EFFECTS OF VARIETY AND NITROGEN ON VEGETATIVE GROWTH, MORPHOLOGY AND HEAD YIELD OF BROCCOLI (*Brassica oleracea* var *italica* L.)

A THESIS

BY

R.H.S. RASEL

DEPARTMENT OF AGRICULTURAL BOTANY

SHER-E-BANGLA AGRICULTURAL UNIVERSITY

DHAKA -1207

EFFECT OF VARIETY AND NITROGEN ON VEGETATIVE GROWTH, MORPHOLOGY AND HEAD YIELD OF BROCCOLI (*Brassica oleracea* var *italica* L.)

BY

R.H.S. RASEL

Registration No. : 10-03923

A Thesis

Submitted to the Department of Agricultural Botany
Sher-e-Bangla Agricultural University, Dhaka, in partial
fulfillment of the requirements
for the degree
of

MASTER OF SCIENCE
IN
AGRICULTURAL BOTANY

SEMESTER: JANUARY-JUNE, 2018

Approved by:

Prof. Asim Kumar Bhadra	**Dr. Mohd. Moniruzzaman**
Supervisor	**Co-Supervisor**
Department of Agricultural Botany	**PSO, Plant Physiology Section**
Sher-e-Bangla Agricultural University	**Horticulture Research Centre, BARI**

Dr. Kamrun Nahar
Chairman
Examination Committee

Department of Agricultural Botany
Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka-1207

CERTIFICATE

This is to certify that the thesis entitled **“EFFECT OF VARIETY AND NITROGEN ON VEGETATIVE GROWTH, MORPHOLOGY AND HEAD YIELD OF BROCCOLI (*Brassica oleracea* var *italica* L.)”** submitted to the Department of Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTERS OF SCIENCE** in **AGRICULTURAL BOTANY**, embodies the result of a piece of bona fide research work carried out by **R.H.S. RASEL**, Registration No. **10-03923** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated:
Dhaka, Bangladesh

(Prof. Asim Kumar Bhadra)
Supervisor
Department of Agricultural Botany
Sher-e-Bangla Agricultural University
Dhaka-1207

Dedicated to

My

Beloved Parents

ACKNOWLEDGEMENTS

All praises are due to the ***"Almighty Allah"*** *who kindly enabled the author to complete the research work and the thesis leading to Master of Science.*

The author feels proud to express his profound respect, deepest sense of gratitude, heartful appreciation to ***Prof. Asim Kumar Bhadra,*** *Dept. of Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh, for his constant inspiration, scholastic guidance and invaluable suggestions during the conduct of the research and for his constructive criticism and whole hearted co-operation during preparation of this thesis.*

The author expresses his heartfelt gratitude and indebtedness to ***Dr. Mohd. Moniruzzaman****, Principal Scientific Officer, Plant Physiology Section, Horticulture Research Centre, Bangladesh Agricultural Research Institute, Gazipur for his assistance in planning and execution of the study and for his constructive instruction, critical reviews and heartiest co-operation during preparation of the manuscript.*

The author also expresses his heartfelt thanks to ***Dr. Kamrun Nahar,*** *Chairman and Associate Professor, Dept. of Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka.*

The author also express his heartfelt thanks to all the teachers of the Dept. of Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka for their help, valuable suggestions and encouragement during the period of the study.

The author is also wishes to acknowledge his indebtedness to the Farm Division of Sher-e-Bangla Agricultural University, Dhaka for their co-operation in the implementation of research works. The author is also thankful to Arif Bhai for his constant encouragement.

At last but not the least, the author feels indebtedness to his beloved parents and relatives, whose sacrifice, inspiration, encouragement and continuous blessing paved the way to his higher education.

The Author

EFFECT OF VARIETY AND NITROGEN ON VEGETATIVE GROWTH, MORPHOLOGY AND HEAD YIELD OF BROCCOLI (*Brassica oleracea* var *italica* L.)

ABSTRACT

An experiment was conducted at the Farm of Sher-e-Bangla Agricultural University, Dhaka during October 2017 to March 2018 to examine the effects of variety and nitrogen on vegetative growth, morphology and curd yield of broccoli (*Brassica oleracea* var *italica* L.). The experiment consisted of two varieties, namely ‘Premium crop’ and ‘Green sprouting’ and four different levels of nitrogen *viz.* 0 kg ha^{-1}, 100 kg ha^{-1}, 200 kg ha^{-1} and 300 kg ha^{-1}. The experiment was laid out in a two factorial Randomized Complete Block Design with three replications. There were 8 treatment combinations in all. Variety of Green sprouting gave maximum plant height, number of leaves $plant^{-1}$, stem length of curd, stem length, diameter of primary curd, weight of primary curd, number of secondary curd $plant^{-1}$, weight of secondary curd $plant^{-1}$. The maximum curd yield (19.28 t ha^{-1}) was recorded from ‘Green sprouting’. Application of 200 kg N ha^{-1} recorded maximum plant height, leaves $plant^{-1}$, stem length of curd, head length, diameter of primary curd, weight of primary curd, number of secondary curd $plant^{-1}$, weight of secondary curd $plant^{-1}$ and the highest curd yield (16.68 t ha^{-1}). Application of 200 kg N ha^{-1} coupled with ‘Green sprouting’ gave the maximum curd yield of 21.08 t ha^{-1}.

LIST OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

cm	=	Centimeter
DAT	=	Days after transplanting
et al.,	=	and others
Kg	=	Kilogram
Kg ha^{-1}	=	Kilogram per hectare
g	=	gram (s)
m	=	Meter
RCBD	=	Randomized Complete Block Design
LER	=	Land Equivalent Ratio
LSD	=	Least Significant Difference
MP	=	Muriate of Potash
TSP	=	Triple Super Phosphate
P^H	=	Hydrogen ion conc.
t ha^{-1}	=	ton per hectare
%	=	Percent

CHAPTER I

INTRODUCTION

Broccoli (*Brassica oleracea* var. *italica* L.) is an important cole crops belongs to the family Brassicacea. There are three classes of broccoli, i.e. green, white and purple, among them green type broccoli is the most popular (Shoemaker *et al*., 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 70g 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.

Variety plays an important role in producing high yield of broccoli because different varieties perform differently for their genotypic characters also vary from genotype to genotype. Improved variety is the first and foremost requirement for initiation and accelerated crop production program. The cultivar itself plays a great role for higher yield of the crop. There is a wide scope of increasing broccoli production with the introduction of new suitable hybrid cultivars from abroad. There are many hybrid broccoli varieties available in the market, which have been imported by different seed companies. Prior to recommendation for farmers, varietal performances need to be determined.

Of all the major nutrients provided to agricultural crops, nitrogen is generally considered the most important for plant growth. It is a constituent of many components in plants, including all proteins, which build cell material and plant tissue and production of chlorophyll, making photosynthesis possible.

Many enzymes need nitrogen for assimilation of nutrients and also the nucleic acids involved in reproduction of the genetic code, DNA and RNA, is dependent of nitrogen. (Teiz and Zeiger, 2004).

Nitrogen can be taken up by the plant as either nitrate (NO_3^-) or ammonium (NH_4^+) ions. Nitrate is the form most easily taken up by plant roots since it is soluble in water. In most agricultural soils, the amount of nitrate is significantly larger than the quantity of ammonium because of nitrification that converts ammonium to nitrate (Bartholomew and Clark, 1965).

The amount of available nitrogen during the season is often not enough for high yields and good quality. The nitrogen in the soil at planting is affected by many factors, for example previous crop, fertilization history, precipitation since the last crop, soil humus content, soil texture and temperature (Tremblay *et al.*, 2001). Much of the nitrogen left in the soil the previous year can be lost through leaching. Often the root system of the seedlings or transplants is too limited to reach nitrogen from lower soil layers. Nitrogen fertilizer is therefore added to the field. Chemical fertilizers can be either organic (like manure) or inorganic with different composition of ammonium, nitrate, urea, etc. Since broccoli requires large quantities of nitrogen to produce high yields and the timing of nitrogen uptake is crucial for optimum growth, inorganic fertilizers are often used.

They are easier to apply and the grower knows exactly the amount of nitrogen applied and approximately when it is available to the crop.

Basing nitrogen fertilization solely on crop yield response constitutes an environmental risk, since maximum yields are often obtained with high amounts of nitrogen corresponding to low recovery rates (Zebarth *et al.*, 1995). Nitrogen should be added to the crop when the need is the largest. With only one application at transplanting, the grower is tempted to apply a high N rate to avoid deficiencies under favorable growth conditions. With this approach the risk of leaching is high, but the use of a split application can satisfy plant need and avoid environmental hazard. In Quebec the recommendation for broccoli is a split application of 85 kg N ha^{-1} at transplanting and another 50 kg N ha^{-1}, 4 to 5 weeks later (CRAAQ 2003).

Nitrogen has a high influence on plant growth and development. Nitrogen is an important element for economic vegetable production, and is especially required for successful production when grown in poor mineral soils. The extra nitrogen is thought to reduce overall risk associated with crop production. Nitrogen management strategies should be used on vegetable farms to minimize the nitrogen that would be lost to the environment. Temperature, nitrogen, and water are the most important environmental factors for yield and quality of broccoli.

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

1. To observe the influence of nitrogen on vegetative growth and morphology of broccoli.
2. To search the suitable and optimum dose of nitrogen for yield maximization of broccoli.
3. To find out the best variety for realization of higher yield of broccoli.

CHAPTER II

REVIEW OF LITERATURE

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

2.1 Effect of variety on growth and yield of broccoli

Richardson (2016) carried to the evaluation of the broccoli (*Brassica oleracea* L. var. *italica*) variety 'Imperial' was conducted in a replicated small plot trial at the Gladstone Road Agricultural Centre during 2016, to examine yield and quality under local field conditions. Yield responses for the broccoli variety were fairly consistent over the harvest period. The 'Imperial' variety displayed heads that were uniform and attractive in appearance, with thick, sturdy stems. The final harvest saw an increase in broccoli head weight and head size. Head width, or diameter, increased by 3-4 cm from the first harvests to the last harvest. The potential yield for 'Imperial' was determined at 35 tons ha^{-1}.

Breeding of open pollinated (OP) varieties for organic farming gains further importance as varieties developed from CMS-hybridization and cell fusion are no longer accepted by some organic farming associations.

For broccoli (*Brassica oleracea* var. *italica*), the availability of OP varieties is very limited. In a participatory breeding project the German NGO Kultursaat e.v. and the University of Hohenheim tested new OP genotypes for agronomic parameters and sensory traits in 2012 and 2013. Agronomic traits of hybrids and OP genotypes varied widely. Some OP genotypes showed similar head weights and head diameters as the standard hybrids, while others were much lower in weight and head diameter. In the sensory assessments, untrained consumers were able to differentiate between the different genotypes. The OP genotype CHE-MIC showed the highest acceptance amongst consumers in both years. CHE-MIC has the potential to be commercially successful if further selection for homogeneity takes place (Wolf *et al.*, 2014).

Karistsapol *et al.*, (2013) studied at Prince of Songkla University, Hat Yai, Songkhla, Thailand. The study was conducted in split-plot in a randomized complete block design with four replications. The broccoli can be adapted to shading by increasing seedling survival rate, plant height and plant width. Consequently, the broccoli under the shading had the highest in head diameter, head weight and yield which was significantly better than full sunlight. There was a positive impact of the shading on yield and yield attribute of the three varieties.

The highest total yield was obtained from the Yok Kheo under the both full sunlight and shading (10.92 and 8.29 t ha^{-1}, respectively), followed by the Green Queen under the shading (6.21 t. ha^{-1}). The appropriate broccoli variety on growing during dry season in southern Thailand was the Yok Kheo and Green Queen because their growth rate and yield ha^{-1} were higher than of the Top Green and they also had the bigger size and higher quality of head. Particularly, those grown under the shading because of the decreasing light intensive and maximum temperature and the increasing relative humidity compared to the full sunlight. These factors would support the increasing growth and yield of broccoli.

Nooprom *et al.*, (2013) studied at Prince of Songkla University, Hat Yai, Songkhla province, southern Thailand. The trial was aimed to select the suitable planting dates and broccoli varieties for commercial production during the dry season. Split-plot in randomized complete block design was used in this experiment with four replications. From January to June, the Top Green, Green Queen and Yok Kheo had seedling survival rates of 76.53-100.00% except the Special. The Yok Kheo had the highest total yield of 12.31 and10.65 t ha^{-1} when the planting in January and March, respectively. The Yok Kheo is an interesting new hybrid variety which producing the yield higher than the ‘Top Green’ which is popular variety grown in southern Thailand.

The yield of the ‘Green Queen’ was not significantly different from the Top Green. It can be harvested at 11.67 and 9.38 days earlier than the ‘Top Green’ and Yok Kheo, respectively.

Thapa and Rai (2012) were carried out at Horticultural Research Station, Mondouri, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia in West Bengal during 2010-2012 rabi season with objectives to standardize the production technology of sprouting broccoli. Cultivation of these value added vegetables can boost the income of farmers due to very high market price and export demand. The investigations were followed in Randomized Block Design with three replications. Twelve varieties of Broccoli Viz. Fiesta, Princess, Sultan, Nokguk, Early You, KE-180, Priya, Puspa, Grandsino, Rapido, Prema and Packman were evaluated. Observations recorded under the physical and chemical parameters of different varieties of genotype. In general, the performances of this crop with different hybrid varieties proved that there is ample scope to grow broccoli vegetable due to prevailing suitable agro - climatic condition as well as the gaining importance as potential vegetable for export. Among all the varieties of Broccoli Nokguk was found superior, which gave higher yield 145.47 q ha^{-1} in combination with best head formation. Whereas, in chemical analysis KE-180 variety was found outstanding position in chlorophyll b, reducing sugar, total sugar and carotene content among all the other genotypes taken under observation. So, proper management practices are highly required for the cultivation of this crop.

Bhangre (2011) conducted to study the effect of different varieties (Ganesh Broccoli and Pusa KTS-1) with five spacing (60x60cm, 60x45cm, 45x45cm, 60x30cm, 45x30cm) in Factorial Randomized Block Design with three replications under Pune conditions. The data revealed that cv. GANESH BROCCOLI performed superior over the cv. PUSA KTS-1 with days to 50% harvest (53.4 days), days to last harvest (68.4 days), curd diameter (10.81cm), average weight of curd (154.80 g) and yield per hectare (70.75 q) while, cv. PUSA KTS-1 recorded significantly highest values for growth parameters. Amongst five spacing S (45x30 cm) gave significantly minimum values of the various parameters under study except days to 50% harvest (64.5days), days to last harvest (79.33days) and yield per hectare (77.08 q). However, S (60x60 cm) gave significantly maximum values of various parameters except days to 50% harvest (59.83 days) and days to last harvest (74 days). Interaction effect of different varieties and spacing was found no significant but numerically the interaction effect of V_1S_1 was the best among the all treatment combination except yield per hectare.

2.2 Effect of nitrogen on growth and yield of broccoli

Roni *et al.*, (2014) carried out in the research field and laboratory of the Department of Horticulture, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur-1706 during October 2011 to April 2012 to determine optimum level of nitrogen and spacing for improving the nutritional quality of broccoli. There were 15 treatments in the experiment comprising five levels of N viz., 0, 80, 120,160, and 200 kg ha^{-1} and three plant spacing viz., 60cm x 60cm, 60cm × 45cm, and 60cm × 30cm. The results revealed that the highest ascorbic acid content (50.38 mg/100g) was obtained from S60X30N0 and the highest carotene content (50.67 IU/100g) was found in S60X60N0. Maximum Ca (0.556%) was found in S60X60N0 whereas maximum Fe (159.002 ppm) was in S60X60N200. The maximum P content (0.081%) was observed in SX60N160 and maximum K content (0.854%) was found in S60X45N120. Hussain *et al.*, (2012) conducted at the Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh during winter season, 2007 - 2008 to determine the effects of N and B on the yield and hollow stem disorder of broccoli. Four levels of N as 0, 60, 120, 180 kg ha^{-1} and four levels of B as 0, 0.5, 1.0 and 1.5 kg ha^{-1} constituting sixteen treatments were applied in a split plot design with three replications. Applied N and B had significant impact on the yield and hollow stem disorder of broccoli. The highest curd yield of 15.14 t ha^{-1} was obtained by 180 kg N ha^{-1}. The incidence of hollow stem disorder was increased by increasing rate of N application and the highest value of hollow stem index of 1.38 was found with 180 kg N ha^{-1}.

Yoldas *et al.*, (2008) conducted to determine the effects of nitrogen (N) doses on yield, quality, and nutrient content in broccoli heads. Treatments consisted of 0, 150, 300, 450, and 600 kg N ha^{-1}. Nitrogen rates significantly increased yield, average weight of main and secondary heads, and the diameter in broccoli compared to control. The highest total yield (34631 kg ha^{-1}) was obtained at 300 kg N ha^{-1}. At harvest, the highest amount of the total N in broccoli heads was measured at 450 kg N ha^{-1} application. Potassium (K), calcium (Ca), magnesium (Mg), iron (Fe), and zinc (Zn) content increased with increases in nitrogen treatments but, phosphorus (P), copper (Cu), manganese (Mn), boron (B), and sodium (Na) contents were not influenced. Also, removed nutrients by broccoli head were highest at 300 kg ha^{-1} N rate.

Broccoli (*Brassica oleracea* L. var. *italica*) is a crop benefiting greatly from nitrogen fertilization and the risk of leaching to groundwater is high. Nine N fertilizer treatments, from 0 to 225 kg N ha^{-1} and two irrigation treatments, irrigated and non-irrigated, were arranged in a split-plot design. Nitrogen had a curvilinear effect on marketable yield; an increase was seen up to an application of 165 kg N ha^{-1} where the response plateaued. Hollow stem was the only disorder related to N application noticed in this project. It was seen only in treatments receiving more than 165 kg N ha^{-1} and the number of heads affected was very low. Plant uptake of N was strongly affected by nitrogen application and a large effect from irrigation was observed at harvest.

The difference could only be explained by leaching early in the season and denitrification during the season. The risk of leaching early in the season is critical when the amount of precipitation and/or irrigation is above field capacity. Sap test, SPAD chlorophyll meter and Dualex were compared as a way to monitor nitrogen status. Sap test was the method showing the largest effect among different N applications but also the largest variability. The SPAD chlorophyll meter was very sensitive to differences in nitrogen application, even though it had the narrowest span from high to low fertilized plants.

The Dualex showed the best relationship with plant nitrogen uptake. It quickly showed differences among N application and a good correlation with yield. The use of a reference plot is recommended to decrease the influence of factors other than N affecting test results and to obtain relative values that can be used in different conditions (Mellgren, 2008).

Pramanik (2007) carried out an experiment at the Horticulture farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from September 2006 to February 2007 to study the effect of nitrogen and phosphorus on the growth and yield of cabbage. The experiment was laid out by RCBD with three replications.

The experiment consisted of two factors. Factor A: four levels of nitrogen (No = control, N_1 = 200 kg ha^{-1}, N_2= 260 kg ha^{-1} and N_3= 320 kg ha^{-1}) and Factor B: four levels of phosphorus (Po= control, P_1= 110 kg ha^{-1}, P_2= 120 kg ha^{-1} and P_3= 130 kg ha^{-1}). At harvest, the maximum plant height (34.76 cm), thickness of head (17.06 cm), gross and marketable yield of head were recorded in 260 kg N ha^{-1} while the control gave the lowest results.

Haque (2006) conduct an experiment in field condition to study the effect of nitrogen-phosphorus fertilization on growth, yield and nutrient content of cabbage. The experiment was laid out in randomize block design with three replications. The yield and yield components were maximized by N_3P_2 fertilizer treatment. Nutrient content of cabbage varied with fertilizer treatment. The maximum amount of reducing sugar, ascorbic acid, phosphorus were found at the highest rate of N-P fertilization whereas accumulation of titrable acidity, iron, calcium were maximum at the rate of N_2P_2 treatment.

However pH, ash content was more or less same throughout the experiment. The recent introduction of nutrient management legislation in Ontario may force vegetable growers to reduce nitrogen (N) application. Experiments were conducted on mineral soil in Simcoe, Ontario in 2000 and 2001 to re-evaluate the N needs of cabbage. Nitrogen application rates of 0, 85, 170, 255, and 340 kg ha^{-1} were applied 75% $plant^{-1}$ and 25% side dress to Atlantis, a mid-season cultivar. Total yield, marketable yield, weight per head, head density, and head size were assessed at harvest. In 2001, total yield showed a peak at 265 kg N ha^{-1} while in 2001 no significant effect was recorded. Head size and weight per head increased with increasing N rate only in 2000, reflecting differences in yield. Cabbage density was generally unaffected by N rate. Days to maturity decreased with increasing N rate reaching a minimum at 245 and 226 kg ha^{-1} in 2000 and 2001, respectively. Nitrogen rates above current recommended levels are beneficial in maximizing cabbage yields in wet years and minimizing days to maturity (Westerveld *et al.,* 2005).

Burghardt (2001) observed that under sub-optimal total nutrients supply, a foliar fertilizer (12N: 4P: 6K) at concentrations up to 15% was tolerated, without leaf damage by dwarf beans, carrots, beetroots, endives, Broccoli, leeks and white cabbages. These concentrations were equivalent to >100 kg N ha^{-1}.

Plant development and leaf color improved and yields increased by 12 to 74%. Crop quality was unchanged in most crops by foliar spraying, but it improved in beetroots and leeks. Leaf nitrate content was little affected by foliar spraying.

Kumar and Rawat (2002) conducted an experiment on cabbage (*Brassica oleracea* L. var *capitata*) CV. "Pride of India" to study the effect of different levels of nitrogen (0,50, 100, 150 and 200 kg N ha^{-1}) and spacing (30 x 60 cm, 45 x 60 cm and 60 x 60 cm) on the quality and yield of cabbage. The nitrogen had significant affect the TSS (%), dry matter percent, chlorophyll content (mg g^{-1}), and compactness of head (rank marks), head diameter (cm), head weight (g) and yield (q ha^{-1}). The maximum TSS, dry matter percent, chlorophyll content, and head diameter were recorded in 200 kg N ha^{-1}. However, the highest head weight (1127.22 g) and yield (312.42 q ha^{-1}) was recorded in application of 150 kg N ha^{-1}. Spacing also affected the quality and yield of cabbage. The quality improved with increase in spacing. Highest yield of 303.09 q ha^{-1} was recorded in 30 x 60 cm spacing.

Several authors have shown the importance of timing the application of nitrogen. Nkoa *et al.*, (2003) showed in an experiment in hydroponics that the nitrogen uptake of broccoli is bell shaped. It increased to reach a maximum at 30 days after transplantation and then decreased to harvest time, 60 days after transplantation.

They showed that both higher and lower contents of nitrogen in the water, compared to optimum, reduced growth rate. This was especially observed on young broccoli plants, 15 days after transplantation, with excessive plant nitrogen concentration.

When comparing the optimum concentration of 100 mg N L^{-1} to 175 mg N L^{-1} they observed a 50 percent reduction in growth.

The study also showed that the broccoli plants utilized the nitrogen best during the first 30 days of growth. During this time a concentration of 100 mg gave optimal growth rates, while after the 30 days a concentration of 175 mg L^{-1} was optimal. Even though the root system is small during the first half of the growth period, 62 percent of the nitrogen required to reach maturity was taken up during this time (54 percent between 15 and 30 days). Studies made by Bowen *et al.*, (1999), Vagen (2003), Shelp and Liu (1991) and Magnifico *et al.*, (1979) also showed the small nitrogen uptake during the first weeks after transplantation and a more rapid uptake around midseason.

As compared to Nkoa *et al.*, (2003) they showed a high nitrogen uptake for a longer time, until just a few weeks before harvest with the maximum during head formation.

Trials made by Riley and Vagen (2003) showed no effect of increasing nitrogen fertilizer from 150 to 250 kg ha^{-1} in broccoli.

When plant nitrogen status was high the relation between crop yield and plant nitrogen status was low. They also showed that split application of nitrogen gave significantly higher yields as compared to a single application. However, Everaarts and de Willigen (1999) showed that split application had no or a negative effect on yield. Babik and Elkner (2002) showed that split application was preferable when low pre-plant rates were used (100 kg N ha^{-1}) together with irrigation. At higher pre-plant rates (300 and 500 kg N ha^{-1}) when irrigation was not used, no increase in yield was observed. Bracey *et al.*, (1995), showed no significant response on yield to either pre-plant or side dress nitrogen rates, even though the amount differed from 179 to 348 kg N ha^{-1}.

Babik and Elkner (2002) showed that for every increase of nitrogen application (100, 200, 400 and 600 kg N ha^{-1}), yield increased significantly. Kowalenko and Hall (1987), showed that broccoli yield increased with nitrogen applications of up to 250 kg ha^{-1}. Broccoli yield increased curvilinearly with increasing rates of nitrogen fertilizer and maximum yields were obtained at rates between 436 and 558 kg ha^{-1} (Zebarth *et al.*, 1995). Kahn *et al.*, (1991), showed no significant effect on marketable head weight in three out of four experiments when using nitrogen rates between 112 and 224 kg ha^{-1}.

The nitrogen concentration in heads and above- ground residues increased significantly with increasing amount of nitrogen fertilizer but the timing of application had little effect. Recoveries of around 50 percent of the applied nitrogen were recorded (Riley and Vagen, 2003).

When deciding the amount of nitrogen fertilizer to apply, the grower needs to consider the rate of mineralization during the season. Mineralization of organic matter and residues is more rapid in light-textured soils than heavier soils (De Neve and Hofman, 1998). Mineralization is strongly affected by the carbon:nitrogen ratio. The higher the ratio, the lower the rate of mineralization.

Temperature and moisture play an important role in the microbial activity responsible for the mineralization. With lower temperatures and limited moisture the mineralization rates will be slower (Neeteson and Carton, 2001). A mineralization rate of around 5 kg N ha^{-1} per week has been estimated in earlier studies (Tremblay *et al.*, 2001; Fink and Scharpf, 2000). This would mean that mineralization add around 50 kg N ha^{-1} during a broccoli season (10 weeks).

Nitrogen fertilizer is usually banded on vegetable crops, because of the distance between the rows, to minimize leaching and get an effective uptake. Everaarts and De Willigen (1999a), showed that there was a significant response in yield both to method of application and amount of nitrogen applied. Band placed nitrogen was more effective than broadcast. Their study showed that the nitrogen required in the soil, applied and mineralized during the growing season, for optimum yield was 270 kg N ha^{-1} for banded fertilizer. For broadcast application 275 kg N ha^{-1} were required, however with lower yield compared to banded. Bracy *et al.*, (1995), on the other hand showed no difference in yield between fertilizer applied to the surface or banded. Tremblay *et al.*, (2001) concluded that nitrogen uptake for an average yield is around 260 kg N ha^{-1}. Eveerarts and de Willigen (1999b) reported a maximum nitrogen uptake of 300 kg N ha^{-1} and that split application did not influence nitrogen uptake.

Most studies have shown that the proportion of nitrogen taken up by broccoli decreased with increasing amount of fertilizer (Riley and Vagen, 2003; Eveerarts and de Willigen, 1999b; Zebarth *et al.*, 1995; Letey *et al.*, 1983). One study has shown the opposite (Kowalenko and Hall, 1987). Fink and Scharpf (2000) and Greenwood and Draycott (1988), both showed that the recovery rate of fertilizer nitrogen and soil mineral nitrogen was not affected by the amount of nitrogen applied.

In a study by Beverly *et al.*, (1986), yield decreased at excessive nitrogen applications, which could indicate salt injury. They also showed that different nitrogen treatments did not affect the number of days to maturity but higher applications increased the growth rate, which resulted in higher yields.

Bracy *et al.,* (1995), Kahn *et al.,* (1991) and Kowalenko and Hall (1987) also showed no effect on maturity rate when increasing nitrogen supply. Babik and Elkner (2002) showed that split application of high amounts of nitrogen fertilizer did not affect plant mass or the number of days to harvest. The amount of nitrogen applied however did affect the earliness of harvest. Irrigation hastened the yielding of broccoli but it only affected the yield significantly in the highest nitrogen amount (600 kg ha^{-1}) both as single or split application. Excessive water has shown to decrease yield for a given nitrogen treatment (Beverly *et al.*, 1986).

In a study made on wheat by Westerman *et al.,* (1994), yield differences due to nitrogen application were small when water was limited but otherwise large.

An increase in nitrogen application to increase yield can be detrimental to harvest quality. Hollow stem is one of the most common physiological disorders in broccoli (Tremblay 1989). An elliptical crack is formed during the initiation of the central inflorescence in the center of the stem. Broccoli for the fresh market is particularly sensitive to hollow stem since the base of the head is displayed to the customer.

A brown discoloration of the hole prior to or after harvest may occur depending on whether the discoloration is of non-pathogenic or pathogenic origin (Tremblay 1989).

Several authors have shown a relationship between hollow stem and nitrogen application in broccoli (Babik and Elkner 2002, Belec *et al.*, 2001, Tremblay 1989, Hipp 1974, Cutcliffe 1972). Other factors affecting hollow stem are the environment (Shattuck *et al.*, 1986) and cultivar and spacing (Cutcliffe 1975). Babik and Elkner (2002) and Scaife and Wurr (1989) (cauliflower) showed an increase in the number of hollow stem when irrigation was used together with high nitrogen application.

Another physiological disorder affected by nitrogen fertilization is head rot (Vagen 2003, Everaarts 1994, Canaday 1992). The disorder first appears as a water-soaked lesion followed by soft rotting of the tissue (Ludy and Powelson, 1997). Head rot is a serious disease of broccoli and yield losses can be as high as 100 percent (Everaarts 1994). Several bacteria, Pseudomonas and Erwinias, have been targeted as a cause of the disease (Ludy and Powelson, 1997, Everaarts 1994). Head rot is favoured by damp, wet conditions which favour bacterial growth and disease development (Ludy and Powelson, 1997).

Brown bead is a physiological disorder that causes many rejects in the region of Quebec. When the heads approach marketable maturity, sign of brown bead is yellowing followed by brown discoloration of the unopened floral buds (Jenni *et al.*, 2001). Compared to hollow stem and soft rot, brown bead is more severe when nitrogen application is low (Jenni *et al.*, 2001).

Everaarts and Willigen (1999) conducted to the effects of the amount and the method of nitrogen application on yield and quality of broccoli were studied during three seasons. Different amounts of nitrogen fertilizer were applied broadcast or band placed at planting. Band placement of fertilizer increased the yield in five out of eight experiments. Application of nitrogen results in larger heads.

No relationship was found between mineral nitrogen at planting and optimum nitrogen applications because of the narrow range of amounts of mineral nitrogen at planting. Split application had no or a negative effect on yield and therefore is not recommended. For optimum yields it is recommended to apply 270 kg of nitrogen per hectare, minus the mineral nitrogen in the soil layer 0-60 cm at planting, band placed at planting. For broadcast application 275 kg of nitrogen minus mineral nitrogen applied at planting is recommended, but yield will be lower as com-pared with band placement of fertilizer.

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 14 October 2017 to 18 March 2018. 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 I.

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 II.

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 Planting material

The variety of 'Premium crop' and 'Green sprouting' broccoli was used in the experiment. The seeds of the variety were collected from Masud Seed Company, 174, Siddique Bazar, Dhaka-1000.

3.5 Seedbed preparation

Seedbed was prepared on 12 October 2017 for raising seedlings of broccoli and the size of the seedbed was 3m×1m. For making seedbed, the soil was well ploughed to lose friable and dried masses to obtained good tilth. Weeds, stubbles and dead roots were removed from the seedbed. Cowdung was applied to prepared seedbed. The soil was treated by Sevin 50WP @ 5kg ha^{-1} 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 seed borne diseases.

3.7 Seed sowing

Seeds were sown on 29 October 2017 in the seedbed. Sowing was done 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 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 20 November 2017.

3.9 Treatment of the experiment

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

Factor A: Variety

1. V_1=Premium crop
2. V_2=Green sprouting

Factor B: Nitrogen

1. N_0=0 kg ha^{-1}
2. N_1=100 kg ha^{-1}
3. N_2=200 kg ha^{-1}
4. N_3=300 kg ha^{-1}

3.10 Design and layout of the experiment

The two factorial experiments were 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 8 plots where 8 treatments combination were distributed randomly. There were 24 unit plots altogether in the experiment. The size of the each plot was 4.0m × 2.0m. 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.

3.11 Land preparation

The plot selected for conducting the experiment was opened in the 3rd 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 fertilizers

Following doses of fertilizer were recommended for broccoli production.

Fertilizer	**Dose**
N	As per treatment
P	30 kg ha^{-1}
K	100 kg ha^{-1}

3.11.2 Transplanting

The seedbed was watered before uprooting the seedlings to minimize the damage of roots. Twenty two days old healthy seedlings were transplanted at the spacing of 60 cm × 50 cm in the experimental plots on 23 November 2017. 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 Earthing up

Earthing up was done only on unmulched plots by taking the soil from the space between the rows at 15 days 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 gL^{-1} 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 plant^{-1}

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 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).

3.13.4 Curd length

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

3.13.5 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).

3.13.6 Weight of primary curd

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

3.13.7 Number of secondary curd plant^{-1}

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

3.13.8 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).

3.13.9 Yield plant^{-1}

The yield plant^{-1} was calculated by averaging the weights of ten randomly harvested curds and secondary curds and expressed in kilogram (kg).

3.13.10 Yield per plot (kg)

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

3.13.11 Yield per hectare (ton)

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 DISCUSSIONS

The experiment was conducted to effect of variety and nitrogen on vegetative growth, morphology and head yield of broccoli (*Brassica oleracia var italica* L.). Data of the different parameters analyzed statistically and the results have been presented in the Tables 1 to 4 and Figures 1 to 4. The results of the present study have been presented and discussed in this chapter under the following headings.

4.1 Plant height

The plant height was recorded at different stages of growth 20, 40 and 60 days after transplanting (DAT). The plant height varied due to different variety (Fig.1). During the period of plant growth the maximum plant height (34.34, 44.68 and 56.41cm at 20, 40 and 60 DAT, respectively) was observed in V_2 (Green sprouting) treatment. On the other hand minimum plant height (30.66, 39.35 and 50.83 cm at 20, 40 and 70 DAT, respectively) was observed in V_1 (Premium crop) treatment. The varietal effect on plant height was supported by Haque (2005).

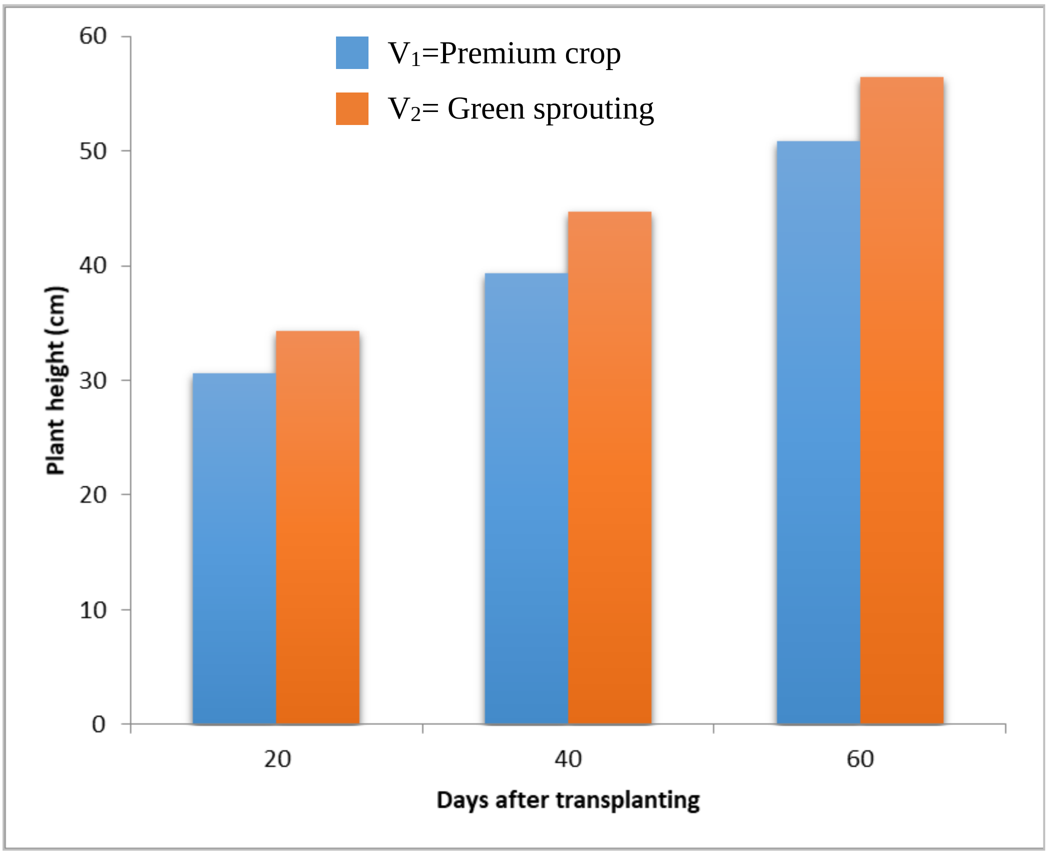


Figure 1. Effect of variety on plant height of broccoli at different days after transplanting

The variation on plant height of broccoli was shown due to different nitrogen level at 20, 40 and 60 DAT. During the period of plant growth the tallest plant (33.63, 43.47 and 55.58 cm at 20, 40 and 60 DAT, respectively) was observed in N_2 (200 kg N ha^{-1}) treatment and minimum (30.95, 40.08, 50.92 cm at 20, 40 and 60 DAT) in N_0 (control) treatment (Figure 2). The results showed that the plant height at different DAT was increased in N_2. This might be due to the fact that higher N uptake by plants possibly got favorable condition for better growth than those of others. This result is in agreement with the findings of (Khadir *et al.*, 1989 and Singh *et al.*, 2007) where the author reported that plant height increase with increasing the doses of nitrogen at certain level.

The plant height was significantly influenced by the interaction effect of variety and nitrogen. The combined effect of variety and nitrogen at different days after transplanting was also significant. The tallest plant (35.37, 46.47 and 59.03 cm at 20, 40 and 60 DAT, respectively) was found from the Green sprouting and 200 kg N ha^{-1} treatment (V_2N_2) and the lowest (30.95, 40.08 and 50.82 cm at 20, 40 and 60 DAT, respectively) from Premium crop variety and control treatment (V_1N_0) treatment (Table 1).

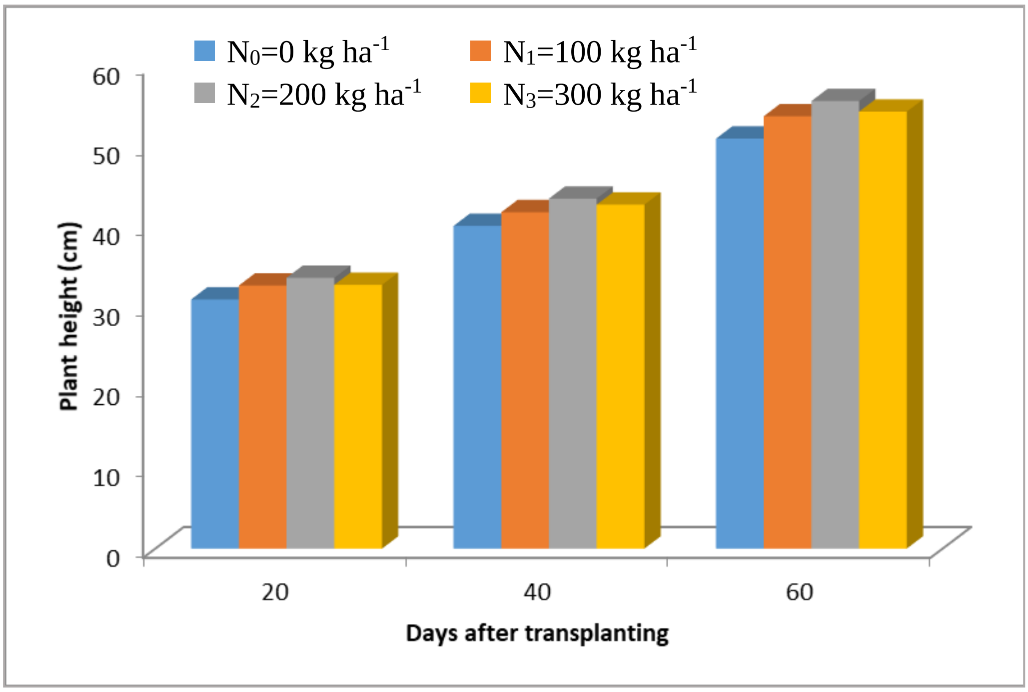


Figure 2. Effect of nitrogen on plant height of broccoli at different days after transplanting

Table 1. Combined effect of variety and nitrogen on plant height of broccoli

Treatment	Plant height at		
	20 DAT	40 DAT	60 DAT
V_1N_0	28.50 c	37.63 e	48.80 c
V_1N_1	31.17 bc	39.47 d	51.00 bc
V_1N_2	31.90 abc	40.47 d	52.13 bc
V_1N_3	31.07 bc	39.83 d	51.37 bc
V_2N_0	33.4 ab	42.53 c	53.03 b
V_2N_1	34.17 ab	44.10 bc	56.40 a
V_2N_2	35.37 a	46.47 a	59.03 a
V_2N_3	34.43 ab	45.60 ab	57.17 a
$LSD_{(0.05)}$	3.60	1.83	3.14
CV (%)	6.32	5.49	5.34

4. 2 Number of leaves plant^{-1}

Applications of variety increase the production of leaves plant^{-1} at 20, 40 and 60 DAT. The maximum number of leaves plant^{-1} (6.68, 10.23 and 12.78 at 20, 40 and 60 DAT, respectively) was produced by (V_2) treatment and the minimum (5.53, 1019 and 11.42 at 20, 40 and 60 DAT, respectively) was produced by V_1 treatment. These results might be due to cause of genetical characters of cultivars that caused higher and lower number of leaves plant^{-1}. An insignificant variation was found in case of production of leaves plant^{-1} due to the effect of nitrogen (Figure 4). The maximum number of leaves (6.45, 10.55 and 12.35 at 20, 40 and 60 DAT, respectively) was obtained from N_2 treatment. The N_0 (control) treatment gave minimum number of leaves (5.52, 9.58 and 11.60) plant^{-1} showing insignificantly different result from other treatments. It was revealed that with the increases of nitrogen, number of leaves plant^{-1} also increased at certain level. The trend of the present results was agreed to that of Sandhu *et al.,* (1999), Pramanik (2007) and Singh *et al.,* (2007).

The number of leaves plant^{-1} was also significantly influenced by the interaction effect of variety and nitrogen. The number of leaves plant^{-1} was recorded to be the highest (7.13, 10.87 and 12.23 at 20, 40 and 60 DAT, respectively, respectively) from the treatment combination of V_2N_2 treatment. The lowest number of leaves (5.00, 8.97 and 10.67 at 20, 40 and 60 DAT, respectively) was observed from the V_1N_0 treatment (Table 2).

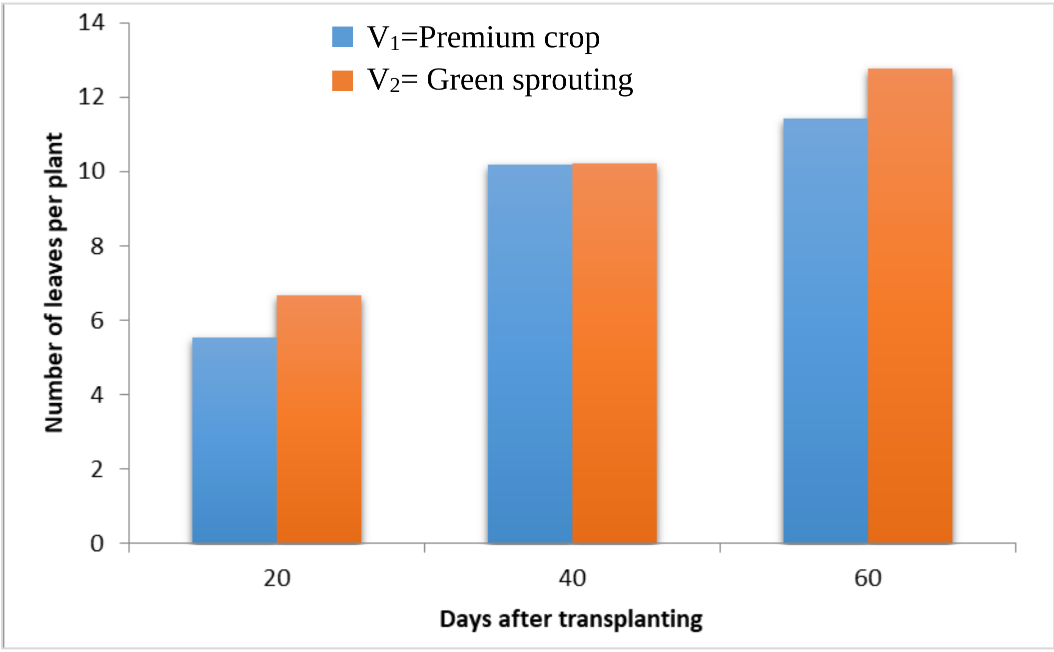
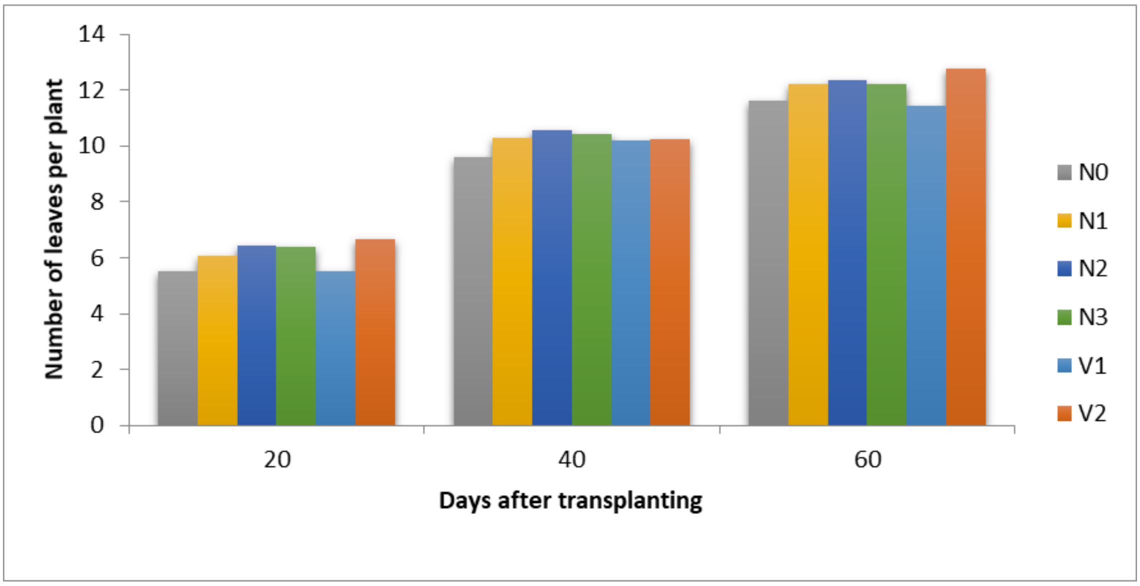


Fig. 3. Effect of variety on number of leaves plant^{-1} of broccoli at different days after transplanting



N_0=0 kg ha^{-1}, N_1=100 kg ha^{-1}, N_2=200 kg ha^{-1}, N_3=300 kg ha^{-1}

Fig. 4. Effect of nitrogen on number of leaves plant^{-1} of broccoli at different days after transplanting

Table 2. Combined effect of variety and nitrogen on number of leaves plant^{-1} of broccoli

Treatment	Number of leaf plant^{-1}		
	20 DAT	40 DAT	60 DAT
V_1N_0	8.97 b	10.67 b	9.47 c
V_1N_1	10.33 ab	11.53 ab	10.17 bc
V_1N_2	10.33 ab	11.83 ab	10.30 bc
V_1N_3	9.97 ab	11.63 ab	10.13 bc
V_2N_0	10.20 ab	12.53 a	10.93 abc
V_2N_1	10.27 ab	12.90 a	11.27 ab
V_2N_2	10.87 a	12.87 a	12.23 a
V_2N_3	10.77 a	12.77 a	11.53 ab
$LSD_{(0.05)}$	1.33	1.41	1.36
CV (%)	7.44	6.67	7.24

4.3 Stem length of curd

Variety exhibited a significant influence on stem length of curd of broccoli plants (Table 3). The highest stem length of curd (11.49 cm) was measured from V_2 while the lowest (10.02 cm) was recorded in V_1. Varietal effect was observed on shoot / stem length due to its phenotypical characters (Haque, 2005) and this result on stem length is supported by Haque, 2005.

Application of nitrogen significantly influenced the stem length of curd of broccoli plants (Table 3). The maximum stem length of curd (11.27 cm) was measured from N_2 which was statistically identical with other while the minimum (10.20 cm) was recorded from N_0. Data of stem length under the present study was in agreement with Souza *et al.,* (2008).

Stem length of curd significantly influenced by the interaction effect of variety and nitrogen (Table 3). The maximum stem length of curd (12.23 cm) was measured from V_2N_2 which was statistically identical from other while the minimum (9.47 cm) was recorded from V_1N_0. Stem length of curd is important for curd yield. Stem length of curd was significantly influenced by nitrogen application.

Table 3. Interaction effect of varieties and nitrogen on Stem length of curd, curd length, diameter of primary curd and weight of primary curd of broccoli

Treatment	Stem length of curd (cm)		Curd length (cm)		Diameter of primary curd (cm)		Weight of primary curd (kg)	
Effect of variety								
V_1	10.02		11.66		12.78		0.55	
V_2	11.49		13.58		16.48		0.69	
CV (%)	7.24		5.30		4.83		4.64	
Effect of nitrogen								
N_0	10.20	b	11.72	b	13.45	b	0.60	
N_1	10.72	ab	12.67	ab	14.62	ab	0.63	
N_2	11.27	a	13.12	a	15.52	a	0.64	
N_3	10.83	ab	12.97	a	14.93	a	0.63	
$LSD_{(0.05)}$	0.73		1.03		1.34		NS	
CV (%)	7.24		5.30		4.83		4.64	
Combined effect of variety and Nitrogen								
V_1N_0	9.47	c	10.67	d	11.90	d	0.50	b
V_1N_1	10.17	bc	11.93	c	12.73	cd	0.55	b
V_1N_2	10.30	bc	12.17	c	13.47	c	0.57	b
V_1N_3	10.13	bc	11.87	c	13.03	cd	0.55	b
V_2N_0	10.93	abc	12.77	bc	15.00	b	0.66	a
V_2N_1	11.27	ab	13.40	ab	16.50	a	0.70	a
V_2N_2	12.23	a	14.17	a	17.57	a	0.69	a
V_2N_3	11.53	ab	14.07	a	16.83	a	0.72	a
$LSD_{(0.05)}$	1.36		1.17		1.24		0.08	
CV (%)	7.24		5.30		4.83		4.64	

4.4 Curd length

Variety exhibited an influence on curd length of broccoli plants (Table 3). The maximum curd length **(**13.58 cm) was recorded from V_2 while the minimum (11.66 cm) was measured from V_1. The data obtained on thickness of head was conformity with Haque (2005).

Application of nitrogen significantly influenced the curd length of broccoli plants (Table 3). The maximum curd length **(**13.12 cm) was measured from N_2 which was statistically similar to that of N_3, while the minimum (11.72 cm) was recorded from N_0. This results revealed that the curd length increase with nitrogen application. Optimum nitrogen ensured proper growth of plant and consequently the maximum thickness of head. The trend of the present results was agreed to that of Csizinszky and Schyster (1985), Pramanik (2007) and Singh *et al.,* (2007) where they observed that the high N rate (257 kg ha^{-1}) increased head size in both seasons.

Curd length was significantly influenced by the interaction effect of variety and nitrogen (Table 3). The maximum curd length **(**14.17 cm) was measured from V_2N_2 which was statistically similar to that of V_2N_3 while the minimum (10.67 cm) was recorded from V_1N_0. Curd length is important for curd yield. Curd length was significantly influenced by variety and nitrogen application.

4.5 Diameter of primary curd

The results on effects of variety showed that variety had significant effect on diameter of primary curd of broccoli plants (Table 3). The maximum curd diameter (16.48 cm) was measured from V_2 which while the minimum (12.78 cm) was measured from V_1. Similar results were obtained by Haque (2005) and Muhammad and Javed (2001) with their experiments.

Application of nitrogen had a significant influence on diameter of primary curd of broccoli plants (Table 3). The maximum curd diameter (15.52.0 cm) was measured from N_2 which was statistically similar to that of N_3 while the minimum (13.45 cm) was recorded from N_0. Higher doses of nitrogen ensured vigorous growth of plant and consequently the highest diameter of head but it makes lesser compactness of leaves. The trend of the present results were agreed to that of Ghanti *et al.,* (1982), Csizinszky and Schyster (1985), Gupta (1987), Parmar *et al.,* (1999), Pramanik (2007) and Singh *et al.,* (2007) reported higher diameter in cabbage with increased nitrogen rates that favored the growth of plants and it was more usefully utilized in head diameter.

Primary curd diameter was significantly influenced by the interaction effect of variety and nitrogen (Table 83). The maximum primary curd diameter (17.57 cm) was measured from V_2N_2 which was statistically similar to that of V_2N_3 and V_2N_1 while the minimum (11.9 cm) was recorded from V_1N_0. Primary curd diameter is important for curd yield of broccoli. Diameter of the primary curd was significantly influenced by variety and nitrogen application.

4.6 Weight of primary curd

A significant variation was observed on primary curd weight due to the use of variety (Table 3). The maximum primary curd weight (0.69 kg) was measured from V_2 while the minimum primary curd weight (0.55 kg) was recorded from V_1.

Nitrogen showed an insignificant influence on weight of primary curd of broccoli plants (Table 3). The maximum primary curd weight (0.64 kg) was measured from N_2 while the minimum weight of primary curd (0.660 kg) was recorded from N_0. It was revealed that the primary curd weight increased with nitrogen application at certain level.

Weight of primary curd was significantly influenced by the interaction effect of variety and nitrogen (Table 3). The maximum primary curd weight (0.70 kg) was measured from V_2N_2 while the minimum (0.50 kg) was recorded from V_1N_0. Weight of primary curd is important for increasing total production of broccoli.

4.7 Number of secondary curd plant^{-1}

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. Variety exhibited an influence on number of secondary curd of broccoli plants (Table 4). The maximum numbers of secondary curds (3.14) were observed from V_2 and while the minimum numbers of secondary curds (1.98) were observed from V_1.

Nitrogen exhibited an insignificant influence on number of secondary curd of broccoli plants (Table 4). The maximum numbers of secondary curds (2.92) were observed from N_2 while the minimum numbers of secondary curds (2.20) were observed in N_0. It was revealed that the number of secondary curd increased with nitrogen application.

Number of secondary curd was significantly influenced by the interaction effect of variety and nitrogen (Table 4). The maximum numbers of secondary curds (3.67) were observed from V_2N_2 treatment while the minimum (1.73) were recorded from V_1N_0 treatment, which was statistically similar with V_1N_1 treatment.

Table 4. Interaction effect of varieties and nitrogen on curd yield and yield contributing characters of broccoli

Treatment	Number of secondary curd		Weight of secondary curd (g)		Curd yield/ plant (kg)		Curd yield/ha (t)	
Effect of variety								
V_1	1.98		65.33		0.29		11.45	
V_2	3.14		103.42		0.48		19.28	
CV (%)	5.84		4.12		5.73		5.73	
Effect of nitrogen								
N_0	2.20		72.48	c	0.34		13.55	c
N_1	2.34		80.67	b	0.38		15.28	b
N_2	2.92		92.67	a	0.42		16.68	a
N_3	2.78		91.67	a	0.40		15.95	ab
$LSD_{(0.05)}$	NS		3.76		NS		1.10	
CV (%)	5.84		4.12		5.73		5.73	
Combined effect of variety and Nitrogen								
V_1N_0	1.73	e	61.30	e	0.25	e	10.15	e
V_1N_1	1.83	e	62.33	e	0.29	d	11.61	de
V_1N_2	2.17	d	71.33	d	0.31	d	12.28	d
V_1N_3	2.17	d	66.33	de	0.29	d	11.75	de
V_2N_0	2.66	c	83.67	c	0.42	c	16.95	c
V_2N_1	2.84	c	99.00	b	0.47	b	18.95	b
V_2N_2	3.67	a	117.0	a	0.53	a	21.08	a
V_2N_3	3.39	b	114.0	a	0.50	a	20.15	ab
$LSD_{(0.05)}$	0.26		6.09		0.02		1.54	
CV (%)	5.84		4.12		5.73		5.73	

4.8 Weight of secondary curd

Weight of secondary curd of broccoli plant is important for increasing total yield. Variety had an influence on secondary curd weight of broccoli plants (Table 4). The maximum secondary curd weight (103.42 g) was measured from V_2 and the minimum (65.33 g) was recorded from V_1.

Application of nitrogen exhibited a significant influence on weight of secondary curd of broccoli plants (Table 4). The maximum secondary curd weight (92.67 g) was recorded from N_2 which was statistically similar to that of N_3 while the minimum (72.48 g) was recorded from N_0. It was revealed that the plot covered by nitrogen gave higher yield than control plot. Weight of secondary curd was significantly influenced by the interaction effect of variety and nitrogen (Table 8). The maximum secondary curd weight (117.0 g) was measured in V_2N_2 which was statistically similar to that of V_2M_3, while the minimum (61.33 g) was recorded from V_1N_3.

4.9 Curd yield plant^{-1}

Yield plant^{-1} is important for increasing total yield. Variety exhibited an influence on yield plant^{-1} of broccoli (Table 4). The maximum yield (0.48 kg) was recorded from V_2 while the minimum (0.29 kg) was measured in V_1.

The results achieved by Haque (2005), Muhammad and Javed (2001) was similar to the present study. Application of nitrogen exhibited an insignificant influence on yield $plant^{-1}$ (Table 4). The maximum yield (0.42 kg) was recorded from N_2 that was while the minimum (0.34 kg) was measured in N_0. Optimum doses of nitrogen ensured proper growth of plant and consequently the highest fresh weight of head $plant^{-1}$.

The trend of the present result was agreed to that of Ghanti *et al.,* (1982), Gupta (1987), Parmar *et al.,* (1999), Mahesh-Kumar (2002), Pramanik (2007) and Singh *et al.,* (2007) reported higher yields in cabbage with increased nitrogen rates. This was attributed to the fact that higher nitrogen levels favored the growth of plants with larger leaf area and it was more usefully utilized in head formation.

Significant variation was recorded due to the combined effect of variety and nitrogen in terms of yield $plant^{-1}$ in broccoli (Table 4). The highest yield $plant^{-1}$ (0.53kg) was observed from V_2N_3, which was statistically similar with V_2N_3 and the lowest (0.25 kg) was found in V_1N_0 treatment combination.

4.10 Curd yield (t ha^{-1}) of broccoli

Yields of broccoli varied significantly due to different variety. The maximum yield (19.28 t ha^{-1}) was found from (V_2) treatment. The minimum yield (11.45 t ha^{-1}) was found from (V_1) treatment (Table 4). The results achieved by Haque (2005), Muhammad and Javed (2001) was similar to the present study.

The yield of broccoli hectare was found to be statistically significant due to nitrogen (Table 4). The highest yield (16.68 t ha^{-1}) was obtained from N_2 treatment and the lowest (13.55 t ha^{-1}) in this regard was obtained from N_0 treatment. It was revealed that with the increases of nitrogen individual weight $plant^{-1}$ increased. The results achieved by Haque (2005), Muhammad and Javed (2001) was similar to the present study. Ghanti *et al.*, (1982), Gupta (1987) and Parmar *et al.*, (1999) reported higher yields in cabbage with increased nitrogen rates. This was attributed to the fact that higher nitrogen levels favored the growth of plants with larger leaf area and it was more usefully utilized in head formation, head diameter and gross mass of heads.

A significant combined effect of variety and nitrogen was also observed on yield of broccoli per hectare. The highest marketable yield of broccoli (21.08 t ha^{-1}) was obtained from Green sprouting with 200 kg N ha^{-1} nitrogen (V_2N_2) treatment and the lowest (10.15 t ha^{-1}) was in the Premium crop variety with contro treatment (V_1N_0) has been presented in table 4.

CHAPTER V

SUMMARY AND CONCLUSION

An experiment was conducted at the farm of Sher-e-Bangla Agricultural University, Dhaka during the period from October 2017 to March 2018 to examine the effect of variety and nitrogen on vegetative growth, morphology and head yield of broccoli (*Brassica oleracia* var *italica* L.). The experiment consisted of two varieties viz. Premium crop (V_1) and Green sprouting (V_2) and four different level of Nitrogen viz. 0 kg ha^{-1} (N_0), 100 kg ha^{-1}(N_1), 200 kg ha^{-1}(N_2) and 300 kg ha^{-1}(N_2). The experiment was laid out in Randomized Complete Block Design (factorial) with three replications. There were 8 treatment combinations in all.

Data on different growth and yield parameters such as plant height, number of leaves $plant^{-1}$, stem length of curd, curd length, diameter of primary curd, weight of primary curd, number of secondary curd $plant^{-1}$, weight of secondary curd, yield $plant^{-1}$ and yield (t ha^{-1}) of broccoli were recorded and analyzed statistically.

Variety exhibited an influence on the plant height, number of leaf, stem length of curd, curd length, diameter of primary curd, weight of primary curd, number of secondary curd $plant^{-1}$, weight of secondary curd of broccoli plants. The maximum plant height (34.34, 44.68 and 56.41cm at 20, 40 and 60 DAT, respectively) was observed in V_2 (Green sprouting) treatment. The maximum number of leaves plant^{-1} (6.68, 10.23 and 12.78 at 20, 40 and 60 DAT, respectively), stem length of curd (11.49 cm), curd length (13.58 cm), curd diameter (16.48 cm), primary curd weight (0.69 kg), numbers of secondary curds (3.14), and secondary curd weight (103.42 g) was produced by (V_2) treatment.

Different level of nitrogen exhibited a significant influence on the plant height, stem length of curd, curd length, diameter of primary curd, weight of primary curd, number of secondary curd plant^{-1}, weight of secondary curd of broccoli plants. The tallest plant (33.63, 43.47 and 55.58 cm at 20, 40 and 60 DAT, respectively) was observed in N_2 (200 kg N ha^{-1}) treatment. The maximum number of leaves (6.45, 10.55 and 12.35 at 20, 40 and 60 DAT, respectively), length of curd (11.27 cm), curd length (13.12 cm), curd diameter (15.52.0 cm) primary curd weight (0.64 kg), numbers of secondary curds (2.92), curd weight (92.67 g) was obtained from N_2 treatment.

By the treatment combinations at 20, 40 and 60 DAT the plant height, number of leaf, stem length of curd, curd length, diameter of primary curd, weight of primary curd, number of secondary curd plant^{-1}, weight of secondary curd of broccoli plants was significantly influenced.

The tallest plant (35.37, 46.47 and 59.03 cm at 20, 40 and 60 DAT, respectively) was found from the Green sprouting and 200 kg N ha^{-1} treatment (V_2N_2).

The number of leaves plant^{-1} was recorded to be the highest (7.13, 10.87 and 12.23 at 20, 40 and 60 DAT, respectively, respectively) from the treatment combination of V_2N_2 treatment. The maximum stem length of curd (12.23 cm) was measured from V_2N_2. The maximum curd length (14.17 cm) was measured from V_2N_2. The maximum primary curd diameter (17.57 cm), primary curd weight (0.70 kg) numbers of secondary curds (3.67) and secondary curd weight (117.0 g) was measured from V_2N_2.

Yield parameters like yield plant^{-1}, and yield per hectare varied significantly due to variety, nitrogen and treatment combinations of variety and nitrogen. Yield plant^{-1} is important for increasing total yield. The maximum yield (0.48 kg) was recorded from V_2. The maximum yield (0.42 kg) was recorded from N_2 (200 kg N ha^{-1}). The highest yield plant^{-1} (0.53kg) was observed from V_2N_3, The maximum yield (19.28 t ha^{-1}) was found from (V_2) treatment.

The minimum yield (11.45 t ha^{-1}) in this respect was found from control treatment. The highest yield (16.68 t ha^{-1}) was obtained from N_2 treatment and the lowest (13.55 t ha^{-1}) in this regard was obtained from N_0 treatment. The yield of broccoli hectare was found to be statistically significant due to nitrogen. The highest yield (16.68 t ha^{-1}) was obtained from N_2 treatment and the lowest (13.55 t ha^{-1}) in this regard was obtained from N_0 treatment.

A significant combined effect of variety and nitrogen was also observed on yield of broccoli per hectare. The highest marketable yield of broccoli (21.08 t ha^{-1}) was obtained from Green sprouting with 200 kg N ha^{-1} nitrogen (V_2N_2) treatment and the lowest (10.15 t ha^{-1}) was in the Premium crop variety with contro treatment (V_1N_0).

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

I. The variety 'Green sprouting' gave the highest curd yield of broccoli.

II. Application of 200 kg N ha^{-1} produced the tallest plant, maximum number of leaves $plant^{-1}$, stem length of curd, curd length, diameter of primary curd, weight of primary curd, number of secondary curd $plant^{-1}$, weight of secondary curd, curd yield $plant^{-1}$ and thus gave the maximum curd yield of broccoli.

III. The variety 'Green sprouting' coupled with application of 200 kg N ha^{-1} gave the maximum curd yield which was identical with the combination of the same variety and 300 kg N ha^{-1}.

RECOMMENDATION

i. Green sprouting in combination with 200 kg N ha^{-1} was suitable for broccoli cultivation.

ii. The study might be conducted at the same Agro Ecological Condition for the confirmation of the result.

REFERENCES

Babic, I., and K. Elkner. (2000). The effect of nitrogen fertilization and irrigation on yield and quality of broccoli. Workshop Towards and Ecologica Sound Fertilization in Field Vegetable Production ISHS. Acta Horticulturae. p. 57.

Babik I. and Elkner K. (2002). The effect of nitrogen fertilization and irrigation on yield and quality of broccoli. Acta Horticulturae. **571**: 33-43

Bartholomew W. V. and Clark F. E. (1965) Soil Nitrogen. Academic Press Inc, USA

Belec C., Villeneuve S., Coulombe J. and Tremblay N. (2001) Influence of nitrogen fertilization on yield, hollow stem incidence and sap nitrate concentration in broccoli. *Canadian J. Plant Sci.* **81**: 765 - 772

Beverly R. B., Jarrell W. M. and Letey J. Jr. (1986). A nitrogen and water response surface for sprinkler-irrigated broccoli. Agronomy Journal **78**: 91-94

Bhangre, K.K., Sonawane, P.C. and Warade, S.D. (2011). Effect of different varieties and spacing on growth and yield parameters of broccoli (*Brassica oleracea* L. var. *Italica plenck*) under Pune conditions, *Asian J. Hort.*, **6**(1): 74-76.

Bowen P. A., Zebarth B. J. and Toivonen P. M. A. (1999) Dynamics of nitrogen and dry matter partitioning and accumulation in broccoli (*Brassica oleracea* var. *italica*) in relation to extractable soil inorganic nitrogen. *Canadian J. Plant Sci*. **79**: 277-286

Bracey R. P., Parish R. L. and Bergeron P. E. (1995) Sidedress N application methods for broccoli production. *J. vegetable crop production*, **1**(1): 63-71

CRAAQ (2003). Guide de référence en fertilisation. 1st edition. Quebec, Canada.

Csizinszky, A. A. and Schyster, D. J. 1985. Resposnse of cabbage to insecticide schedule, plant spacing and fertilizer rates. *J. Amer. Soc. Hort. Sci*., **110**(6): 888-893.

Cutcliffe J. A. (1972). Effects of plant spacing and nitrogen on incidence of hollow stem in broccoli. *Canadian J. Plant Sci.* **52**: 833 - 834

De Neve S. and Hofman G. (1998). N mineralization and nitrate leaching from vegetable crop residues under field conditions: A model evaluation. *Soil Biology and Biochemistry*. **30**(14): 2067-2075

Everaarts A. P. and de Willigen P. (1999a). The effect of nitrogen and the method of application on yield and quality of broccoli. *Netherlands J. Agril. Sci*. **47**: 123-13.

Everaarts A. P. (1994) Nitrogen fertilization and head rot in broccoli. Netherlands Journal of Agricultural Science **42-3**: 195-201

Everaarts, A.P. and De Willigen, P.DE. (1999). The effect of nitrogen and the method of application on yield and quality of broccoli. *Netherlands J. Agril. Sci*. **47**:123-133.

Ghanti, P., G. Sounda, P. K. Jana and M. G. Som. 1982. Effect of levels of nitrogen, phosphorus and spacing on yield characters of cabbage. Veg. Sci., **9**(l): 1-4.

Haque, K.M.F. (2005). Influence of variety and time of planting on the yield performance and nutrient contents of cabbage (*Brassica oleracea* L.). Dhaka, Bangladesh: Bangladesh Council of Scientific and Industrial Research. Bangladesh-Journal-of-Scientific-and-Industrial-Research. 2005; **40**(3/4): 211-218.

Hussain, M. J., Sirajul Karim, A. J. M. Solaiman, A. R. M. and Haqu, M. M. (2012). Effects of Nitrogen and Boron on the Yield and Hollow Stem Disorder of Broccoli (*Brassica oleracea var. italica*). *The Agriculturists* .**10**(2): 36-45.

Karistsapol, N., Quanchit, N. and Te-Chato Sompong. (2013). Effect of shading and variety on the growth and yield of broccoli during the dry season in southern Thailand. *Intel. J. Plant, Animal and Environ. Sci*. **3**(2):111-115.

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

Khadir, H. A. Marazat, S. K. and Sadon S. A. 1989.Effect of different levels of urea fertilizer, and plant spacing on growth and yield of cabbage. Dirasa. **6**(9):88-105.

Kumar, M. and Rawat, T. S. 2002.Effect of nitrogen and spacing on the quality and yield of cabbage (*Brassica oleracea* L. var. *capitata*).*Agric. Sci. Digest*. **22**(2): 90-92.

Lincolin, C. P. 1987. Vegetable Characteristics, Production and Marketing. John Wiley, New York. p. 217.

Mellgren, R. (2008). Effect of irrigation and nitrogen treatments on yield, quality, plant nitrogen uptake and soil nitrogen status and the evaluation of sap test, SPAD chlorophyll meter and Dualex to monitor nitrogen status in broccoli. Master thesis in biology, 45 hp. Department of Horticulture. Swedish University of Agricultural Sciences.

Muhammad, I. and Javed, U. (2001). Response of Chinese cabbage cultivars to different levels of nitrogen with constant doses of phosphorus and potassium under the agro-climatic conditions of Chilas (Diamer). Peshawar, Pakistan: NWFP Agricultural University. *Sarhad J. Agri*., **17**(1): 81-85.

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

Nooprom, K. and Santipracha**,** Q. (2013). Effects of planting dates and varieties on growth and yield of broccoli during rainy season. *American J. Agril. and Biol. Sci*. **8**(4): 357-361

Pramanik, S. 2007. Effect of nitrogen and phosphorus on the growth and yield of cabbage (*Brassica oleracea* var *capitata* L.).MS thesis, Department of Horticulture, SAU, pp. 1-50.

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

Richardson, K. VA. (2016). Evaluation of the broccoli (*Brassica oleracea* L. var. *italica*) variety imperial. gladstone road agricultural centre crop research report no**. 23**

Roni, M. S. Zakaria M., Hossain, M. M., and Siddiqui M. N. **(**2014)**.** Effect of plant spacing and nitrogen levels on nutritional quality of broccoli *(Brassica oleracea* L.). *Bangladesh J. Agril. Res*. **39**(3):491-504.

Sandhu, K. S., Chahai, B. S., Singh, D. and Sandha, M. S.1999. Effect of population density and nitrogen on growth characters and yield of cabbage (*Brassica oleracea* var. *capitata*).Veg. Sci. **26**(2):146-148.

Shoemaker, J.S.; Benjamin, J.E. and Teskey J.Q. 1962. Practical Horticulture. John Wiley, New York. p. 219.

Singh *et al*., 2007. Observing of significant variations in vitamin E content within various cultivars of cabbage and broccoli.

Souza, P. A., Souza, G. L. F. M., Menezes, J. B. and Bezerra, N. F. (2008). Evaluations of cabbage cultivar grown under organic compost and mixed mineral fertilizers. Horticultura Brasileira. **26**(1): 143-145.

Thapa U. and Rai R. (2012) Evaluation of Sprouting Broccoli (*Brassicae oleraceae* var. *italica*) genotypes for growth, yield and quality. *Intel. J. Agric. Sci*., ISSN: 0975-3710 and E-ISSN: 0975-9107, **4**(7), pp-284-286.

Thompson, H. C. and Kally, W. C. 1957. Vegetable Crops, Fifth edition. Mcgrow Hill, New York, p**.** 307.

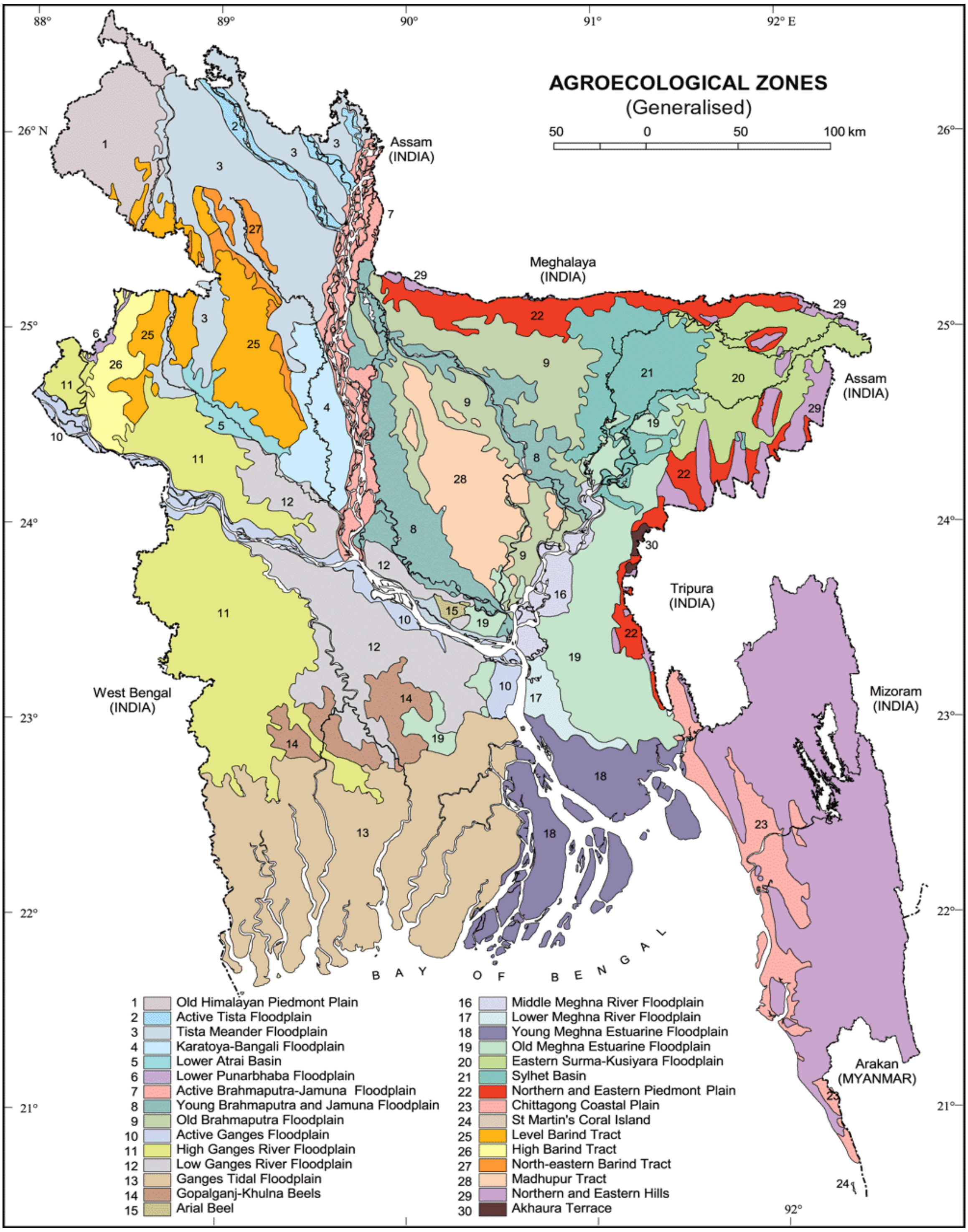
Westerveld, M.R. McDonald and A.W. McKeown (2005). Optimum Nitrogen Fertilization of Summer Cabbage in Ontario. Department of Plant Agriculture University of Guelph Guelph, Ontario Canada.

Wolf,S., Zikeli,S., Fleck, M., Hoenninger, S.G. and Clauepein, W. (2014). Open Pollinated Broccoli Genotypes: Agronomic Parameters and Sensory Attributes. RAHMANN G and AKSOY U (Eds.) (2014) Proceedings of the 4th ISOFAR Scientific Conference.*'Building Organic Bridges',* at the Organic World Congress 2014, 13-15 Oct., Istanbul, Turkey.

Yoldas, f., Safak Ceylan, Bulent Yagmur, and Nilgun Mordogan. (2008). Effects of Nitrogen Fertilizer on Yield Quality and Nutrient Content in Broccoli. *J. Plant Nutrition*, **31**: 1333–1343.

APPENDICES

Appendix I: Experimental location on the map of agro-ecological zones of Bangladesh



Appendix II: Soil characteristics of Sher-e-Bangla Agricultural University Farm, Dhaka analyzed by Soil Resources Development Institute (SRDI), Farmgate, Dhaka

A. Morphological characteristics of the experimental field

Morphological features	**Characteristics**
Location	Farm, SAU, Dhaka
AEZ	Modhupur tract (28)
General soil type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	N/A

Source: Soil Resources Development Institute (SRDI)

B. Physical and chemical properties of the Initial soil

Characteristics	**Value**
Practical size analysis	
Sand (%)	16
Silt (%)	56
Clay (%)	28
Silt + Clay (%)	84
Textural class	Silty clay loam
p^H	5.56
Organic matter (%)	0.25
Total N (%)	0.02
Available P (µgm/gm soil)	53.64
Available K (me/100g soil)	0.13
Available S (µgm/gm soil)	9.40
Available B (µgm/gm soil)	0.13
Available Zn (µgm/gm soil)	0.94
Available Cu (µgm/gm soil)	1.93
Available Fe (µgm/gm soil)	240.9
Available Mn (µgm/gm soil)	50.6

Source: Soil Resources Development Institute (SRDI)

Appendix III: Analysis of variance of the data on plant height of broccoli as influenced by variety and nitrogen at days of planting

Source	Degrees of Freedom	Means square		
		Plant height at		
		20 DAT	40 DAT	60 DAT
Replication	2	10.284	8.934	25.602
Factor A	1	81.402	170.13	187.04
Factor B	3	7.554*	12.769*	23.174*
AB	3	1.047*	0.655*	1.818*
Error	14	4.222	1.094	3.204

*significant at 5% level of probability

Appendix IV: Analysis of variance of the data on number of leaves plant^{-1} of broccoli as influenced by variety and nitrogen at days of planting

Source	Degrees of Freedom	Means square		
		Number of leaf at		
		20 DAT	40 DAT	60 DAT
Replication	2	12.16	3.215	2.042
Factor A	1	46.923	0.01	10.935
Factor B	3	6.6625*	1.118 ^{NS}	0.672 ^{NS}
AB	3	0.037*	1.258*	0.20*
Error	14	0.167	0.577	0.65

*significant at 5% level of probability
NS- Non significant

Appendix V: Analysis of variance of the data on number of branch plant^{-1} of broccoli as influenced by variety and nitrogen

Source	Degrees of Freedom	Means square			
		Stem length of curd (cm)	Curd length (cm)	Diameter of primary curd (cm)	Weight of primary curd (kg)
Replication	2	2.107	3.402	4.042	2.531
Factor A	1	13.054	22.042	81.77	0.115
Factor B	3	1.155*	2.37*	4.542*	0.002 ^{NS}
AB	3	0.178*	0.158*	0.267*	0.001*
Error	14	0.607	0.447	0.498	0.001

*significant at 5% level of probability
NS- Non significant

Appendix VI: Analysis of variance of the data on yield contributing characters of broccoli as influenced by variety and nitrogen

Source	Degrees of Freedom	Means square			
		Number of secondary curd	Weight of secondary curd (g)	Yield (kg plant^{-1})	Yield (t ha^{-1})
Replication	2	2.273	82.667	0.006	10.16
Factor A	1	8.167	8705.9	0.23	368.17
Factor B	3	0.716 ^{NS}	554.17*	0.007*	10.762*
AB	3	0.1*	214.18*	0.00*1	1.287*
Error	14	0.022	12.095	0.0001	0.776

*significant at 5% level of probability