EFFECT OF ORGANIC MANURES ON GROWTH YIELD AND SHELF LIFE OF BROCCOLI CULTIVARS

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CERTIFICATE

This is to certify that thesis entitled, **"Effect of organic manures on growth yield and shelf life of broccoli cultivars"** 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 **SHEIKH MOHAMMAD SHAKILUR RAHAMAN**, Registration No. **09-03750** 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, 2011
Place: Dhaka, Bangladesh

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The Author

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By

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ABSTRACT

An experiment was conducted at the Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka, during November 2010 to February 2011 to study the effect of organic manures on growth, yield and shelf life of broccoli cultivars. The experiment consisted of two factors, Factor A: Four levels of organic manure, viz. M_0: Control; M_1: Vermicompost; M_2: Poultry manure, M_3: Cowdung and Factor B: Three broccoli cultivars, viz. V_1: Premium, V_2: Green magic amd V_3: Forest green. Three storage conditions were used to find shelf life, viz. S_1: Stored in open condition at room temperature (24°C), S_2: Stored in perforated poly-bag at room temperature (24°C) and S_3: Stored in perforated poly-bag at refrigerator (10°C). Organic manures and cultivars had significant effect on days required to curd initiation, diameter and weight of primary curd, number and weight of secondary curds per plant. The highest curd yield of broccoli 9.58 t/ha, was obtained from M_2 and 6.86 t/ha from V_2. The treatment combination of M_2V_2 gave the highest curd yield (10.44 t/ha). For shelf life, broccoli curds stored in S_3 remained good condition for longer time (17.33 days).

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ACRONYMS

ABBREVIATIONS	ELABORATIONS
%	Percent
@	At the rate
°C	Degree centigrade
µg	Microgram
AEZ	Agro-Ecological Zone
Anon.	Anonymous
ANOVA	Analysis of Variance
BARI	Bangladesh Agricultural Research Institute
BAU	Bangladesh Agricultural University
BBS	Bangladesh Bureau of Statistics
BINA	Bangladesh Institute of Nuclear Agriculture
BSMRAU	Bangabandhu Sheikh Mujibur Rahman Agricultural University
Cal.	Calorie
CV	Coefficient of Variation
DAT	Day After Transplanting
df	Degrees of Freedom
DMRT	Duncan's Multiple Range Test
et al.	And others
g	Gram
i.e.	That is
J.	Journal
ns	Non Significant
OM	Organic manure

pH	Hydrogen ion concentration
RCBD	Randomized Complete Block Design
RH	Relative humidity
SAU	Sher-e-Bangla Agricultural University
SRDI	Soil Resource Development Institute

CHAPTER I

INTRODUCTION

Broccoli (*Brassica oleracea* L. var. *italica*) is the most important herbaceous biennial "Cole" crop under Brassicaceae family which is one of the leading vegetables in the world. Broccoli originated in west Europe. There are three classes of sprouting broccoli, i.e. green, white and purple, but the green type is the most popular broccoli (Shoemaker and Teskey, 1962).

In Bangladesh it is planted in early September to late November (Ahmad and Shahjahan, 1991). Broccoli is generally grown in cool winter months in Bangladesh as an annual crop. It is one of the uncommon winter vegetables in Bangladesh which is a horticultural hybrid closely related to cauliflower and is considered as a commercial crop in India (Nonnecke, 1989). Its cultivation in Bangladesh has not been extended much beyond the farms of different agricultural organization. This is mainly due to the lack of awareness regarding its nutritive value and appropriate method of production technology.

It is fairly rich in vitamin A, ascorbic acid and contains appreciable amounts of calcium, phosphorus, riboflavin, thiamin, niacin and iron. Watt (1983) reported that broccoli is more nutritious than any other cole crops such as cabbage, cauliflower and kohlrabi. On the other hand, broccoli is environmentally better adapted than cauliflower, and reported to withstand higher temperature than cauliflower (Rashid, 1976). Its wider environmental adaptability, higher nutritive value, good taste and less risk to crop failure due to various biotic and abiotic factors indicates that there is enough scope for its promotional efforts.

Organic matter 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 manure plays a direct role in plant growth as a source of all necessary macro and micronutrients in available forms during mineralization, improving the physical

and physiological properties of soils. Organic manures, such as cowdung, poultry manure and vermicompost improves the soil structure, aeration, slow release nutrient which support root development leading to higher growth and yield of broccoli. The macronutrients calcium and micronutrients boron, manganese, molybdenum and iron are important for cole crop development. Biologically active soils with adequate organic matter usually supply enough of these nutrients (Udine *et al.*, 2009).

The aim of this work was to compare the variations of health promoting compounds of three broccoli cultivars in relation to their adjustment with organic manure. For that, plant growth, organic manure relations, yield and shelf life were determined. The effects of the organic manure treatments and cultivar factor were analyzed individually.

The post harvest loss of broccoli due to the short shelf life results economic loss of the producers as well as the traders which in turn affects over national economy. No work has yet been conducted in Bangladesh on shelf life of broccoli in terms of suitability for long storage.

Considering the above situation the present study was undertaken with the following objectives:

1. To identify the suitable organic manure for growth and yield of broccoli.
2. To find out the suitable variety for higher yield of broccoli.
3. To find out the effective combination of organic manure and variety on growth and yield of broccoli.
4. To investigate the shelf life of broccoli.

CHAPTER II
REVIEW OF LITERATURE

A number of research works of broccoli have been performed extensively in several countries especially in the South East Asian countries for the improvement of yield and quality. In Bangladesh, little attention has so far been given for the improvement of broccoli varieties or their cultural management. Currently Bangladesh Agricultural Research Institute (BARI) and Bangladesh Institute of Nuclear Agriculture (BINA) have started extensive research on varietals development and improvement of broccoli. Findings of various experiments related to the present study at home and abroad have been reviewed and discussed in this chapter.

2.1 Literature on organic manure

Boari *et al.* (2010) investigated the effects of fertilization and cultivar on yield and quality of broccoli in organic farming. Three levels of organic manure 0, 40 and 80 kg/ha of amino sprint, respectively indicated with F1, F2 and F3 on 4 cultivars of broccoli, were compared. Any effects of fertilization levels were observed on broccoli yield and quality, because of low quantity of main nutritional elements contained in the amino sprint. The most productive cultivar was 'Chevalier'. The nitrate content was low mainly in 'Lord', 'Marathon' and 'Chevalier', and good ascorbic acid content was observed in 'Chevalier' and 'Switch'.

Maurya *et al*. (2008) conducted a field experiment in Pantnagar, Uttaranchal, India to study the effects of the following treatments on broccoli (cv. Fiesta): recommended fertilizers (RF; 120:60:60 kg NPK/ha), farmyard manure (FYM) at 20 t/ha, FYM at 10 t/ha + 50% FR, neem cake at 5 quintal/ha, neem cake at 2.5 quintal/ha + 50% RF, vermicompost at 5 t/ha, vermicompost at 2.5 t/ha + 50% RF, poultry manure at 5 t/ha, and poultry manure at 2.5 t/ha + 50% RF. In 2005-06, poultry manure + 50% RF and FYM + 50% RF resulted in the greatest plant height. In 2006-07, poultry manure + 50% RF, vermicompost +

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

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

Feller *et al.* (2005) reported on the nitrogen requirement of broccoli (*Brassica oleracea* var. *italica*) ranges from 300 to 465 kg/ha. Recommendations for N fertilizer application are accordingly high. High fertilizer rates applied at planting result in a high soil mineral N content that remains high for weeks because the N requirement of the crop is low at early growth stages. Therefore, the risk of leaching is high for several weeks until the available N is finally taken up by the crop. Their study had two objectives: (1) to quantify yield responses to preplant fertilizer application, and (2) to test our hypothesis that the preplant fertilizer rate could be reduced without yield losses by increasing

the N content in the transplants and improving crop establishment. Field experiments (on a sandy soil, an Arenic Luvisol, in Germany, during 2000 and 2001) were carried out on transplants with four levels of N content in dry matter (0.018 to 0.038 g g-1 dry weight), which were tested in all combinations with four fertilizer application timings. All treatments received the same amount of N fertilizer (270 and 272 kg/ha in 2001 and 2002, respectively), but with different rates of supply at the time of planting (0 to 90 kg N fertilizer per ha plus 30 and 28 kg soil mineral N/ha in 2001 and 2002, respectively). Total and marketable yields increased significantly with an increasing N supply at time of planting. In our experiments, in which topdressing was applied 25 days after planting, N supply at planting of 80 to 118 kg/ha was required to obtain maximum marketable yields. The N content in transplants had little effect on growth and yield, and there were no significant interactions between the N content in the transplant and fertilizer timing.

Warman (2005) investigated the 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. 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 Brussels sprouts 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.

Varga *et al.* (2004) conducted a field experiment to study of Broccoli plants supplied with LAD 27, DASA 26/5, NMgS 26-5-6 and NMgS + ammonium nitrate to determine the effects of fertilizer application on the yield of the crop. All the treatments resulted in an increase in the yield of the crop, with LAD 27 application resulting in the highest yield. Nitrate content of broccoli fresh mass ranged from 445 to 1184 mg/kg, with the control recording the lowest nitrate content.

Perin *et al.* (2004) conducted a field experiment to study the residual effects of sunn hemp and millet (*Pennisetum americanum* [P. *glaucum*]), singly or in combination, on the N uptake and yield of broccoli grown after maize were studied in Brazil. Broccoli was supplied with 0 or 150 kg N/ha. The green manures were cultivated from 26 September to 3 December 2001, whereas maize was grown from 4 December 2001 to 28 May 2002. Broccoli was cultivated after maize (5 June to 10 August 2002) under zero tillage and in the presence of maize residues. The green manures had no significant residual effects on the diameter, dry weight of flower buds, and dry matter yield of broccoli. Sunn hemp monocrop increased the content and accumulation of N in the leaves and flower buds of broccoli. Sunn hemp-millet intercropping was more effective in the enhancement of the N content and uptake in leaves and flower buds of broccoli than millet monocropping. The diameter of broccoli buds did not significantly vary in plots without N fertilizer but with sunn hemp and plots supplied with 150 kg N/ha only. However, broccoli yield, and N content and uptake in buds were greater in plots supplied with 150 kg N/ha only than in plots with green manures but without 150 kg N/ha. The utilization of N by broccoli through biological fixation reached 9.15% under sunn hemp monocropping and 8.48% under sunn hemp-millet intercropping.

Kuldeep and Fageria (2004) investigated the response of cauliflower cultivars (Snowball-16 and RC-Job-1) to row spacing (45x45 cm and 60x60 cm) and N fertilizer application (at 120, 150 and 180 kg/ha). A higher curd yield was obtained under 60x60 cm than 45x45 cm, and under 180 kg N/ha than the other N treatments. RC-Job-1 showed better performance than Snowball-16.

Sanjay and Chaudhary (2002) conducted a field experiment to study 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.

2.2 Literature on variety

Apahidean *et al.* (2010) investigated the best way to produce broccoli. They were tested three hybrids: 'Fiesta F_1', 'Marathon F_1' and 'Belstar F_1', also different densities and different ways to set the crop in the field (with two rows or three rows). After cuting the main broccoli sprouts, secondary sprouts (also called side shoots) will start developed. Side shoots will vary in size and weight, depending on the hybrid but as general information, side shoots are smaller than main broccoli heads. Depending on weather cut side shoots at 3 to 5 day intervals for 2 to 3 weeks. Side shoots production was influenced by hybrids, densities and the way that the crop was set in the field. On the poster it will present the influence of side shoots upon final broccoli yields, to see its worth to keep broccoli plants after the main broccoli head its cut.

Charron *et al.* (2005) recorded that on myrosinase [thioglucosidase] catalyzes the hydrolysis of glucosinolates found in the Brassicaceae, generating a variety of bioactive reaction products that may aid in the prevention of some cancers and that are suppressive to soil-borne plant pathogens. Two cultivars each of broccoli (*Brassica oleracea* var. *italica*), Brussels sprouts (*B. oleracea* var. *gemmifera*), cabbage (*B. oleracea* var. *capitata*), cauliflower (*B. oleracea* var. *botrytis*), and kale (*B. oleracea* var. *acephala*) were grown during 2 autumn seasons and 2 spring seasons to determine if myrosinase activity varied by season. Regression models that included mean temperature and photosynthetic photon flux (PPF) during the growing seasons showed that climatic variables explained seasonal differences for myrosinase activity. Activity FW (FW=fresh weight; U g-1) and specific activity (U mg-1) were significantly ($p<=0.05$) affected by season, botanical group and group x season. Activity FW had a negative linear relationship with temperature, and a positive linear but negative quadratic relationship with PPF. Specific activity had a positive linear and a negative quadratic relationship with both temperature and PPF. Therefore the influence of climatic factors on myrosinase activity in Brassica species may affect the potential benefits of the glucosinolate-myrosinase system.

Gutezeit (2004) investigated the effect of watering up to approximately 100% of volumetric available soil water on total biomass, nitrogen (N) balance, and market yield of broccoli crops (*Brassica oleracea* L. convar. *botrytis* var. *italica Plenck*, cv. Emperor) was studied. The experiment was carried out in a microplot field installation on two soil types (alluvial loam and loessal loam) under spring and autumn cultivation and consisted of three soil water regimes: plants received 21 mm of water by irrigation until the soil moisture reached 75% of the available soil water (ASW), treatment 1; 42 mm after the soil moisture reached 55% ASW, treatment 2; and 63 mm after the soil moisture reached 35% ASW, treatment 3. The ASW of the three treatments was measured at a depth of 0.15 m. The total plant mass was significantly affected by the irrigation strategy on the loessal loam in spring and on the alluvial loam

in autumn. The total mass and head mass were lowest when water was applied at 75% ASW in spring and autumn. Calculations of N-balances showed that N losses were large, i.e. more than 70 kg/ha in spring and 130 kg/ha in autumn on the alluvial loam in treatment 1, and were only slightly affected by the irrigation strategy on the loessal loam.

Uzun and Kar (2004) conducted a field experiment on spring to winter in 1999. Cultivar Platini, which is known as sprouting broccoli, was used in the study. Seedlings were raised in module seed trays. Planting procedure was repeated for the times, viz. 25 April (first, P1), 27 May (second, P2) and 27 June 1999 (third, P3). The aim of the study was to see a clear picture of the effects planting times (growing periods) on plant growth parameters, viz. leaf thickness (LT), leaf area (LA), total plant dry weight (TPDW), leaf weight ratio (LWR), stem weight ratio (SWR), root weight ratio (RWR), specific leaf area (SLA), leaf area ratio (LAR), net assimilation rate (NAR) and relative growth rate (RGR) and plant growth accordingly. The results showed that LWR decreased with time after planting while SWR increased with time. Generally, later planting times resulted in higher SWR and LWR while early planting times had higher RWR. Both LAR and SLA declined with ontogeny. Earlier planted plants had higher LAR and SLA. NAR and RGR were found to be lower with earlier plantings. LA and TPDW varied with planting times and ontogeny. Both LA and TPDW increased with time after planting and plants from earlier plantings had lower LA and TPDW values. LT was higher at later planting times and increased with time. Significant positive and negative relationships were also found between plant growth parameters.

2.3 Literature on shelf-life of broccoli

Reddy *et al.* (2010) carried out an experiment on storage conditions to study the effects of packaging treatments, postharvest cooling delay and storage

duration on color, texture, ascorbic acid content, weight loss and glucosinolate retention in crown-cut heads of broccoli were studied. Broccoli stored in shrink wrap film lost 3.7% of its original weight, whereas ice packaging resulted in 17.4% weight loss during storage. Long postharvest cooling delay and storage duration negatively affected broccoli color. Broccoli heads stored in shrink wrap packaging retained firmness longer than broccoli stored in ice. Ascorbic acid retention was improved in shrink wrapped broccoli, but retention decreased as postharvest cooling delay and storage duration lengthened. Shrink wrapped broccoli exhibited improved retention of the glucosinolate, glucoraphanin. During storage, "Gypsy" broccoli maintained better quality than "Everest" with respect to color, ascorbic acid retention and weight loss. However, "Everest" retained texture (firmness) better after 35 days of storage. Shrink wrap packaging and shorter postharvest cooling delays preserve broccoli quality and increase shelf life.

Esmail (2006) conducted an experiment on storage conditions to study the effect of some different packages on the keeping quality of broccoli heads, Brassica oleracea var. italica cv. Tokyo Dome hybrid during storage. Two types of packages were examined, namely: cardboard carton boxes of three different sizes (30x20x10, 40x30x9 and 45x30x14 cm), and non perforated and perforated polyethylene bags at the size of 45x30 cm, where the ventilation holes percentage of perforated bags were 0.15, 0.30 and 0.45%. The evaluation of the various packages proved that large boxes (45x30x14 cm) and non-perforated polyethylene bags were the promising ones in minimizing the heads loss in weight and the unmarketable percentage. Moreover, all packages retained more T.S.S., ascorbic acid, total chlorophyll and total sugars as compared to the control treatment.

Jacobsson *et al.* (2004) conducted an experiment to study the storage conditions on five polymeric films were studied to determine their ability to retain the colour, weight and texture of broccoli (Brassica oleracea L. var. Italica "Monterey"). The materials were oriented polypropylene (OPP),

polyvinyl chloride (PVC) and two different low-density polyethylenes (LDPE), one of which contained a sachet reported to absorb ethylene. The broccoli was packaged and stored at 4 and 10 degrees C for 4 weeks. The weight, colour, chlorophyll content and texture were monitored during storage as well as O< sub>2</ sub> and CO< sub>2</ sub> concentrations inside the packages. Packaging prolonged the broccoli shelf-life by up to 14 days. The shelf-life varied depending on the packaging material and quality parameter considered. The atmosphere was modified inside the packages; however, no package provided the recommended atmosphere (O< sub>2</ sub> 1-2% and CO< sub>2</ sub> 5-10%) for broccoli. Packaging in OPP resulted in the highest CO< sub>2</ sub> concentration, 6%, whiles the lowest O< sub>2</ sub> concentration, 9%, was created in the LDPE package without a sachet for ethylene absorption. Storage in LDPE without ethylene absorber resulted in the overall longest shelf-life. Broccoli stored in PVC deteriorated faster than broccoli packaged in the other materials. The influence of packaging material was greater at the higher temperature.

Ping and Wu (2001) carried out an experiment to study the storage conditions on the Broccoli (cultivars Lilu, Luling and B-53) which was stored at 0, 10, or 20 degrees C after immersion in hot water (38-52 degrees C) for 10 or 30 minutes. Yellowing rate of broccoli was significantly decreased and shelf life significantly increased when broccoli was treated at 42-46 degrees C and then stored at 10 or 20 degrees C. Heat injury occurred when the treatment was higher than 46 degrees C. Broccoli shelf life was 2-3 days longer when stored at 10 degrees C and 1-2 days longer when stored at 20 degrees C after hot water treatment at 46 degrees C. There was no significant effect of treatment on shelf life after long-term storage at 0 degrees C. Weight loss was reduced by hot water treatment, and the respiratory behaviour of the broccoli also changed.

King and Morris (1994) found that ethylene production during storage showed no consistent relationship to yellowing. However time until onset of yellowing was broadly related to the basal level of ethylene production. The maximum

storage life at 20^0C is approximately 72 hrs. Branchless are useful model system for investigation of broccoli senescence.

Barth *et al*. (1993) observed that broccoli spears were packed using a semi permeable polymeric film and stored 96 hours at 20^oC, CO_2 and O_2 concentration within the packages equilibrated to about 9 and 3 percent, respectively. Relative to non-packed spears, ascorbic acid, chlorophyll and moisture retention were greater.

Bastrash *et al*. (1993) carried out an experiment to study the storage of broccoli. They observed that the atmosphere consisting of 6% CO_2 and 2% O_2 resulted in extended storage of broccoli florets from 5 weeks in air to 7 weeks. This was demonstrated by delayed yellowing, prolonged chlorophyll retention, and reduced development of mold and offensive odors and better water retention. These beneficial effects were especially noticeable when the florets were returned from control atmosphere storage at 4^oC to normal air 20^oC.

Tan *et al.* (1993) conducted an experiment to study the storage characteristics and quality of 4 broccoli cultivars stored at 1^0C for three weeks in folded high-density polyethylene bags. After storage they were still green, compact and marketable. After exposure to 26^oC for another two days, most of the heads turned yellow and were non-marketable.

An experiment was conducted in Kasetsart University, Bangkok, Thailand on modified atmosphere storage of broccoli. The vegetable (broccoli) stored either at 5^0C or 10% had a storage life of 16 days.

Deschene *et al*. (1991) observed that when freshly cut heads of broccoli were stored in air control atmosphere at 23^0C or 10^0C the florets rapidly senescent. Chlorophyll levels declined by 80-90% within 4 days at 20^0C and within 10 days at 10^0C. Broccoli florets senescence those are sensitive, directly or indirectly to ambient CO_2 and O_2 concentrations.

Kalieber and Wills (1991) reported that an optimum storage life about 8 weeks was attained at 0^0C and 100% relative humidity but close control of these conditions were required. Reducing the O_2 concentration and increasing CO_2 concentration could extend storage life.

Xue *et al*. (1991) conducted an experiment and observed that the effects of low density polyethylene (LDPE) films mixed with ethylene absorbent or far infrared radiation ceramics and of the moisture absorbent in an LDPE bag on freshness keeping of broccoli. The storage life of broccoli in LDPE bags was more than twice as long as for non-packaged broccoli. Yellowing and wilting of broccoli were observed without packaging and off flavor was observed in LDPE packaging.

Beraid (1990) conducted an experiment with nitrogen fertilizer on stored cabbage. They found that maximum severity in storage head treated with high nitrogen and suggested that application of nitrogen fertilizer in excess of 180 kg N/ha must be avoided.

Makhlouf *et al*. (1989) carried out an experiment on long-term storage of broccoli under controlled atmosphere. The cv. Stolto was stored for 6 weeks at 1^0 C under the N containing the following percentages of CO_2/O_2 0/20%, 6/2.5%, 10/2.5% and 15/2.5%. Color and chlorophyll retention was better under control atmosphere then in air. Storage under control atmosphere also delayed the development of soft rot and mould. Among the atmosphere tested, 6% CO_2 and 2.5% O_2 was the best for long term (3 weeks) maintenance of broccoli quality while avoiding physiological injury.

Apelond (1985) carried out an experiment on storage of Chinese cabbage and found that the head were stored for 90 to 120 days respectively at 2.5^{o}C or 5^{o}C in 0.5, 2.5 or 5% CO_2 and 1-20.5% O_2 in different combination.

Mertens (1985) conducted an experiment on storage conditions of important Chinese cabbage and found that harvested head of the Chinese cabbage cv.

WR-60, which was susceptible to vein browning were stored at 1^0, 2.5^0 or at 1^0 C with various CO_2/O_2 percentage for 3 or 4 weeks.

CHAPTER III

MATERIALS AND METHODS

This chapter describes the materials used and methods followed in the experiment. It includes a brief description of experimental site, soil, crop, climate, treatments, experimental design, land preparation, transplanting of seedling, intercultural operations, harvesting, data recording, collection and preparation of soil and plant samples and the methods for the chemical analysis and statistical analysis.

3.1 Experimental site

The plants of broccoli were grown at the Horticulture Farm, Sher-e-Bangla Agricultural University (SAU), Dhaka-1207, Bangladesh. The experiment was carried out during rabi season (October 15, 2010 to February 15, 2011). The location of the experimental site was at 23.75^0 N latitude and 90.34^0 E longitude with an elevation of 8.45 meter from sea level.

3.2 Climate

The experimental area was situated in the sub-tropical climatic zone, which was characterized by heavy rainfall during the month of April to September and scanty rainfall during the rest period of the year. Details of weather data in respect of temperature (^{O}C), rainfall (cm) and relative humidity (%) for the study period were collected from the Meteorological Department of Bangladesh, Agargoan, Dhaka, (Appendix II).

3.3 Soil

Soil of the study site was silty clay loam in texture belonging to series. The area represents the Agro-Ecological Zone of Madhupur tract (AEZ No. 28) with pH 5.8-6.5, ECE-25.28. The analytical data of the soil sample collected from the experimental area were determined in the Soil Resource Development Institute (SRDI), Soil Testing Laboratory, Khamarbari, Dhaka and have been presented in Appendix I.

3.4 Plant materials used in the experiment

The hybrid varieties are ‘Premium’, ‘Green magic’ and ‘Forest green’ of broccoli were used in the experiment. The seeds of the hybrid variety were produced by Holland and China and were collected from Khustia Seed Store, Mirpur-11, Dhaka-1216.

3.5 Seedbed preparation

Seedbed was prepared on 26 October 2010 for raising seedlings of broccoli and the size of the seedbed was 3 m×1 m. For making seedbed, the soil was well ploughed and converted into loose friable and dried masses to obtained good tilth. Weeds, stubbles and dead roots were removed from the seedbed. The soil was treated by Seven 50WP @ 5 kg/ha 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 such as leaf spot, blight, anthracnose, etc.

3.7 Seed sowing

Seeds were sown on 28 October 2010 in the seedbed. Sowing was done thinly in lines spaced at 5 cm distance. Seeds were sown at a depth of 2 cm and covered with a fine layer of soil followed by light irrigation by water can. Thereafter the beds were covered with dry straw to maintain required temperature and moisture. The cover of dry straw was removed immediately after emergence of seed sprout. When the seeds were germinated, shade by bamboo mat (Chatai) was provided to protect the young seedlings from scorching sunshine and rain.

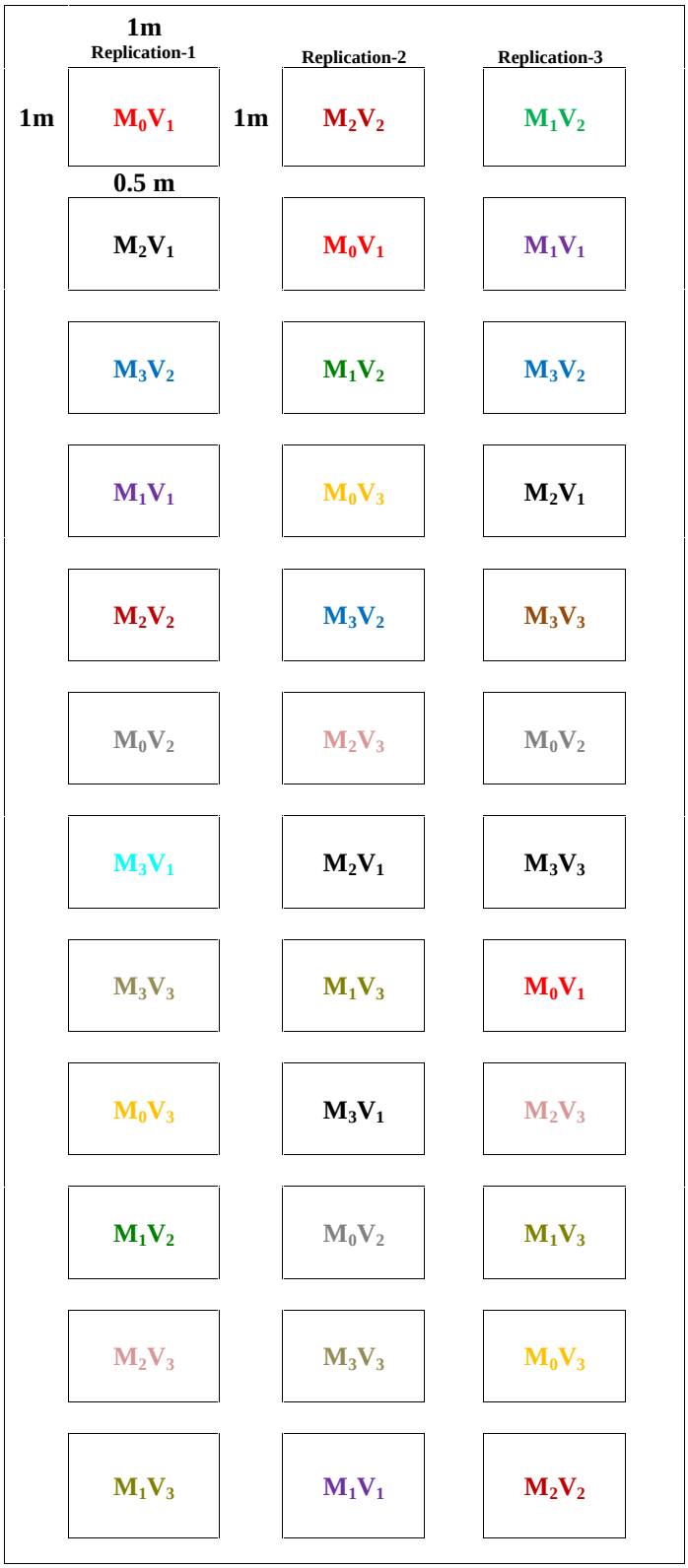
3.8 Raising of seedlings

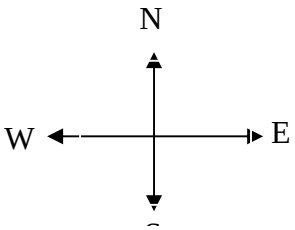
Light watering and weeding were done several times. No chemical fertilizers were applied for rising of seedlings. Seedlings were not attacked by any kind of insect or disease. Healthy and 21 days old seedlings were transplanted into the experimental field on 18 November 2010.

3.9 Layout and design

The field experiment was conducted by Randomized Complete Block Design (RCBD) with three replications. Two factors were used in the experiment viz. four levels of organic manure and three varieties. The experimental plot was first divided into three blocks. Each block consisted of 12 plots. Thus, the total number of plots were 36.

Different combinations of organic manure and varieties were assigned to each plot as per design of the experiment. The size of a unit plot was 3 m × 3 m. A distance of 0.5 m between the plots and 1.0 m between the blocks were kept. Thus the total area of the experiment was 43.5 m × 13 m.





Plot size: 3 m x 3 m
Spacing: 75cm x 60cm
Spacing between plots: 0.5 m
Spacing between replication: 1 m

Factor A: Organic Manures
M_0: Control
M_1: Vermicompost
M_2: Poultry manure
M_3: Cowdung

Factor B: Broccoli cultivars
V_1: Premium
V_2: Green magic
V_3: Forest green

Fig. 1. Field layout of the experiment

Factor A. Four levels of organic manure coded as M

M_0 = Control (No organic manure)

M_1 = Vermicompost (15 t/ha)

M_2 = Poultry manure (20 t/ha)

M_3 = Cowdung (25 t/ ha)

Factor B. Three varieties coded as V

V_1= Premium

V_2 = Green magic

V_3 = Forest green

There are 12 treatment combinations are given below:

$\mathbf{M_0V_1}$	$\mathbf{M_2V_2}$
$\mathbf{M_1V_1}$	$\mathbf{M_3V_2}$
$\mathbf{M_2V_1}$	$\mathbf{M_0V_3}$
$\mathbf{M_3V_1}$	$\mathbf{M_1V_3}$
$\mathbf{M_0V_2}$	$\mathbf{M_2V_3}$
$\mathbf{M_1V_2}$	$\mathbf{M_3V_3}$

3.10 Cultivation procedure

3.10.1 Land preparation

The experimental area was first opened on 15 October 2010 with a disc plough to open direct sunshine to kill soil born pathogens and soil inhabitant insects. It was prepared by several ploughing and cross ploughing with a power tiller followed by laddering to bring about a good tilth. The land was leveled, corners were shaped and the clods were broken into pieces. The weeds, crop residues and stables were removed from the field. The doses of manure were applied and finally leveled. The soil of the plot was treated by Seven 50wp @ 5kg/ha to protect the young plants from the attack of mole cricket, ants and cutworm.

3.10.2 Application of manure

According to the treatment vermicompost, poultry manure and cowdung were applied during the land preparation with 8.10 kg, 10.80 kg and 13.50 kg per plot respectively. No chemical fertilizer were used here as a basal dose.

3.10.3 Transplanting

The seedbed was watered before uprooting the seedlings to minimize the damage of roots. At the time of uprooting, care was taken so that root damage became minimum and some soil remained with the roots. Twenty one days old healthy seedlings were transplanted at the spacing of 75 cm × 60 cm in the experimental plots on 18 November 2010. 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 transplanted seedlings were shaded for five days with the help of transparent polythene to protect them from scorching sunlight, watering was done up to five days until they became capable of establishing on their own root system.

3.10.4 Intercultural operations

3.10.4.1 Gap filling

Very few seedlings were damaged after transplanting and gap filling was carried out with new seedlings from the same stock.

3.10.4.2 Weeding

The plants were kept under careful observation. Three times weeding were done during cropping period, viz. 4th and 19th December'10 and 3rd January'11, for proper growth and development.

3.10.4.3 Spading

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

3.10.4.4 Irrigation

Irrigation was given by observing the soil moisture condition. Four times irrigation was done during crop period, viz. 5th, 15th, 25th December'10 and 5th January'11, for proper growth and development of plants.

3.10.4.5 Earthing up

Earthing up was done by taking the soil from the space between the rows on 4th December 2010.

3.10.4.6 Insects and disease control

Few plants were damaged by mole crickets and cut worms after the seedlings were transplanted in the experimental plots. Seven 80WP was dusted to the soil before irrigation to controlled mole crickets and cut worms on 4th December 2010. Some of the plants were infected by alternaria leaf spot disease caused by *Alternaria brassicae*. Rovral 50WP @ 20 g per 10 litre of water was sprayed to prevent the spread of the disease on 24th December 2010. Bird pests such as nightingale (bulbuli) were seen visiting the broccoli field very frequently. The nightingale visited the fields from 8 to 11 a.m. and 4 to 6 p.m. The birds were found to puncture the soft leaves and initiating curd and were controlled by striking of a metallic container.

3.11 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 26 December 2010 and was completed on 14 February 2011. The curds were harvested with 20 cm of stem attached with the sprouts.

3.12 Data collection

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.

3.12.1 Plant height

Plant height was measured from base to the tip of the longest leaf at 15, 30 and 45 days after transplanting (DAT). A meter scale was used to measure plant height of the plant and expressed in centimeter (cm).

3.12.2 Number of leaves per plant

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

3.12.3 Leaf length

The length of the leaf was measured from the base of the petiole to the tip at 15, 30 and 45 DAT. A meter scale was used to measure the length of the leaves and expressed in centimeter (cm).

3.12.4 Leaf breadth

The large leaf breadth was measured on 15, 30 and 45 DAT. A meter scale was used to measure the large breadth of the leaves and expressed in centimeter (cm).

3.12.5 Plant canopy

Plant canopy was measured by using a meter scale on 15, 30 and 45 DAT. Plant canopy was measured at different directions and finally the average of all directions was recorded and expressed in centimeter (cm).

3.12.6 Days required for curd formation

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

3.12.7 Main curd diameter

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

3.12.8 Main curd weight

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

3.12.9 Number of secondary curds

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

3.12.10 Weight of secondary curd

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

3.12.11 Yield per plant

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

3.12.12 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)

3.12.13 Yield per hectare

The yield per hectare was calculated out from the per plot yield data.

3.13 Laboratory experiment:

Laboratory experiment was carried out after harvesting the curds to find out the shelf life of curd at different storage conditions. The storage conditions were as follows:

i) Stored in open condition at room temperature (24^0C) = S_1
ii) Stored in perforated polyethylene bags at room temperature (24^0C) = S_2
iii) Stored in perforated polyethylene bags at refrigerator (10^0 C) = S_3

The three mature broccoli curds were selected for each treatment. The selected broccoli curds were kept in a perforated polythene bag. The changes of florets color (just started to yellowish) were recorded by eye estimation. Laboratory trial comprised of twelve (12) treatment combinations with three storage conditions.

3.13.1 Data collection

Data on shelf life (days) was estimated until yellowing of florets under different storage condition.

3.14 Statistical analysis

The recorded data on different parameters were statistically analyzed with the help of MSTAT program. The treatment means were separated by Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1983) at 5% level of significance for interpretation of the results.

CHAPTER IV
RESULTS AND DISCUSSION

The present study was conducted to determine the effect of different organic manure on growth, yield and shelf life of broccoli cultivars. Data on different yield contributing characters and yield were recorded at 15, 30 and 45 days after transplanting. The analysis of variance (ANOVA) of the data on different yield components and yield are given in Appendices IV-VII. The results have been presented and discussed, and possible interpretations are given under the following headings.

4.1 Plant height

Application of organic manure exhibited a significant influence on the height of broccoli plants at 15, 30 and 45 days after transplanting (DAT) (Fig. 1, Appendix IV). At 15 DAT, the tallest plant (32.01 cm) was recorded in the poultry manure application (M_2) and the lowest (12.96 cm) was recorded from control treatment M_0. At 30 DAT, the highest plant height (50.65 cm) was recorded from M_2 and the shortest (24.88 cm) was found from M_0. The highest plant height (56.96 cm) was obtained from M_2 and the lowest (35.32 cm) was recorded from M_0 treatment at 45 DAT. Efficiency of nitrogen uptake enhanced vegetative growth of broccoli plants. Mishra and Indulkarl(1993); Sharma *et al*. (2002), Singh (2004) and Reddy and Padmaja (2005) found the same results in the present investigation.

Different varieties showed no significant influence on the height of broccoli plants at 15, 30 and 45 DAT (Fig. 2, Appendix IV). At 15 DAT, plant height ranged from 25.30 to 25.44 cm. The highest plant height (25.44 cm) was obtained from V_2 which was statically similar with V_1 and V_3. At 30 DAT, plant height ranged from 40.30 to 42.27 cm. This was statistically similar to V_1, V_2 and V_3. At 45 DAT, plant height ranged from 47.98 to 49.97 cm. This was also statistically similar to V_1, V_2 and V_3.

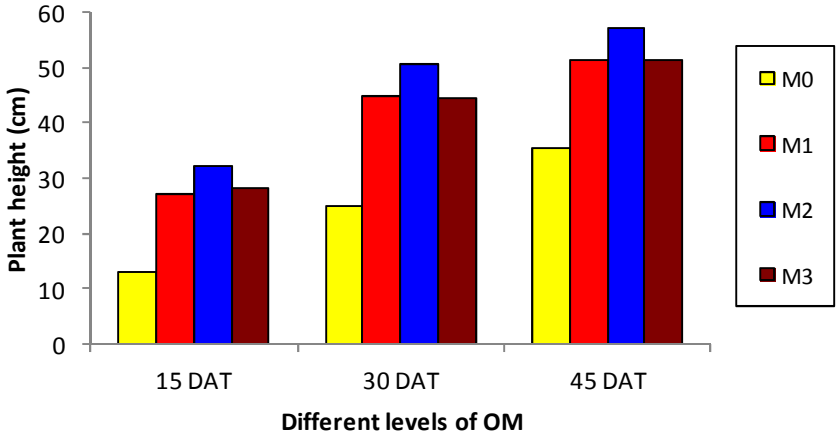


Fig. 2. Effect of different organic manure on plant height of broccoli

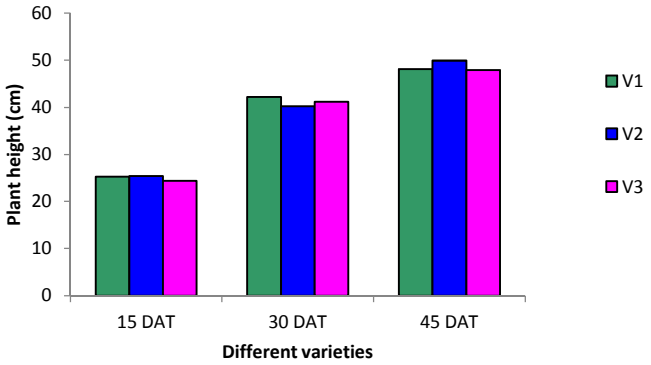


Fig. 3. Effect of different varieties on plant height of broccoli

The plant height was significantly influenced by the treatment combinations at 15, 30 and 45 DAT (Table 1, Appendix IV). At 15 DAT, plant height ranged from 12.30 cm to 34.80 cm. The highest plant height (34.80 cm) was observed in combination M_3V_1 and the lowest (12.30 cm) was recorded from M_0V_1. At 30 DAT, plant height ranged from 24.07 cm to 54.40 cm. The highest plant height (54.40 cm) was observed in M_2V_2 and the lowest (24.07 cm) was recorded from M_0V_2. At 45 DAT, plant height ranged from 34.77 cm to 66.77 cm. The highest plant height (66.77 cm) was observed in M_2V_2 and the lowest (34.77 cm) was recorded from M_0V_2. It was reveled that the plant height increased with the increased in DAT. Similar results were found by other scientists like Wyatt *et al.* (1989), Singh (2004) and Reddy *et al.* (2005).

4.2 Number of leaves per plant

Application of organic manure exhibited a significant influence on the number of leaves of broccoli plants at 15, 30 and 45 DAT (Fig. 3, Appendix IV). Minimum number of leaves (6.66) was found with cow dung application at 45 DAT and Maximum number of leaves (11.33) was found in control treatment at 45 DAT, per plant. This result was coincided with those reported by Fong *et al.* (1996) and Abou *et al.* (2006)

Different varieties exhibited a significant influence on the number of leaves of broccoli plants at 15, 30 and 45 DAT (Fig. 4, Appendix IV). At 15 DAT, number of leaves per plant ranged from 4.917 to 5.167. The maximum number of leaves (5.167) was found in V_2 and the minimum number of leaves (4.91) in V_3. At 30 DAT, the maximum number of leaves (8.16) was found in V_2 while the minimum number of leaves (8.00) was found in V_1. At 45 DAT, the maximum number of leaves (8.16) was found in V_2 while the minimum number of leaves (8.5) was found in V_1.

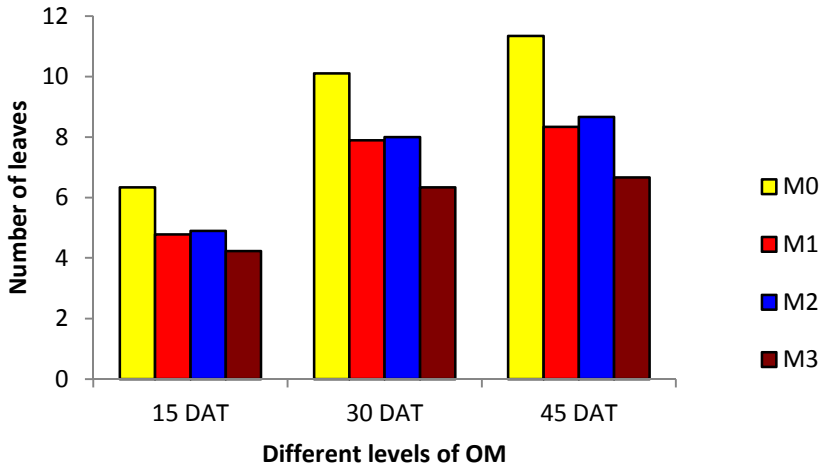


Fig. 4. Effect of different organic manure on number of leaves of broccoli

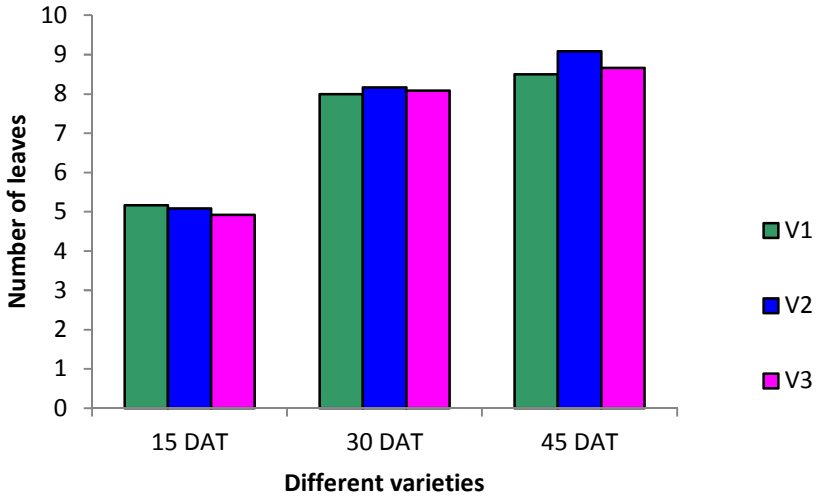


Fig. 5. Effect of different varieties on number of leaves of broccoli

The number of leaves was significantly influenced by the treatment combinations at 15, 30 and 45 DAT (Table 1, Appendix IV). At 15 DAT, number of leaves per plant ranged from 4.00 to 6.33. The maximum number of leaves (6.33) was observed in M_0V_1, which was statistically similar to that of M_0V_2, M_0V_3while the minimum number of leaves (4.00) was recorded from M_3V_2. At 30 DAT, number of leaves per plant ranged from 6.33 to 10.33 The maximum number of leaves (10.33) was observed in M_0V_1, which was statistically similar to that of M_0V_2 and M_0V_3 and the minimum number of leaves (6.33) was recorded from M_3V_3. At 45 DAT, number of leaves per plant ranged from 6.667 to 12.33. The maximum number of leaves (12.33) was observed in M_0V_2 and the minimum number of leaves (6.66) was recorded from M_3V_3. Corroborative results were found by Raut and keder (1981), Balyan *et al.* (1988) and Wyatt *et al.* (1989).

4.3 Plant canopy

Application of organic manure exhibited a significant influence on the plant canopy of broccoli plants at 15, 30 and 45 days after transplanting (DAT) (Fig. 5, Appendix IV). At 15 DAT, the plant canopy ranged from 22.56 cm to 43.74 cm. The largest plant canopy (43.74 cm) was found in the poultry manure application (M_2) and the lowest plant canopy (22.56 cm) was recorded from control treatment (M_0). At 30 DAT, plant canopy ranged from 27.04 cm to 44.20 cm. The largest plant canopy (44.20 cm) was recorded from M_2. At 45 DAT, the plant canopy ranged from 31.52 cm to 48.23 cm. The largest plant canopy (48.23 cm) was recorded from M_2. At 15, 30 and 45 DAT the largest plant canopy was found with the application of poultry manure. Poultry manures play a direct role in plant growth as a source of all necessary macro and micronutrients. Similar result was coincided with those reported by Abou *et al.* (2006).

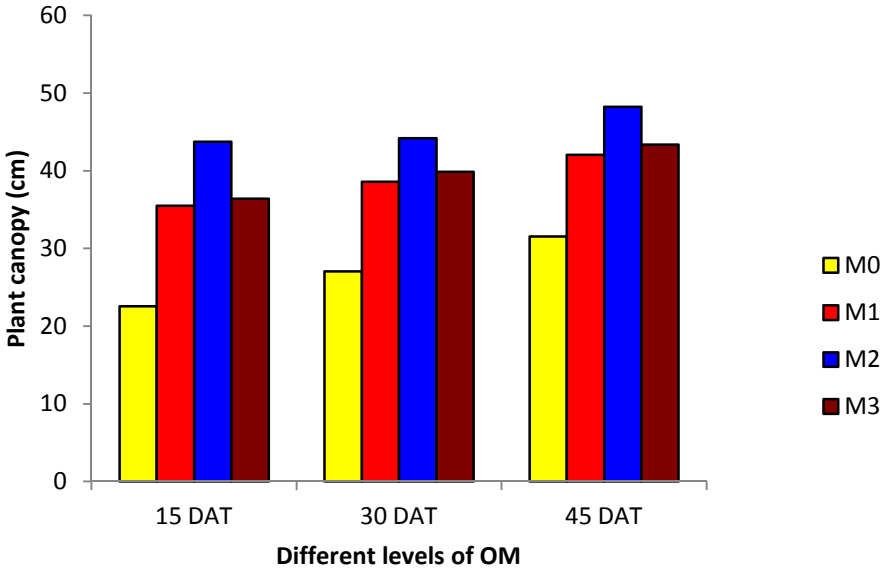


Fig. 6. Effect of different organic manure on plant canopy of broccoli

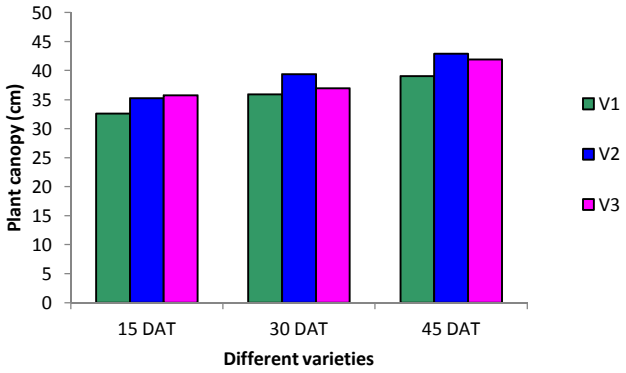


Fig. 7. Effect of different varieties on plant canopy of broccoli

Table 1. Combined effect of different organic manure and variety on plant height, number leaf and plant canopy of broccoli

Treatments	Plant height			Number of leaf			Plant canopy		
	15 DAT	30 DAT	45 DAT	15DAT	30 DAT	45DAT	15DAT	30DAT	45DAT
M_0V_1	12.30 g	25.27 g	36.02 e	6.33 a	10.33 a	11.00 b	22.73 f	28.67 d	33.40 g
M_0V_2	13.33 g	24.07 g	34.77 e	6.33 a	10.00 a	12.33 a	22.93 f	26.33 d	30.47 h
M_0V_3	13.23 g	25.33 g	35.20 e	6.33 a	10.00 a	10.67 b	22.03 f	26.13 d	30.70 h
M_1V_1	28.80 cd	47.17 cd	52.40 b	5.00bc	7.66 b	8.00 c	35.77 cde	38.77 bc	41.87 d
M_1V_2	25.87 f	41.23 f	48.47 d	4.67 bcd	8.00 b	8.33 c	33.47 e	36.07 c	39.80 ef
M_1V_3	26.67 ef	46.37 d	53.07 b	4.67 bcd	8.00 b	8.66 c	37.20 cd	40.93 b	44.47 c
M_2V_1	31.77 b	49.20 b	51.70bc	5.00 bc	7.66 b	8.33 c	35.37 cde	36.4 c	38.43 f
M_2V_2	34.80 a	54.40 a	66.77 a	5.33 b	8.33 b	9.00 c	49.87 a	56.8 a	60.40 a
M_2V_3	29.47 c	48.30 bc	52.43 b	4.33 cd	8.00 b	8.66 c	46.00 b	39.33 bc	45.87 bc
M_3V_1	28.30 cd	47.47 cd	52.60 b	4.33 cd	6.33 c	6.66 d	36.53 cd	39.87 bc	42.60 d
M_3V_2	27.77 de	41.50 f	49.90cd	4.00 d	6.33 c	6.66 d	34.87 de	38.27 bc	40.90 de
M_3V_3	28.22 cd	44.80 e	51.23bc	4.33 cd	6.33 c	6.66 d	37.73 c	41.50 b	46.60 b
$LSD_{0.05}$	0.34	0.66	0.30	0.77	0.34	0.55	1.32	1.30	1.12
CV (%)	3.17	1.94	2.19	10.14	7.69	6.67	4.20	5.44	2.60

Means in the column followed by different letter(s) differed significantly by DMRT at 5% level of significance

Different varieties exhibited a significant influence on the plant canopy of broccoli plants at 15, 30 and 45 DAT (Fig. 6, Appendix IV). At 15 DAT, plant canopy per plant ranged from 32.60 cm to 35.74 cm. The largest plant canopy (35.74 cm) was found in V_3. At 30 DAT, the largest plant canopy (39.38 cm) was found in V_2. At 45 DAT, the largest plant canopy (42.89 cm) was found in V_2 while the minimum (39.07 cm) was found in V_1.

The plant canopy was significantly influenced by the treatment combinations of organic manure and varieties at 15, 30 and 45 DAT (Table 1, Appendix IV). At 15 DAT, plant canopy per plant ranged from 22.03 cm to 49.87 cm. The largest plant canopy (49.87 cm) was observed in combination of M_2V_2, which was statistically similar to that of M_2V_3, while the minimum (22.03 cm) was recorded from the combination of M_0V_3. At 30 DAT, plant canopy per plant ranged from 26.13 cm to 56.80 cm. The largest plant canopy (56.80 cm) was observed in M_2V_2 and the minimum (26.13 cm) was recorded from M_0V_3. At 45 DAT, plant canopy per plant ranged from 30.47 cm to 60.40 cm. The plant canopy (60.40 cm) was observed in M_2V_2 and the minimum (30.47 cm) was recorded from M_0V_2. It was appeared that plant canopy differed significantly due to the combined application of different organic manure and varieties.

4.4 Leaf length

Organic manure had a significant influence on the length of leaves of broccoli plants at 15, 30 and 45 DAT (Fig. 7, Appendix V). At 15 DAT, leaf length ranged from 14.03 cm to 25.17 cm. Poultry manure (M_2) produced the longest leaf (25.17 cm), while the lowest (14.03 cm) was found in control plots (M_0). At 30 DAT, leaf length ranged from 19.98 cm to 37.22 cm. The largest leaf (37.22 cm) was recorded from M_2, while the smallest leaf (19.98 cm) was recorded from M_0. At 45 DAT, leaf length ranged from 26.50 cm to 51.63 cm. The longest leaf (51.63 cm) was recorded from M_2, while the smallest (26.50 cm) was recorded from M_0. Organic manures have slow release nutrients all over the growth season. Poultry manure is rich in its nitrogen and nutrient

content. This favorable condition creates better nutrient absorption and favors for vegetative growth. Consequently highest leaf length was found by poultry manure. Similar result was obtained by other investigator such as Abou *et al.* (2006).

There had a significant influence of varieties on broccoli plants in respect of leaf length at 15, 30 and 45 DAT (Fig. 8, Appendix V). At 15 DAT, leaf length ranged from 19.55 cm to 21.61 cm. V_2 produced the longest leaf (21.61 cm). Similar trend of result was found at 30 DAT and 45 DAT. At 30 DAT, V_2 produced the longest leaf (32.06 cm) whereas V_3 produced the smallest leaf (28.83 cm). At 45 DAT, the largest leaf (43.28 cm) was found in V_2 and the smallest leaf (40.32 cm) was found in V_3.

The leaf length was significantly influenced by the treatment combinations of organic manure & varieties at 15, 30 and 45 DAT (Table 2, Appendix V). At 15 DAT, leaf length ranged from 12.80 cm to 30.97 cm. The largest leaf (30.97 cm) was observed in combination of M_2V_2, while the smallest (12.80 cm) was recorded from M_0V_3. At 30 DAT, leaf length ranged from 19.33 cm to 45.53 cm. The largest leaf length (45.53 cm) was observed in M_2V_2, while the smallest (19.33 cm) was recorded from M_0V_3. At 45 DAT, leaf length ranged from 26.13 cm to 60.63 cm. The largest leaf length (60.63 cm) was observed in M_2V_2, while the smallest (26.13 cm) was recorded from M_0V_2.

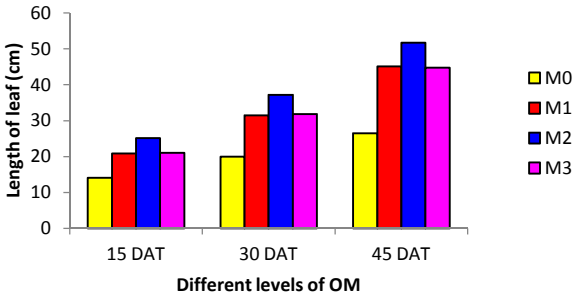


Fig. 8. Effect of different organic manure on leaf length of broccoli

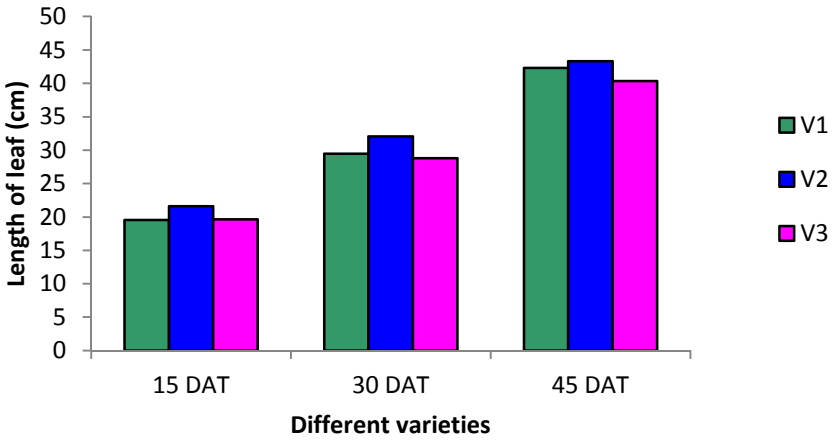


Fig. 9. Effect of different varieties on leaf length of broccoli

4.5 Leaf breadth

Organic manure had a significant influence on the leaf breadth of broccoli plants at 15, 30 and 45 DAT (Fig. 9, Appendix V). At 15 DAT, leaf breadth ranged from 5.63 cm to 10.13 cm. Poultry manure (M_2) produced the largest leaf breath (10.13 cm), while the lowest (10.13 cm) was found in control plots

(M_0). At 30 DAT, leaf breadth ranged from 8.11cm to 15.61 cm. The largest leaf breadth (15.61 cm) was recorded from M_2, while the smallest leaf breadth (8.11 cm) was recorded from M_0. At 45 DAT, leaf breadth ranged from 10.51 cm to 18.60 cm. The largest leaf breadth (18.60 cm) was recorded from M_2, while the smallest (10.51 cm) was recorded from M_0. Poultry manure is rich in its nitrogen and nutrient content which enhance vegetative growth and photosynthetic activity of broccoli plants.

There had a significant influence of varieties on broccoli plants in respect of leaf breadth at 15, 30 and 45 DAT (Fig. 10, Appendix V). At 15 DAT, leaf breadth ranged from 7.80 cm to 8.95 cm. V_2 produced the largest leaf breadth (8.95 cm). At 30 DAT, V_2 produced the largest leaf breadth (12.92 cm) whereas V_1 produced the smallest leaf breadth (10.56 cm). At 45 DAT, the largest leaf breadth (16.28 cm) was found in V_2 and the smallest leaf breadth (13.63 cm) was found in V_1.

The leaf breadth was significantly influenced by the treatment combinations of organic manure and varieties at 15, 30 and 45 DAT (Table 2, Appendix V). At 15 DAT, leaf breadth ranged from 5.50 cm to 12.13 cm. The largest leaf breadth (12.13 cm) was observed in combination of M_2V_2, while the smallest (5.50 cm) was recorded from M_0V_1. At 30 DAT, leaf breadth ranged from 8.03 cm to 21.93 cm. The largest leaf breadth (21.93 cm) was observed in M_2V_2, while the smallest (8.03 cm) was recorded from M_0V_3. At 45 DAT, leaf breadth ranged from 10.27 cm to 25.73 cm. The largest leaf breadth (25.73 cm) was observed in M_2V_2, while the smallest (10.27 cm) was recorded from M_0V_2.

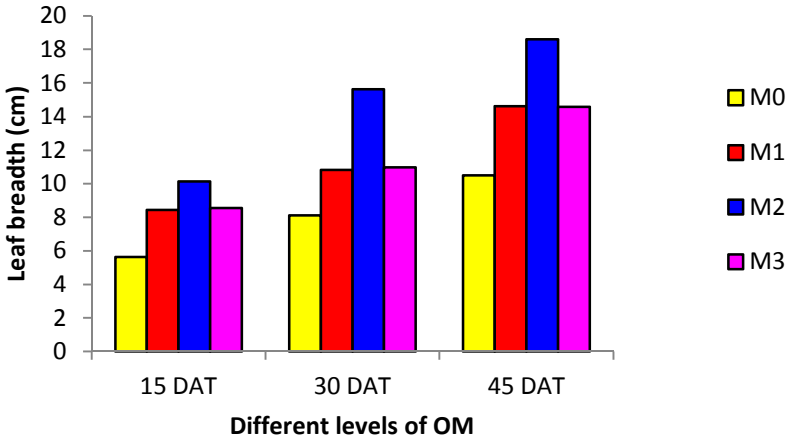


Fig. 10. Effect of different organic manure on leaf breadth of broccoli

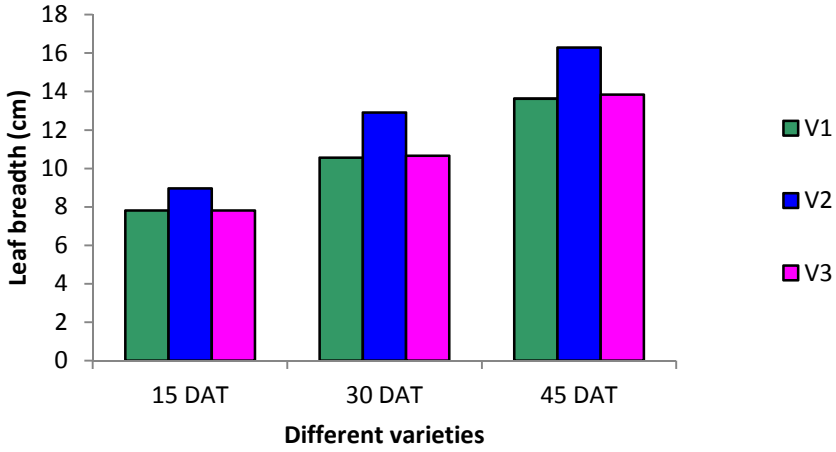


Fig. 11. Effect of different varieties on leaf breadth of broccoli

Table 2. Combined effect of different organic manure and varieties on leaf length and leaf breath of broccoli

Treatments	Leaf length			Leaf breadth		
	15 DAT	30 DAT	45 DAT	15 DAT	30 DAT	45 DAT
M_0V_1	14.43 f	21.03 e	27.20 g	5.50 c	8.23 d	10.33 c
M_0V_2	14.87 f	19.60 f	26.13 g	5.86 c	8.06 d	10.27 c
M_0V_3	12.80 g	19.33 f	26.17 g	5.53 c	8.03 d	10.93 c
M_1V_1	20.43 de	31.67 cd	46.20 d	8.23 b	10.90 c	14.67 b
M_1V_2	21.03 cd	31.27 d	42.67 e	8.93 b	10.93 c	14.57 b
M_1V_3	21.17 cd	31.47 d	46.40 cd	8.16 b	10.67 c	14.67 b
M_2V_1	22.03 bc	33.20 b	46.80 cd	9.00 b	12.07 bc	15.13 b
M_2V_2	30.97 a	45.53 a	60.63 a	12.13 a	21.93 a	25.73 a
M_2V_3	22.37 b	32.93 bc	47.47 c	9.26 b	12.83 b	14.93 b
M_3V_1	21.17 cd	32.13 bcd	49.00 b	8.50 b	11.07 c	14.40 b
M_3V_2	19.60 e	31.87 bcd	43.70 e	8.90 b	10.77 c	14.57 b
M_3V_3	22.27 b	31.60 cd	41.27 f	8.26 b	11.13 c	14.80 b
$LSD_{0.05}$	0.23	0.33	0.45	0.11	0.63	0.19
CV (%)	2.91	2.49	1.67	7.26	6.62	4.53

Means in the column followed by different letter(s) differed significantly by DMRT at 5% level of significance

4.6 Days to required for curd initiation

The number of days was required for curd initiation was significantly influenced by organic manure application (Table 3, Appendix VI). It was ranged from 52.33 to 56.67 days. The lowest (52.33 days) days were required curd initiation by the application of poultry manure (M_2) and the highest (56.67 days) days were required in control treatment (M_0). The result indicated that poultry manure plays role for vegetative growth and forced the plants to reach reproductive stages earlier. Effect of poultry manure due to the fact high content of phosphorus is mainly responsible for improving the quality and quantity of produce by way of increasing metabolic activities in the plant system. Mitra *et al.* (1990) reported that application of phosphorus has tened the crop to reach reproductive stage, which was agreed with the present finding.

The different varieties did not show the significantly influenced on the number of days required for curd imitation (Table 4, Appendix VI). It was ranged from 55.63 to 56.38 days. The lowest (55.63 days) days were required for curd initiation performed by V_2 and the highest (56.38) days were required by V_3.

There was significant variation among the treatment combinations of organic manure & varieties in days to curd initiation (Table 5, Appendix VI). The maximum days (58.50 days) were required in the treatment combination of M_0V_3, while the minimum (55.00 days) days required for curd initiation in the combination of M_2V_2.

4.7 Main curd diameter

Application of organic manure exhibited a significant influence on curd diameter of broccoli plants (Table 3, Appendix VI). The maximum curd diameter (15.03 cm) was recorded from poultry manure (M_2), while the minimum curd diameter (8.13 cm) was observed in control treatment (M_0). The curd diameter increased for the application of poultry manure due to the fact high content of phosphorus. Phosphorus plays role of energy storage, cell

division and cell enlargement. Sharma *et al.* (2002) and Singh (2004) were found same result in the present investigation.

Different varieties showed a significant influence on curd diameter of broccoli plants (Table 4, Appendix VI). The maximum curd diameter (13.15 cm) was recorded from V_2, while the minimum curd diameter (11.74 cm) was observed in V_3. This result was revealed that the curd diameter increased with the different varieties.

Curd diameter was significantly influenced by the treatment combinations of organic manure and varieties (Table 5, Appendix VI). The maximum curd diameter (14.90 cm) was observed in the treatment combination of M_2V_2, while the minimum curd diameter (7.60 cm) was recorded from the combination of M_0V_2. Main curd diameter is important for curd yield. Diameter of the curd was significantly influenced by different organic manure treatments.

4.8 Main curd weight

Organic manure exhibited a significant influence on main curd weight of broccoli plants (Table 3, Appendix VI). The maximum main curd weight (323.00 g) was recorded from poultry manure application (M_2), while the minimum main curd weight (102.00 g) was observed in control treatment (M_0). Phosphorus was mainly responsible for improving the quality and quantity by the way of increasing metabolic activities. Such effect of phosphorus was due to the fact of use of poultry manure in broccoli plant. Similar trend of the result was found by other scientists like Balyan *et al.* (1988) and Singh (2004).

Different varieties had a significant influence on main curd weight of broccoli plants (Table 4, Appendix VI). The maximum main curd weight (296.90 g) was recorded from variety V_2, while the minimum main curd weight (197.50 g) was observed in variety V_1.

Main curd weight was significantly influenced by the treatment combinations of organic manure & varieties of broccoli (Table 5, Appendix VI). The maximum main curd weight (366.00 g) was observed in the treatment combination of M_2V_2, while the smallest (41.67 g) was recorded from the combination of M_0V_1. Main curd weight of broccoli plant is important for increasing total production.

4.9 Number of secondary curd per plant

The secondary curds were those, which develop after harvest of the main curd. Number of secondary curd of broccoli plant is important for increasing total production. Application of organic manure exhibited a significant influence on number of secondary curd of broccoli plants (Table 3, Appendix VIThe maximum numbers of secondary curds (3.00) were recorded from the application of poultry manure (M_2), while the minimum (1.22) were observed in control treatment (M_0). This might be caused of photosynthesis, cell division and cell enlargement. In poultry manure has higher content phosphorus. Similar effect of phosphorus has been reported by Sharma *et al.* (2002).

Different varieties exhibited a significant influence on number of secondary curds of broccoli plants (Table 4, Appendix VI). The maximum numbers of secondary curds (2.33) were recorded from V_2 variety, while the minimum number of secondary curds (1.75) was observed in V_3.

Number of secondary curds was significantly influenced by the treatment combinations of organic manure & varieties (Table 5, Appendix VI). The maximum number of secondary curds (4.33) was observed in the treatment combination of M_2V_2, while the minimum (1.00) were recorded from the combination of M_0V_3.

4.10 Secondary curd weight

Secondary curd weight of broccoli plant is important for increasing total yield. Organic manure had a significant influence on secondary curd weight of

broccoli plants (Table 3, Appendix VI). The maximum secondary curd weight (98.67 g) was recorded from M_2 and the minimum (51.11 g) was observed in M_0. This might be caused of photosynthesis, cell division and cell enlargement. Similar effects of phosphorus have been reported by Sharma *et al.* (2002).

Varieties exhibited a significant influence on secondary curd weight of broccoli plants (Table 4, Appendix VI). The maximum secondary curd weight (92.00 g) was recorded from V_2 while the minimum (59.50 g) was observed in V_1.

Secondary curd weight was significantly influenced by the treatments combination of organic manures and varieties (Table 5, Appendix VI). The maximum secondary curd weight (117.70 g) was observed in M_2V_2 and the minimum (32.33 g) was recorded from M_0V_1.

Table 3. Effect of different organic manure on curd diameter, curd weight, number of secondary curd and weight of secondary curd of broccoli

Treatments	Days required for curd initiation	Main curd diameter (cm)	Main curd weight (g)	Number of secondary curd	Weight of secondary curd (g)
M_0	56.67 a	8.133 c	102.0 d	1.22 c	51.11 d
M_1	55.17 a	13.03 b	262.9 c	1.88 b	80.00 b
M_2	52.33 a	15.03 a	323.0 a	3.00 a	98.67 a
M_3	55.83 a	12.99 b	300.9 b	2.00 b	72.89 c
$LSD_{0.05}$	0.22	0.12	0.55	0.31	0.90
CV (%)	1.99	8.45	1.22	23.38	3.00

Means in the column followed by different letter(s) differed significantly by DMRT at 5% level of significance

Table 4. Effect of different varieties on curd diameter, curd weight, number of secondary curd and weight of secondary curd of broccoli

Treatments	Days required for curd initiation	Curd diameter (cm)	Main curd weight (g)	Number of secondary curd	Weight of secondary curd (g)
V_1	56.00 a	12.00 b	197.50 c	2.00 ab	59.50 c
V_2	55.63 a	13.15 a	296.90 a	2.33 a	92.00 a
V_3	56.38 a	11.74 b	247.20 b	1.75 b	75.50 b
$LSD_{0.05}$	0.89	0.76	0.90	0.66	0.45
CV (%)	1.99	8.45	1.22	23.38	3.00

Means in the column followed by different letter(s) differed significantly by DMRT at 5% level of significance

Table 5. Combined effect of different organic manure and varieties on curd diameter, curd weight, number of secondary curd and weight of secondary curd of broccoli

Treatments	Days required for curd initiation	Main curd diameter (cm)	Main curd weight (g)	Number of secondary curd	Secondary curd weight (g)
M_0V_1	56.00 a	8.067 f	41.67 k	1.33 cd	32.33 g
M_0V_2	57.50 a	7.60 f	165.0 i	1.33 cd	70.00 d
M_0V_3	58.50 a	8.33 ef	99.33 j	1.00 d	51.00 f
M_1V_1	56.25 a	9.83 de	220.0 h	2.00 bc	62.33 e
M_1V_2	57.00 a	12.17 bc	303.7 d	1.67 bcd	97.67 b
M_1V_3	55.25 a	11.67 bc	265.0 f	2.00 bc	80.00 c
M_2V_1	56.00 a	13.17 b	280.7 e	2.33 b	80.67 c
M_2V_2	55.00 a	14.90 a	366.0 a	4.33 a	117.70 a
M_2V_3	56.00 a	11.67 bc	322.3 c	2.33 b	97.67 b
M_3V_1	55.75 a	12.63 b	247.70 g	2.33 b	62.67 e
M_3V_2	56.00 a	13.33 b	353.00 b	2.00 bc	82.67 c
M_3V_3	55.75 a	10.67 cd	302.00 d	1.67 bcd	73.33 d
$LSD_{0.05}$	0.45	0.12	0.78	0.46	0.98
CV (%)	1.99	8.45	1.22	23.38	3.00

Means in the column followed by different letter(s) differed significantly by DMRT at 5% level of significance

4.11 Yield per plant

Yield per plant is important for increasing yield. Application of organic manure exhibited a significant influence on yield per plant (Table 6, Appendix VII). The maximum yield (479.70 g) was recorded from M_2 while the minimum (160.80 g) was observed in M_0.

Different varieties showed a significant influence on yield per plant (Table 7, Appendix VII). The maximum yield (343.70 g) was recorded from V_2 while the minimum (252.30 g) was observed in V_1.

Combined effect of different manures and varieties showed a significant effect on yield per plant (Fig. 8, Appendix VII). The maximum yield (522.30 g) was observed in the treatment combination of M_2V_2 while the minimum (120.70 g) was recorded from M_0V_1.

Table 6. Effect of different organic manure on yield of broccoli

Treatments	Yield / plant (g)	Yield / plot (kg)	Yield/ha (t)
M_0	160.80 d	2.89 d	3.21 d
M_1	222.60 c	4.01 c	4.44 c
M_2	479.70 a	8.63 a	9.58 a
M_3	328.80 b	5.93 b	6.58 b
$LSD_{0.05}$	0.10	0.32	0.12
CV (%)	1.15	1.01	1.02

Means in the column followed by different letter(s) differed significantly by DMRT at 5% level of significance

Table 7. Effect of different varieties on yield of broccoli

Treatments	Yield/ plant (g)	Yield/ plot (kg)	Yield/ ha (t)
$\mathbf{V_1}$	252.30 c	4.54 c	5.04 c
$\mathbf{V_2}$	343.70 a	6.18 a	6.86 a
$\mathbf{V_3}$	297.80 b	5.37 b	5.96 b
$LSD_{0.05}$	0.04	0.07	0.23
CV (%)	1.15	1.01	1.02

Means in the column followed by different letter(s) differed significantly by DMRT at 5% level of significance

4.12 Yield per plot

The yield per plot in sprouting broccoli consists of the main curd and the secondary curd those develop after the removal of the main one. Application of organic manure exhibited a significant influence on yield per plot of broccoli plants (Table 6, Appendix VII). The maximum yield (8.63 kg) was recorded from M_2 while the minimum (2.89 kg) was observed in M_0.

Different varieties exhibited a significant influence on yield per plot of broccoli plants (Table 7, Appendix VII). The maximum yield (6.18 kg) was recorded in V_2 while the minimum (4.54 kg) was observed in V_1.

Yield per plot was significantly influenced by the treatment combinations of organic manure & varieties of broccoli (Fig. 13, Appendix VII). The maximum yield per plot (9.40 kg) was observed in M_2V_2 while the minimum (2.17 kg) was recorded from M_0V_1.

Table 8. Combined effect of different organic manure and varieties on yield of broccoli.

Treatments	Yield/ plant (g)	Yield/ plot (kg)	Yield/ ha (t)
M_0V_1	120.7 k	2.17 k	2.410 k
M_0V_2	200.0 h	3.60 h	3.993 h
M_0V_3	161.7 j	2.91 j	3.227 j
M_1V_1	172.0 i	3.09 i	3.440 i
M_1V_2	273.3 f	4.92 f	5.457 f
M_1V_3	222.3 g	4.00 g	4.437 g
M_2V_1	438.3 c	7.89 c	8.757 c
M_2V_2	522.3 a	9.40 a	10.44 a
M_2V_3	478.3 b	8.61 b	9.557 b
M_3V_1	278.3 f	5.01 f	5.557 f
M_3V_2	379.0 d	6.82 d	7.570 d
M_3V_3	329.0 e	5.98 e	6.637 e
$LSD_{0.05}$	0.87	0.44	0.23
CV (%)	1.15	1.01	1.02

Means in the column followed by different letter(s) differed significantly by DMRT at 5% level of significance

4.13 Yield per hectare

Application of organic manure exhibited a significant influence on yield per hectare of broccoli plants (Table 6, Appendix VII). The maximum yield (9.58 t/ha) was recorded from M_2 while the minimum yield (3.21 t/ha) was observed in M_0.

Different varieties showed a significant influence on yield per hectare of broccoli plants (Table 7, Appendix VII). The maximum yield (6.86t/ha) was recorded from V_2 while the minimum yield (5.04t/ha) was observed in V_1.

Yield per hectare was significantly influenced by the treatments combination of organic manure (Fig. 8, Appendix VII). Yield per hectare ranged from 2.41t to 10.44t. The maximum yield per hectare (10.44t/ha) was observed in M_2V_2 while the minimum (2.41t/ha) was recorded from M_0V_1. The increase in the total yield resulting by organic manuring may be attributed to that organic manuring enhanced soil aggregation, soil aeration and increasing water holding capacity and offers good environmental conditions for the broccoli plants. Poultry manure is rich in its nitrogen and nutrients content. This favorable condition creates better nutrients absorption and favors the growth and development of curd weight which in true reflects better vegetative growth photosynthetic activity. Consequently higher total yield would be obtained by poultry manure. Similar trend of results was found by Abou *et al*. (2006).

4.14 Relationship of different characters of broccoli with yield

The yield of broccoli was positively correlated (Figures 15-23) with plant height (R^2 = 0.54), number of leaves (R^2 = 0.180), plant canopy (R^2 = 0.509), leaf length (R^2 = 0.545), leaf breath (R^2 = 0.552), curd diameter (R^2 = 0.660), curd weight (R^2 = 0.685), number of secondary curd (R^2 = 0.585), weight of secondary curd (R^2 = 0.678). This indicated that with the increased in the above mentioned characters the yield positively increased. Curd weight (R^2=0.685) had the most intimate relationship with yield, suggesting that broccoli plant producing higher curd diameter, curd weight, number of secondary curd, weight of secondary curd, yield per plant, number of leaves, leaf length, leaf breath, plant height and plant canopy will produce high economic yield and vice-versa.

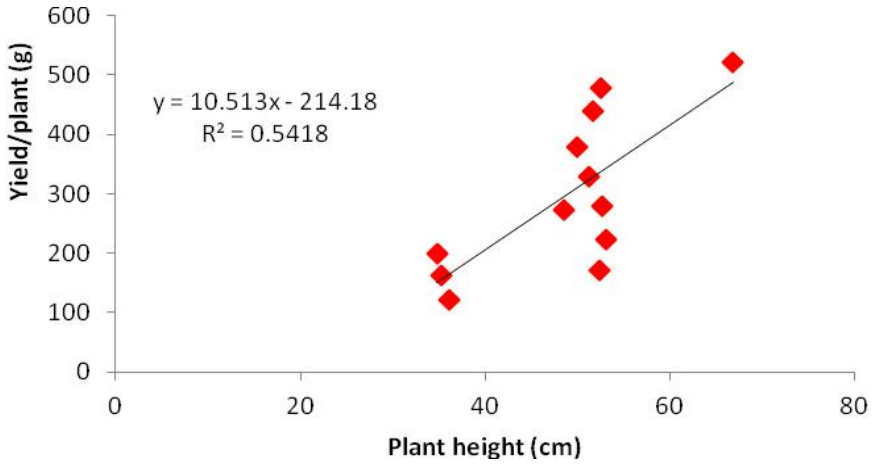


Fig. 12. Relationship between plant height and yield/plant of broccoli.

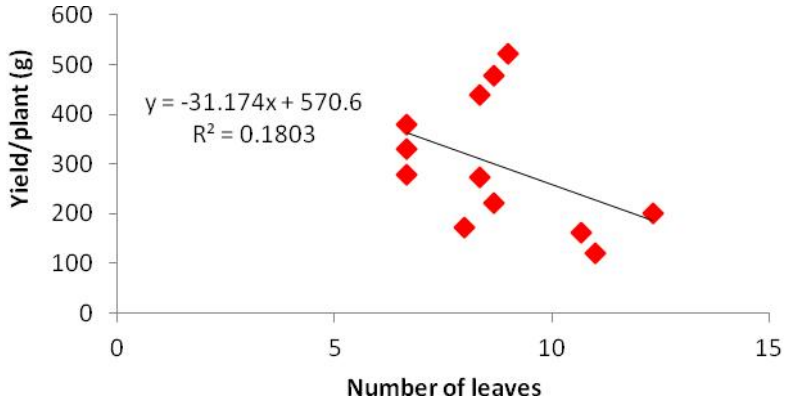


Fig. 13. Relationship between number of leaves and yield/plant of broccoli.

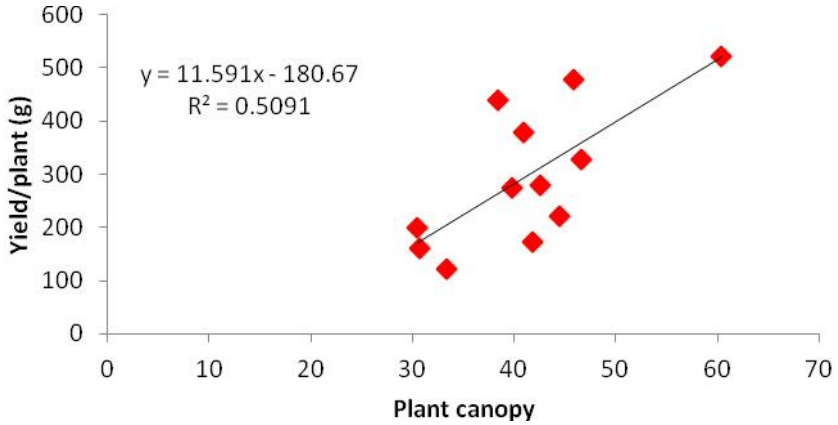


Fig. 14. Relationship between plant canopy and yield/plant of broccoli.

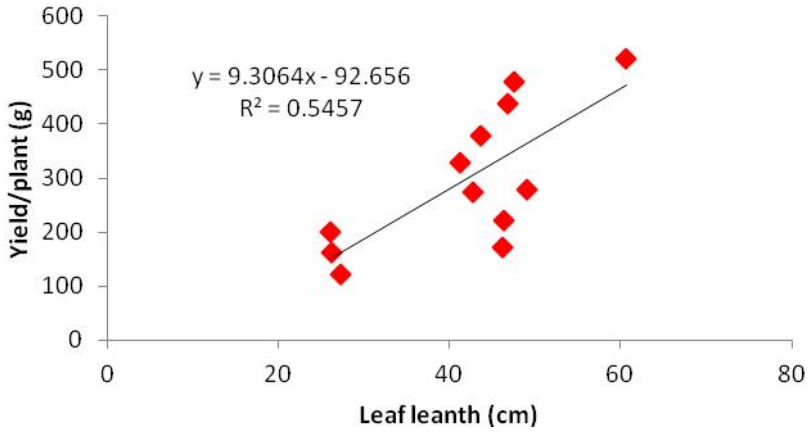


Fig. 15. Relationship between leaf length and yield/plant of broccoli.

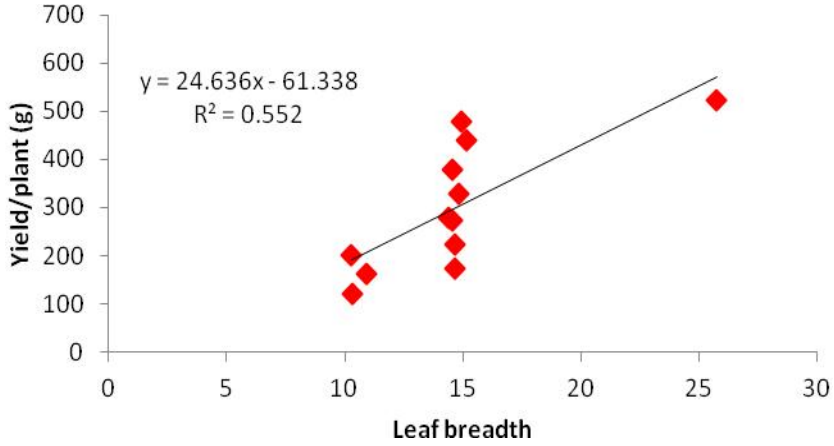


Fig. 16. Relationship between leaf breadth and yield/plant of broccoli.

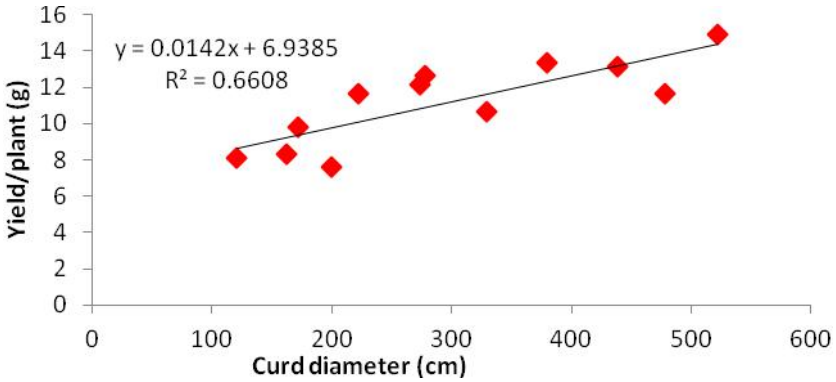


Fig. 17. Relationship between curd diameter and yield/plant of broccoli.

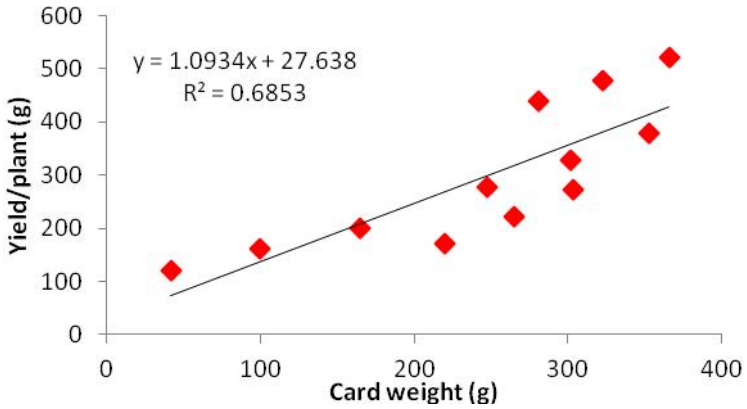


Fig. 18. Relationship between curd weight and yield/plant of broccoli.

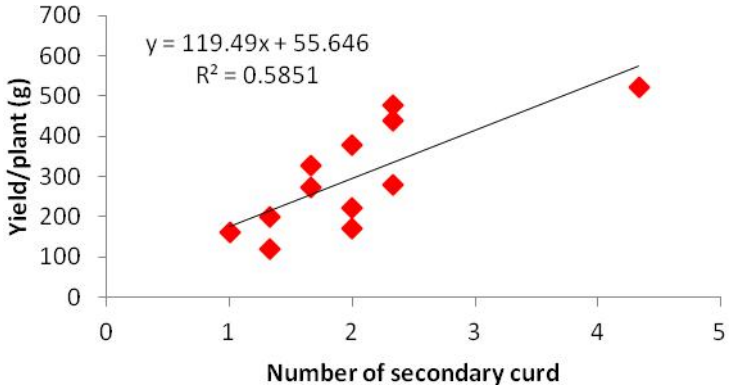


Fig. 19. Relationship between number of secondary curd and yield/plant of broccoli.

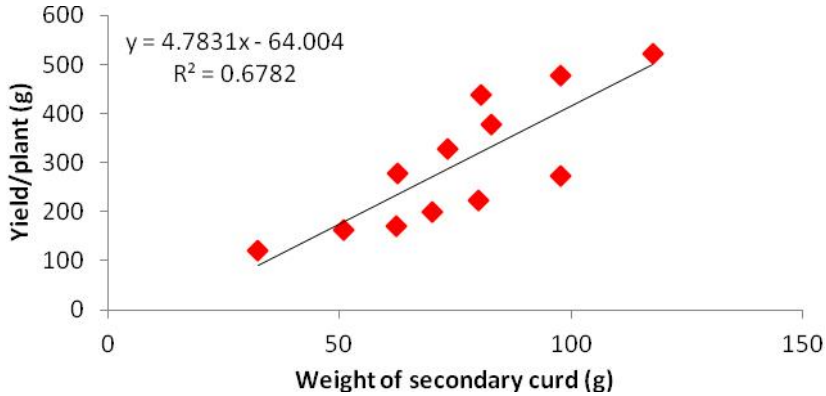


Fig. 20. Relationship between weight of secondary curd and yield of broccoli.

Table 9. Phenotypic correlation among the yield and yield contributing characters of Broccoli

Characters	Plant height	Number of leaves	Plant canopy	Leaf length	Leaf breadth	Curd diameter	Curd weight	No. of secondary curd	Wt. of secondary curd	Yield /plant
Plant height	1									
Number of leaves	0.867**	1								
Plant canopy	0.946**	0.982**	1							
Leaf length	0.730*	0.956**	0.898**	1						
Leaf breadth	0.769**	0.982**	0.932**	0.990**	1					
Curd diameter	0.752*	0.972**	0.917**	0.998**	0.998**	1				
Curd weight	0.914**	0.983**	0.989**	0.908**	0.944**	0.929**	1			
No. of secondary curd	0.901**	0.991**	0.989**	0.928**	0.960**	0.947**	0.998**	1		
Wt. of secondary curd	0.904**	0.988**	0.989**	0.919**	0.954**	0.939**	0.999**	1.000**	1	
Yield /plant	0.849**	0.990**	0.967**	0.972**	0.986**	0.981**	0.981**	0.988**	0.985**	1

** Significant at 1% level of probability

4.15 Post-harvest preservation

Almost all vegetables are known to exhibit a rise in respiration after harvest. A high rate of respiration deteriorates the storage quality of vegetable. Post-harvest changes i.e. yellowing of florets take place rapidly in broccoli and make it unsuitable for consumption if appropriate storage conditions are not maintained.

Organic manure exhibited a significant influence on shelf life of broccoli at different storage conditions viz., open at room temperature, polyethylene bag at room temperature and polyethylene bag at refrigerator (Table 10).

Shelf life of broccoli in open at room temperature condition ranged from 1.90 to 2.32 days. The maximum shelf life (2.32 days) of broccoli was found in M_2 and minimum (1.90 days) was found in M_0.

Shelf life of broccoli in polyethylene bag at room temperature condition ranged from 3.02 to 4.52 days. The maximum shelf life (4.52 days) of broccoli was found in M_2 and minimum (3.02 days) was found in M_0.

Shelf life of broccoli in polyethylene bag at refrigerator condition ranged from 12.10 to 17.11 days. The maximum shelf life (17.11 days) of broccoli was found in M_2 and minimum (12.10 days) was found in M_0. It was revealed that the shelf life of broccoli decreased with the control application in all the three storage condition. Among the three storage condition it was found that the shelf life of broccoli increased in the polyethylene bag at refrigerator condition. This could be due the effect of low temperature in refrigerator. Low temperature minimizes the respiration of broccoli as well as polyethylene bag also minimize the respiration process. Anelli *et al.* (1985), Makhlouf *et al.* (1989) and Tan *et al*. (1993) reported that the cv. Stolto was stored up to 6 weeks at 1^0C under different CO_2 and O_2 concentrations.

Table 10. Effect of different organic manure and storage condition on shelf life (days) of broccoli

Treatments	Storage condition on shelf life (days) of broccoli.		
	Open at room temperature (24^0C)	Polyethylene bag at room temperature (24^0C)	Polyethylene bag at refrigerator (10^0C)
M_0	1.90 c	3.02 c	12.10 b
M_1	2.10 b	4.44 a	15.49 ab
M_2	2.32 a	4.52 a	17.11 a
M_3	1.95 c	3.70 b	13.30 b
$LSD_{0.05}$	0.22	0.87	0.12
CV (%)	7.21	7.21	7.21

Means in the column followed by different letter(s) differed significantly by DMRT at 5% level of significance

Table 11. Effect of different varieties and storage condition on shelf life (days) of broccoli

Treatments	Storage condition on shelf life (days) of broccoli.		
	Open at room temperature (24^0C)	Polyethylene bag at room temperature (24^0C)	Polyethylene bag at refrigerator (10^0C)
V_1	1.27 b	4.07 c	14.25 a
V_2	2.91 a	5.50 a	14.37 a
V_3	1.77 c	4.32 b	14.23 a
$LSD_{0.05}$	0.12	0.56	0.77
CV (%)	7.18	7.18	7.18

Means in the column followed by different letter(s) differed significantly by DMRT at 5% level of significance

Table 12. Combined effect of different organic manure, varieties and storage condition on shelf life (days) of broccoli

Treatments	Storage condition on shelf life (days) of broccoli.		
	Open at room temperature (24^0C)	Polyethylene bag at room temperature (24^0C)	Polyethylene bag at refrigerator (10^0C)
M_0V_1	1.75 gh	4.16 gh	13.50 ef
M_0V_2	2.50 bc	5.95 ab	16.67 ab
M_0V_3	2.25 cd	5.56 bc	16.17 ab
M_1V_1	2.23 cd	4.91 ef	15.50 ab
M_1V_2	1.93 fg	4.66 fg	15.00 bc
M_1V_3	1.91 g	4.41 fg	14.50 cd
M_2V_1	1.96 ef	4.50 fg	14.15 de
M_2V_2	2.75 a	6.16 a	17.33 a
M_2V_3	1.56 hi	3.66 ij	12.67 fg
M_3V_1	1.76 gh	3.91 hi	13.93 ef
M_3V_2	1.46 i	3.23 jk	12.32 gh
M_3V_3	1.35 i	2.66 k	11.25 h
$LSD_{0.05}$	0.09	0.80	0.43
CV (%)	9.04	9.04	9.04

Means in the column followed by different letter(s) differed significantly by DMRT at 5% levels of significance

Varieties exhibited a significant influence on shelf life of broccoli at different storage conditions viz., open at room temperature, polyethylene bag at room temperature and polyethylene bag at refrigerator (Table 11).

Shelf life of broccoli in open at room temperature condition ranged from 1.27 to 2.91 days. The maximum shelf life (2.91 days) of broccoli was found in V_2 and minimum (1.27 days) was found in V_1.

Shelf life of broccoli in polyethylene bag at room temperature condition ranged from 4.07 to 5.50 days. The maximum shelf life (5.50 days) of broccoli was found in V_2 and minimum (4.07 days) was found in V_1.

Shelf life of broccoli in polyethylene bag at refrigerator condition ranged from 14.23 to 14.37 days. The maximum shelf life (14.37 days) of broccoli was found in V_2 and minimum (14.23 days) was found in V_3. Among the three storage condition it was found that the shelf life of broccoli depends at the polyethylene bag at refrigerator condition. This could be due the effect of low temperature in refrigerator. Low temperature minimizes the respiration of broccoli as well as polyethylene bag also minimize the respiration process. The positive effect of polymeric film was also reported by Barth *et al*. (1993).

Combined application of organic manure and varieties exhibited a significant influence on shelf life of broccoli at different storage conditions viz., open at room temperature, polyethylene bag at room temperature and polyethylene bag at refrigerator (Table 12). Shelf life of broccoli in open at room temperature condition ranged from 1.35 to 2.75 days. The maximum shelf life (2.75 days) of broccoli was found in M_2V_2 and the minimum (1.35 days) was found in M_3V_3.

Shelf life of broccoli in polyethylene bag at room temperature condition ranged from 2.66 to 6.16 days. The maximum shelf life (6.16 days) of broccoli was found in M_2V_2 and minimum (2.66 days) was found in M_3V_3.

Shelf life of broccoli in polyethylene bag at refrigerator condition ranged from 11.25 to 17.33 days. The maximum shelf life (17.33 days)

of broccoli was found in M_2V_2 and the minimum (11.25 days) was found in M_3V_3.

It was revealed that the shelf life of broccoli increased with the various organic manure applications in all the three storage conditions. Among the three storage conditions it was found that the shelf life of broccoli increased in the polyethylene bag at refrigerator condition. This could be due the effect of low temperature in refrigerator. Low temperature minimizes the respiration of broccoli as well as polyethylene bag also minimize the respiration process.

CAPTER V
SUMMARY AND CONCLUSION

An experiment entitled “Effect of different organic manure on growth, yield and shelf life of three broccoli cultivars” at Horticulture Farm, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from November 2010 to February 2011. The experimental site was located under the Modhupur Tract (AEZ-28) and it was medium high land with adequate irrigation facilities. The soil was having a texture was silty clay loam with pH 5.8-6.5, ECE-25.28. The experiment was laid out in split plot Randomized Complete Block Design with three replications (RCBD). There were twelve treatments with three replications. Total numbers of unit plots were thirty six. The unit plot size was 3 m x 3 m, treatment dose was vermicompost 15 t/ha, poultry manure 20 t/ha and cow dung 25 t/ha.

The parameters recorded were plant height, number of leaf, plant canopy, leaf length, leaf breath, days required for curd initiation, main curd diameter, main curd weight, number of secondary curd, weight of secondary curd, yield per plant, yield per plot, yield per hectare and shelf life (days).

All the growth characters like plant height, number of leaf, plant canopy, leaf length, leaf breath, days required for curd initiation, main curd diameter, main curd weight, number of secondary curd, weight of secondary curd, yield per plant, yield per plot and yield per hectare varied significantly due to different organic manure and varieties.

Application of organic manure exhibited a significant influence on the plant height, number of leaf, plant canopy, leaf length, leaf breath, days required for curd initiation, main curd diameter, main curd weight, number of secondary curd and weight of secondary curd of broccoli plants at 15, 30 and 45 days after transplanting (DAT). Appendix V-VII.

Different varieties exhibited a significant influence on the plant height, number of leaf, plant canopy, leaf length, leaf breath, days required for curd initiation, main curd diameter, main curd weight, number of secondary curd and weight of secondary curd of broccoli plants at 15, 30 and 45 days after transplanting (DAT).

By the treatment combinations at 15, 30 and 45 DAT the plant height, number of leaf, plant canopy, large leaf breath, large leaf length, days required for curd initiation, main curd diameter, main curd wt., number of secondary curd and wt. of secondary curd of broccoli plants was significantly influenced. In all the cases combination of M_2V_2were found significant.

Yield parameters like yield per plant, yield per plot yield per hector varied significantly due to different organic manure, varieties and different treatments combination. Yield per plant is important for increasing total yield. Application of organic manure exhibited a significant influence on yield per plant. The maximum yield (9.58 t) was recorded from poultry manure $M_{2.}$ Different varieties exhibited a significant influence on total yield per plant. The maximum yield (6.86 t) was recorded from V_2 (Green magic). Yield per plant was significantly influenced by the treatment combinations of organic manure & varieties of broccoli. The maximum yield (10.44 t) was recorded from the treatment combination of $M_2V_{2.}$

In case of storage conditions broccoli curds kept in polyethylene bag in refrigerator at 4^0C showed highest shelf life (17.87 days) while the lowest shelf life (1.35 days) was observed when the curds were open at room temperature 24^0C without polyethylene bag.

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

- Use of poultry manure is an effective method for successful broccoli production, which may also improve the soil health and save the use of costly chemical fertilizers.
- "Green Magic" variety of broccoli has better vegetative growth, yield and storage condition.
- In combination of organic manures and varieties the highest yield was found with the combination of poultry manure and green magic variety.
- In polyethylene bags at 10^0C in refrigerator showed the highest shelf life.

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APPENDICES

Appendix I. Results of mechanical and chemical analysis of soil of the experimental plot

A. Morphological characteristics

Morphological features	Characteristics
Location	Horticulture Farm, SAU, Dhaka
AEZ	Modhupur tract (28)
General soil type	Shallow redbrown terrace soil
Land Type	Medium high land

Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained

Source: Soil Resource Development Institute (SRDI)

B. Mechanical analysis

Constituents	Percent
Sand	27
Silt	43
Clay	30

Source: Soil Resource Development Institute (SRDI)

C. 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 average temperature, relative humidity and total rainfall of the experimental site during the period from September 2010 to March 2011

Month	Air temperature (^{0}C)		R. H. (%)	Total rainfall (mm)
	Maximum	Minimum		
October' 10	29.18	18.26	81	39
November'10	25.82	16.04	78	0
December'10	22.4	13.5	74	0
January'11	24.5	12.4	68	0
February'11	27.1	16.7	67	3
March'11	31.4	19.6	54	11

Source: Bangladesh Metrological Department (Climate and weather division) Agargaon, Dhaka

Appendix III. 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

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 (1988)

Appendix IV. Analysis of variance of the data on plant height, number of leaf and leaf length

Source of variation	Degrees of freedom	Plant height			Number of leaf			Plant canopy		
		15 DAT	30 DAT	45 DAT	15 DAT	30 DAT	45 DAT	15 DAT	30 DAT	45 DAT
Replication	2	0.57	0.82	0.10	0.11	0.08	2.25	0.04	0.577	1.92
Factor A (Organic manure)	3	624.08**	1142.34**	781.33 **	7.29 **	21.65 **	33.58 **	697.01**	483.08 **	445.50 **
Factor B (Variety)	2	3.88 **	11.72**	14.46 **	0.19 NS	0.08 NS	1.08 NS	34.56 **	37.72 **	47.12 **
Ax B	6	8.60 **	26.59**	75.74 **	0.26 NS	0.15 NS	0.63 NS	50.70 **	120.45 **	125.81 **
Error	22	0.63	0.64	1.14	0.26	0.38	0.34	0.34	0.56	0.49

*** Significant at 1% level of probability NS-non significant*

Appendix V. Analysis of variance of the data on leaf length & leaf breath

Source of variation	Degrees of freedom	Leaf length			Leaf breath		
		15 DAT	30DAT	45 DAT	15 DAT	30 DAT	45 DAT
Replication	2	0.05	0.57	1.92	0.46	0.46	0.35
Factor A (Organic manure)	3	191.70**	473.83**	1048.92**	31.53**	87.11**	98.15**
Factor B (Variety)	2	16.22**	34.91**	27.33**	5.29**	21.34**	26.13**
Ax B	6	22.86**	41.13**	72.19**	1.57**	23.08**	29.44**
Error	22	0.34	0.56	0.49	0.35	0.56	0.43

*** Significant at 1% level of probability*

Appendix VI. Analysis of variance of the data on days required to curd initiation, curd diameter, curd weight, number of secondary curd and weight of secondary curd.

Source of variation	Degrees of freedom	Days required to curd initiation	Main curd diameter	Main curd weight	No. of secondary curd	Weight of secondary curd
Replication	2	136.00	1.18	43.36	0.19	2.33
Factor A (Organic manure)	3	1.11**	77.53**	89871.95**	4.84**	3475.40**
Factor B (Variety)	2	2.25**	6.74**	29651.02**	1.02**	3169.00**
Ax B	6	0.86 NS	5.30**	273.28**	1.17**	53.63**
Error	22	1.24	1.29	9.14	0.22	5.15

*** Significant at 1% level of probability NS- non significant*

Appendix VII. Analysis of variance of the data on yield/plant, yield/ plot and yield/ha

Source of variation	Degrees of freedom	Yield/plant	Yield/ plot	Yield/ ha
Replication	2	20.52	0.004	0.005
Factor A (Organic manure)	3	175415.50**	56.90**	70.14**
Factor B (Variety)	2	25025.44**	8.10**	9.97**
Ax B	6	98.18**	0.03	0.04
Error	22	11.74	0.03	0.04

*** Significant at 1% level of probability*