**	31.48**	36.11**
Factor B	3	6.65**	6.57**	16.34**	2.10**	1.98**	2.70**
Ax B	6	0.17*	0.21**	4.98*	0.53**	0.08**	0.15**
Error	22	0.87	0.76	2.03	1.09	0.78	0.23

** = Significant at 1% probability
* = Significant at 5% probability

Appendix VII. Analysis of variance of the data on stem length of curd, crown length, diameter of primary curd, weight of primary curd, number of secondary curd and average weight of secondary curd of broccoli

Source of variation	Degrees of freedom	Stem length of curd (cm)	Crown length (cm)	Diameter of primary curd (cm)	Weight of primary curd (kg)	Number of secondary curd	Average weight of secondary curd (kg)
Replication	2	0.22	0.76	0.85	0.03	0.02	0.00
Factor A	2	6.77**	19.93**	75.98**	0.13**	6.50**	0.31**
Factor B	3	0.51**	2.08**	8.42**	0.01**	0.56*	0.19*
Ax B	6	0.12**	0.37*	1.96**	0.00*	0.549*	0.24*
Error	22	0.023	0.09	0.22	0.00	0.158	0.05

** = Significant at 1% probability
* = Significant at 5% probability

Appendix VIII. Analysis of variance of the data on curd initiation of broccoli

Source of variation	Degrees of freedom	Days required for curd initiation	80% curd initiation
Replication	2	1.361	2.250
Factor A	2	3.361**	11.083**
Factor B	3	3.880**	0.250ns
Ax B	6	2.657*	1.972*
Error	22	0.270	1.523

** = Significant at 1% probability
* = Significant at 5% probability
ns = non significant

Appendix IX. Analysis of variance of the data on yield of broccoli

Source of variation	Degrees of freedom	Yield / plant (kg)	Yield / plot (kg)	Yield/ha (t)
Replication	2	0.001	0.465	1.293
Factor A	2	0.176**	70.566**	195.967**
Factor B	3	0.009**	3.437**	9.542**
Ax B	6	0.001*	0.381*	1.056*
Error	22	0.000	0.157	0.435

** = Significant at 1% probability
* = Significant at 5% probability