EFFECT OF DIFFERENT LEVELS OF GIBBERELIC ACID AND BORON ON GROWTH AND YIELD OF BROCCOLI

ADITI SARKAR

DEPARTMENT OF HORTICULTURE

SHER-E-BANGLA AGRICULTURAL UNIVERSITY
DHAKA-1207

JUNE, 2015

EFFECT OF DIFFERENT LEVELS OF GIBBERELIC ACID AND BORON ON GROWTH AND YIELD OF BROCCOLI

BY

ADITI SARKAR

Reg. No.: 14-06337

A Thesis

Submitted to the Faculty of Agriculture
Sher-e-Bangla Agricultural University, Dhaka
in partial fulfilment of the requirements for the degree of

MASTER OF SCIENCE (MS)

IN

HORTICULTURE

SEMESTER: JANUARY-JUNE, 2015

Approved by:

….…..…………………………

………..………...………..……..…

Dr. Md. Nazrul Islam
Professor
Department of Horticulture
SAU, Dhaka
Supervisor

Dr. Jasim Uddain
Associate Professor
Department of Horticulture
SAU, Dhaka
Co-supervisor

………………………………………………

Asso. Prof. Dr. Tahmina Mostarin
Chairman
Examination Committee
Department of Horticulture

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

CERTIFICATE

This is to certify that the thesis entitled, ***"EFFECT OF GIBBERELLIC ACID AND BORON ON GROWTH AND YIELD OF BROCCOLI "*** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in the partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (MS) in HORTICULTURE,** embodies the result of a piece of *bonafide* research work carried out by ***ADITI SARKAR,*** Registration No. ***14-06337*** 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 during the course of this investigation has been duly acknowledged and style of this thesis have been approved and recommended for submission.

Dated- June, 2015
Dhaka, Bangladesh

Dr. Md. Nazrul Islam
Professor
Department of
Horticulture
Sher-e-Bangla Agricultural
University
Dhaka, Bangladesh-
1207
Supervisor

ACKNOWLEDGEMENT

All praises are due to Almighty Allah, the Great, Gracious and Merciful, Whose blessings enabled the author to complete this research work successfully.

The author like to express her deepest sense of gratitude sincere appreciation to her respected Supervisor ***Professor Dr. Md. Nazrul Islam****, Department of Horticulture, Sher-e-Bangla Agricultural University (SAU), Dhaka, Bangladesh, for his scholastic guidance, support, encouragement and invaluable suggestions and constructive criticism throughout the study period and gratuitous labor in conducting and successfully completing the research work and in the preparation of the manuscript writing.*

The author also expresses her gratefulness and best regards to respected Co-supervisor, ***Associate Professor Dr. Jasim Uddin****, Department of Horticulture, Sher-e Bangla Agricultural University, Dhaka for his scholastic guidance, helpful comments and constant inspiration, inestimatable help, valuable suggestions throughout the research work and preparation of the thesis.*

The author expresses her sincere respect to the Chairman, Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka for valuable suggestions and cooperation during the study period. The author also expresses heartfelt thanks to all the teachers of the Department of Horticulture, SAU, for their valuable suggestions, instructions, cordial help and encouragement during the period of the study.

The author expresses her sincere appreciation to her brother, sisters, relatives, well wishers and friends for their inspiration, help and encouragement throughout the study period.

June, 2015 ***The Author***
SAU, Dhaka.

EFFECT OF DIFFERENT LEVELS OF GIBBERELIC ACID AND BORON ON GROWTH AND YIELD OF BROCCOLI

By
ADITI SARKAR

ABSTRACT

The study was conducted at the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka to find out the effect of different levels of gibberellic acid and boron on growth and yield of broccoli. The experiment consisted of two factors: Factor A: Gibberellic acid(GA_3) (three levels) as- G_0: control, G_1: 100 ppm, G_2: 200 ppm GA_3 and Factor B: boron(B) (three levels) as- B_0: control, B_1: 100 ppm, B_2: 200 ppm B. The two factors experiment was laid out in Randomized Completely Block Design with three replications. In case of different levels of GA_3, the highest main and secondary curd yield (19.55 and 5.43 t/ha) were found from G_2, while the lowest yield (11.53 and 2.55 t/ha) from G_0. For different levels of boron, the highest main and secondary curd yield (16.97 and 4.57 t/ha) were recorded from B_2, whereas the lowest yield (14.36 and 3.19 t/ha) from B_0. Due to interaction effect, the highest main and secondary curd yield (20.51 and 6.21 t/ha) were recorded from $G_2B_{2,}$ whereas the lowest yield (10.42 and 2.30 t/ha) from $G_0B_{0.}$ The highest benefit cost ratio (2.38) was noted from the combination of G_2B_2 and the lowest (1.34) from $G_0B_{0.}$ From growth, yield and economic point of view, it is apparent that the combination of 200 ppm GA_3 with 200 ppm boron was suitable for broccoli cultivation.

LIST OF CONTENTS

CHAPTER	TITLE	PAGE
	ACKNOWLEDGEMENTS	I
	ABSTRACT	II
	LIST OF CONTENTS	III
	LIST OF TABLES	V
	LIST OF FIGURES	VI
	LIST OF APPENDICES	VII
	ABBREVIATIONS AND ACRONYMS	VIII
CHAPTER I	**INTRODUCTION**	**01**
CHAPTER II	**REVIEW OF LITERATURE**	**04**
CHAPTER III	**MATERIALS AND METHODS**	**16**
3.1	Location of the experimental field	16
3.2	Soil of the experimental field	16
3.3	Climate of the experimental area	16
3.4	Plant materials used	16
3.5	Raising of Seedlings	17
3.6	Treatments of the experiment	17
3.7	Layout and design of the experiment	18
3.8	Cultivation procedure	18
3.9	Parameters assessed	21
3.10	Data collection	21
3.11	Statistical analysis	24
3.12	Economic analysis	24
CHAPTER IV	**RESULTS AND DISCUSSION**	**25**
4.1	Plant height	25
4.2	Number of leaves per plant	27
4.3	Days to main curd formation	30
4.4	Days to secondary curd formation	31
4.5	Days to main curd maturity	32
4.6	Days to secondary curd maturity	32
4.7	Stem diameter	33
4.8	Stem length	34
4.9	Curd diameter	34
4.10	Curd length	36
4.11	Leaf area plant^{-1}	37
4.12	Canopy of plant	37
4.13	Leaf dry matter	38

CONTENTS

CHAPTER	TITLE	PAGE
4.14	Curd dry matter	39
4.15	Average weight of main curd	39
4.16	Average weight of secondary curd	40
4.17	Yield plot^{-1} (kg) of main curd	41
4.18	Yield plot^{-1} (kg) of secondary curd	42
4.19	Yield ha^{-1} (ton) of main curd	44
4.20	Yield ha^{-1} (ton) of secondary curd	44
4.21	Economic analysis	47
CHAPTER V	**SUMMARY AND CONCLUSION**	**49**
CHAPTER VI	**REFERENCES**	**53**
CHAPTER VII	**APPENDICES**	**59**

LIST OF TABLES

TABLE	TITLE	PAGE
1	Interaction effect of GA_3 and boron on plant height (cm) of broccoli at different days after transplanting (DAT)	27
2	Interaction effect of GA_3 and boron on number of leaves per plant of broccoli at different days after transplanting (DAT)	30
3	Effect of GA_3 on days to main and secondary curd formation, days to main curd maturity and number of secondary curds plant^{-1} of broccoli	31
4	Effect of boron on days to main and secondary curd formation, days to main curd maturity and number of secondary curds plant^{-1} of broccoli	31
5	Interaction effect of GA_3 and boron on days to main and secondary curd formation, days to main curd maturity and number of secondary curds plant^{-1} of broccoli	33
6	Effect of GA_3 on stem diameter (cm), stem length (cm), curd diameter (cm), curd length (cm) and leaf area plant^{-1} (cm^2) of broccoli	35
7	Effect of boron on stem diameter (cm), stem length (cm), curd diameter (cm), curd length (cm) and leaf area plant^{-1} (cm^2) of broccoli	35
8	Interaction effect of GA_3 and boron on stem diameter (cm), stem length (cm), curd diameter (cm), curd length (cm) and leaf area plant^{-1} (cm^2) of broccoli	36
9	Effect of GA_3 on canopy of plant (cm), leaf and curd dry matter (%) and average weight of main and secondary curd (g) of broccoli	38
10	Effect of GA_3 on canopy of plant (cm), leaf and curd dry matter (%) and average weight of main and secondary curd (g) of broccoli	39
11	Interaction effect of GA_3 and boron on canopy of plant (cm), leaf and curd dry matter (%) and average weight of main and secondary curd (g) of broccoli	41
12	Interaction effect of GA_3 and boron on yield of main and secondary curd of broccoli	47
13	Cost and return of broccoli cultivation as influenced by different levels of gibberellic acid and boron	48

LIST OF FIGURES

FIGURE	TITLE	PAGE
1	Effect of GA_3 on plant height (cm) of broccoli	26
2	Effect of boron on plant height (cm) of broccoli	26
3	Effect of GA_3 on number of leaves per plant of broccoli	29
4	Effect of boron on number of leaves per plant of broccoli	29
5	Effect of GA_3 on yield per plot (kg) of main and secondary curd of broccoli	43
6	Effect of boron on yield per plot (kg) of main and secondary curd of broccoli	43
7	Effect of GA_3 on yield (ton/ha) of main and secondary curd of broccoli	46
8	Effect of boron on yield (ton/ha) of main and secondary curd of broccoli	46

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
I	Map showing the experimental sites under study	60
II	Physical characteristics and chemical composition of soil of the experimental plot	61
III	Monthly record of year temperature, rainfall, relative humidity, soil temperature and sunshine of the experimental site during the period from October, 2014 to January, 2015	61
IV	Error mean square values for plant height of br(different days after transplanting (DAT)	62
V	Error mean square values for number of leaves plant^{-1} of broccoli at different days after transplanting (DAT)	62
VI	Error mean square values for days to main and secondary curd formation, days to main curd maturity and number of secondary curds plant^{-1} of broccoli	62
VII	Error mean square values for stem diameter (cm), stem length (cm), curd diameter (cm), curd length (cm) and leaf area plant^{-1} (cm^2) of broccoli	63
VIII	Error mean square values for canopy of plant (cm), leaf and curd dry matter (%) and average weight of main and secondary curd (g) of broccoli	63
IX	Error mean square values for yield of main and secondary curd of boccoli	63

ABBREVIATIONS AND ACRONYMS

@	:	***At the Rate of***
Abstr.	:	Abstract
AEZ	:	Agro-ecological Zone
Agric.	:	Agriculture
AVRDC	:	Asian Vegetables Research and Development
BARC	:	Bangladesh Agricultural Research Council

BARI	:	Bangladesh Agricultural Research Institute
BAU	:	Bangladesh Agricultural University
BBS	:	Bangladesh Bureau of Statistics
BCR	:	Benefit Cost Ration
cv.	:	Cultivar
DAS	:	Day After Sowing
et al.	:	et alii (and others)
FAO	:	Food and Agriculture Organization Of the United Nati
FW	:	Fresh weight
FYM	:	Farm Yard Manure
Hort.	:	Horticulture
i.e.	:	That is
J.	:	Journal
LSD	:	Least Significant Difference
NS	:	***Non-significant***
RCBD	:	***Randomized Complete Block Design***
Sci.	:	***Science***
Soc.	:	***Society***
UK	:	***United Kingdom***
UNDP	:	***United Nations Development Program***
Viz.	:	***Namely***

CHAPTER I

INTRODUCTION

Broccoli (*Brassica oleracea* var. *italica* L.) is one of the most important cole crops in Bangladesh. It is a biennial crop belonging to the family Brassicaceae. Although originated from west Europe (Prasad and Kumar, 1999), it is well distributed to both the tropical and sub-tropical regions. Broccoli is also cultivated as a commercial crop in India (Nonnecke, 1989) and it has been introduced to Bangladesh in the recent years.

Broccoli is nutritious vegetable which is fairly rich in vitamin A and C, and minerals namely, calcium, phosphorus and iron (Watt, 1963). So it can contribute significantly to improve our diet. It is more nutritious than other cole crop such as cabbage, cauliflower and kholrobi (Thompson and Kell, 1988).

Broccoli can be grown in wide range of soils from light to heavy loam or even in clay that are well supplied with organic matter (Katyal, 1977). The cultivation of broccoli has been extended much beyond the farms of different agricultural organizations in Bangladesh.

Broccoli is grown by a small percentage of home gardeners in Bangladesh during the winter season. It is environmentally better adapted than cauliflower as reported to withstand comparatively higher temperature (Rashid, 1976). The growth and yield of broccoli in Bangladesh are seriously impended compared to that of other countries. The main reason for such poor growth and yield is due to the lack of judicious application of fertilizers, and proper cultural and management practices.

Plant growth regulators (PGRs) are organic substances known for their function in regulating various physiological processes in plants even employed in low concentration. When plants produce these organic substance endogenously, they are termed as phytohormones or plant hormones. These plant hormones act as chemical messengers capable of regulating various physiological processes in accordance with environmental changes (Qasim *et al.*, 2010). The assessment of potential of PGRs in alteration of growth pattern and morphogenesis of plants is frequently correlated with the type and the concentration of PGRs, type of species, stage of application and agro-climatic conditions of harvest etc. Among plant growth regulators, GA_3, kinetin and humic acid exhibited beneficial effect in several crops (Singh *et al.*, 2001 and Shabbir *et al.*, 2015).

Gibberellins are the group of diterpenoid acid derivatives being widely used as plant hormones regulating various developmental processes such as germination, stem elongation, breaking of dormancy in flowers, leaf senescence, fruit senescence, enzyme induction and sex expression etc. GA_3 also has effect on color development (Kim *et al.*, 2009). The application of GA_3 has been found effective in stimulating growth and ultimately yields in vegetable crops. Among the growth regulators GA_3 exhibited beneficial effects in several crops including broccoli. In broccoli, boron deficiency has been reported in many parts of the country very frequently causing browning and hollow stem and ultimately resulting in lower yield having inferior quality. GA_3 exhibited beneficial effect in several cole crops by stimulating cell division or cell enlargement or both (Badawi and Sahhar, 1979) and foliage application of different concentration of GA_3 provide more yield (Rana, 2011 and Jiang, 2005). GA_3 have close relation with growth and yield of broccoli and determination of exact concentrations of GA_3 is important for growth and yield of broccoli. GA_3 singly influence plant growth and yield of broccoli but the effect of this factor on the growth and yield of broccoli have not been studied in details under Bangladesh conditions.

It is evident that balanced application of fertilizer is the prerequisite obtaining higher yield and better quality of broccoli (Brahma *et al*., 2002). Boron is considered as a potential micronutrient that carries out various functions for plant growth. Application of boron significantly increases curd diameter, weight of curd, yield and quality of cauliflower (Kumar *et al*., 2002). In cole crop like cauliflower and broccoli, boron requirement is high. It is essential for translocation of sugar, starches, nitrogen and sulphur (Pandhawa and Bhali, 1976). Boron deficiency causes many anatomical, physiological and biochemical changes. It is required for proper development and differentiation of tissues. In its absence, abnormal formation and tissue development occurs. Direct effects of B are reflected by the close relationship between B supply and pollen producing capacity of the anthers as well as the viability of the pollen grains (Agarwala *et al.*, 1981). Boron deficiency in crops is more widespread than deficiency of any other micronutrient. Nutritional disorder occurs in vegetables include brown heart in rutabaga, turnip and radish roots, and hollow stem in cauliflower and broccoli. Hollow stem disorder is major problem to broccoli production which is responsible to yield reduction is commonly associated with B deficiency (Shelp *et al.*, 1992) as well as higher nitrogen rates (Babik and Elkner, 1999) and an economic concern (Shattuck and Shelp, 1985). It is a common physiological disorder of the *brassicas*. Broccoli cultivar Premium Crop is a susceptible variety to boron deficiency as well as hollow stem disorder. As it was assumed that hollow stem in broccoli is intensified by rapid maturation and increasing nitrogen which has long been associated with B deficiency and was found that a portion of hollow stem disorder in broccoli could be attributed to B deficiency.

Considering this, the present investigation was taken up to fulfil the following objectives.

1) To determine the optimum level of GA_3 for growth and yield of broccoli,
2) To identify the suitable doses of boron for proper growth and yield of broccoli
3) To find out the suitable combination of GA_3 and boron on growth and yield of broccoli.

CHAPTER II

REVIEW OF LITERATURE

Broccoli is one of the most popular vegetable and received much attention to the researcher of different countries including Bangladesh. Like many other vegetables the growth and yield of broccoli are influenced by growth regulators and micronutrient. A number of experiments have been conducted throughout the growing regions but research findings regarding the effect of growth regulators and micronutrient on growth and yield of broccoli under Bangladesh condition is very limited. The literature related to the present study are reviewed in this chapter under the following headings.

2.1 Effect of growth regulators on growth and yield of broccoli

Reza *et al.* (2015) conducted an experiment to find out the influence of GA_3 on growth, yield and yield contributing characters of broccoli *(Brassica oleracea var. Italica)*. Four levels of GA_3 *viz.* G_1: Control, G_2: 25 ppm GA_3, G_3: 50 ppm GA_3 and G_4: 75 ppm GA_3 was used in the experiment. The maximum plant height (31.5 cm), number of leaves (16.6/plant), number of main fingers (12.0/main curd), main curd length (21.3 cm), main curd diameter (19.3 cm), main curd weight (668.0 g/plant) and yield (24.5 t/ha) was found from the application of 50 ppm GA_3, while the minimum from control. It was revealed that, 50 ppm GA_3 gave maximum yield/ha (24.5 tons). It was also found that application of more than 50 ppm GA_3 reduced the yield of broccoli.

Thara *et al.* (2013) designed and carried out an experiment during 2009-10 and 2010-11 at Horticulture Research Station, Mondouri, Bidhan Chandra Krishi Viswavidyalaya, Monhanpur, Nadia, West Bengal, India to determine the effect of GA_3, NAA and their combinations (applied as seedling dipping) on growth, yield and quality improvement of sprouting broccoli. The results clearly indicated significantly good response of the growth regulator applications on growth, yield and quality attributes of sprouting broccoli. GA_3 30 mg/l+NAA 30 mg/l treatment (T_{10}) showed best result with respect to head weight, head diameter, plant height, plant spread, projected yield, number of sprouts/plant and sprout weight. GA_3 60 mg/l treatment (T_2) took least number of days for head initiation, while GA_3 80 mg/l treatment (T_3) proved to be the most effective among all treatments and required minimum days for head initiation to head maturity. Plant growth regulator treatments significantly improved carotene, total sugar and total chlorophyll content, with highest increase have been recorded in case of T_1– GA_3 40 mg/l, whereas maximum ascorbic content has been estimated with T_9– GA_3 20 mg/l + NAA 20 mg/l.

Singh *et al.* (2011) reported that a field experiment was carried out during the winter season of 2009 to 2010 on sprouting broccoli cultivar Palam Samridhi at Horticultural Research Centre and Department of Horticulture, H.N.B Garhwal University, Srinagar (Garhwal) Uttarakhand, India. Four weeks old seedlings were treated before transplanting by dipping their roots for 24 h in different concentration of GA_3 (gibberellic acid), kinetin and their combinations solutions. The GA_3, kinetin and their combination significantly influenced the growth performance, yield and quality characters of sprouting broccoli. GA_3 30 mg/l + kinetin 30 mg/l treatment gave maximum growth and yield of sprouting broccoli whereas, highest vitamin A content found with 40 mg/L GA_3 and vitamin C was found maximum in GA_3 20 mg/l + kinetin 20 mg/l dipping.

The growth and flowering response of a cold-requiring broccoli to a range of temperatures under 10hrs photoperiod and to growth regulator application were investigated by Guo *et al.* (2004). Endogenous gibberellins (GA_3) concentrations were also assessed under these treatments. Flowering and growth of the inflorescence stalk were correlated with plant developmental stage at the time a vernalizing cold treatment. Temperature and its duration also affected flowering and inflorescence development. The most effective temperature for inflorescence induction was 10°C. Flowering did not occur in non vernalized plants (25°C) even though they had been treated with GA_3. Application of GA_3 promoted inflorescence stalk elongation greatly in vernalized plants (10°C), but less so in partially vernalized plants (15 or 20°C). Paclobutrazol sprayed at the 8-9 leaf stage significantly suppressed inflorescence stalk length and slightly delayed flower bud formation and anthesis. Vernalization at 10°C increased endogenous GA_3 content in both leaves and the inflorescence stalk irrespective of GA_3 treatment.

Vijay and Ray (2000) carried out an experiment on thirty day old broccoli seedlings that were transplanted into experimental plots treated with 50 or 100 GA_3, 5 or 10 ppm IBA, 200 ppm NAA at 15 and 30 days of growth. The results clearly revealed that GA_3 at 100 ppm produced the tallest plants, the largest curds and highest curd yields.

Dharmender *et al.* (1996a) conducted an experiment to find out the effect of GA_3 or NAA (both at 25, 50 or 75 ppm) on the yield of broccoli in the field at Jobner, rajastan, India. They recorded the highest yield following treatment with GA_3 at 50 ppm followed by NAA at 50 ppm (557.54 and 528.66 q/ha, respectively). They also reported that combination and highest concentrations of plant growth regulators proved less effective and were uneconomic in comparison to control.

Dhaarmender *et al.* (1996b) studied GA_3 alone or in combination with NAA (both at 25, 50 and 75 ppm) on the growth of cabbage in the field of Horticulture Farm S.K.A. College of Agriculture, Jabnner, Rajstan, India during rabi season (winter) 1993-1994. The best growth parameter like as plant height, plant spread, number of leaves, leaf area and days of maturity was observed following treatment with GA_3 at 50 ppm followed by NAA at 50 ppm. GA_3 at 75 ppm reduced the mean number of days required to start head formation. The highest chlorophyll content in outer leaves was observed following treatment with NAA at 50 ppm.

Aditya and Fordham (1995) carried out an experiment in the field and green house to study the effects of cold exposure and GA_3 during early growth stages on the date of flowering of the tropical broccoli cv. Early Pake and the temperate cv. Lawna. Flowering in cv. Early Pake was advanced by approximately 25 days following vernalization (1 week at 10°C) of 3 weeks old plants. They reported that one week old plants failed to respond to this treatment suggesting juvenile phase lasting up to about the 6 leaf stage in this cultivar.

Islam *et al.* (1993) determined the effective concentration of NAA and GA_3 for promoting growth, yield and ascorbic acid content of cabbage. They used 12.5, 25, 50 and 100 ppm of both the NAA and GA_3 and applied in three different methods i.e., seedling soaked for 12 hours, spraying at 15 and 30 days transplanting. They found that ascorbic acid content increased up to 50 ppm when sprayed twice with both the growth regulator, while its content was declined after wards. They also added that two sprays with 50 ppm GA_3 was suitable both for higher yield and ascorbic acid content of broccoli.

Reddy (1989) reported that exogenous application of GA_3 and urea either alone or in combination enhanced curd size as well as yield. Greatest plant height at curd formation (58.2 cm), curd diameter at maturity (26.8 cm) and increase yield over the control (164 %) were obtained with two application of GA_3.

Sharma and Mishra (1989) stated that plant height, curd formation and curd size of cauliflower can increased with foliar application of plant growth regulators. Several experiments were conducted to increase the yield of cauliflower. GA_3 and IAA have a positive effect on curd formation and size of cauliflower.

Mutho *et al.* (1987) showed that foliar application of different concentration of GA_3, NAA and molybdenum increased the average fresh and dry weight of leaves. Curd and yield of broccoli among the individual treatments, GA_3 proved to be the best for the vegetative growth of curd and yield of broccoli (q/ha) followed by naphthalene acetic acid. The effect of treatment combination $G_2N_2M_2$ (100 ppm GA_3, 120 ppm NAA and 0.2 % molibdenum) gave best results for all parameter of growth and yield.

Patil *et al.* (1987) conducted an experiment in a field trial with the cultivar pride of India applied GA_3 and NAA increased the plant height significantly. The maximum plant height and head diameter and head weight were noticed with GA_3 at 50 ppm following by NAA at 50 ppm. Significant increase in number of outer and inner leaves was noticed with both GA_3 and NAA. Head formation and head maturity was 13 and 12 days earlier with 50 ppm GA_3. Maximum number of leaves and maximum yield (23.83 t/ha) were obtained with 50 pp GA_3.

Pandey and Sinha (1987) reported that photosynthetic area of plant increased when treated with GA_3 and NAA.

Mishra and Singh (1986) conducted an experiment with all possible combinations of the levels of nitrogen (0, 0.5 and 1.0 percent), boron (0, 0.1 and 0.2 percent) and GA_3 (0, 25 and 50 ppm) in the form of urea, boric acid and GA_3 were spraying on snowball-16 cauliflower respectively. Results revealed that there was significant increase in growth characters namely plant height, diameter of stem, number of leaves per plant, weight of plant, curd yield and nitrogen content in stem and leaves due to N, B and GA_3 application. However, length of stem was increased only by GA_3 spray.

Islam (1985) conducted an experiment at the BAU Farm, Mymensingh with applying various growth regulators (CCC, GA_3, NAA and IBA) at 30 days after transplanting of 32 days old seedling, CCC decreased the plant height, size of loose leaves, diameter of cabbage of head and finally the yield. GA_3 increased the plant height, number of loose leaves per plant, size of leaf and finally the yield.

Yabuta *et al.* (1981) reported that application of GA_3 had significantly increased marketable weight, petiole length and number of leaves, leaf area and height of many leafy vegetables.

Abdalla *et al.* (1980) conducted an experiment with broccoli varieties and the plants were treated with different concentration of IBA (5-4 ppm), GA_3 (10-80 ppm) or NAA (120-160 ppm) 4 weeks after twice more at fortnightly intervals. NAA at 160 ppm gave the best result with regard to curd diameter, weight and color. Similar results were obtained from plants treated with GA_3 at 80 ppm and NAA at 40 ppm.

Badawi and Sahhar (1979) conducted a study at the experimental station of the Faculty of Agriculture, Cairo University, Egypt. They spraying 0, 50, 100 and 200 ppm GA_3 and 0, 10, 20 and 40 ppm IBA after 4 and 8 weeks of transplanting to determine the extent of stimulating effect of different concentration of GA_3 and IBA on cabbage.

Chauhan and Bordia (1971) carried out an experiment using Drumhead variety of broccoli to assess the effect of GA_3 at 5, 10, 25, 50 and 100 ppm, NAA at 5, 10, 25, 50 and 100 ppm and 2,4-D at 5, 10, 25, 50 and 100 ppm as per-sowing seed treatment on growth and yield broccoli and mentioned that none of the treatments affected the height of the plants and the time taken for head formation. Maximum weight of head (1.72 kg) was obtained with 50 pmm GA_3 as against 0.81 kg under control.

Chhonkar and Singh (1965) conducted an experiment in Rabi season of 1962-1963 with GA_3 at 5 ppm and 10 ppm after two and three weeks of transplanting. They reported that 5 ppm GA_3 induced larger number of inner leaves in heads, earlier head formation by 16 days, increased head diameter, improved compactness and significantly increased the yield and quality of heads.

In broccoli, Chhonkar and Jha (1963) observed that IAA and IBA at lower concentration were very effective in promoting early recovery and higher percentage of seedling establishment.

Denisova and Lupinovich (1962) found that GA_3 application brought about rapid vegetative growth, which subsequently helped in the early formation of large and compact heads. The probable cause of this may be increased nutrient transport from root to the aerial parts and increased rate of photosynthesis and accelerated transport of photosynthesis by GA_3.

Anderson *et al.* (1948) found increased growth in broccoli by the application of GA_3 and NAA. This was found to have significant effect due to synergistic action.

2.2 Effect of boron on growth and yield of broccoli and other cole crops

Pizetta *et al.* (2005) observed the effects of boron fertilizer application on the yields of broccoli, cauliflower and cabbage were evaluated through an experiment carried out in Sao Paulo, Brazil, on a sandy soil low in available boron. Five boron levels (0, 2, 4, 6 and 8 kg/ha as borax) were applied in broccoli cauliflower and cabbage. Organic manure and chemical fertilizers, including borax were applied in the planting furrow before seedling transplant and plant were harvested at 63-93 days after planting date. The yield intervals obtained with broccoli, cauliflower and cabbage varied according to the following intervals 16.9 to 20.5 t/ha, 21.6 to 29.6 t/ha and 40.5 to 46.3 t/ha, respectively. The increase in production observed in broccoli and cabbage yield was linear with boron levels and the boron effect on cauliflower yield was quadratic. The maximum cauliflower yield (30 t/ha), treatment with 5.1 kg/ha of B was necessary. Broccoli and cabbage were less sensitive than cauliflower to boron deficiency and toxicity. Quality of the curds decreased when 2 or 6 kg/ha B was applied to cauliflower.

A glass house experiment was conducted by Annesar *et al.* (2004) with various macro and micronutrients in 2004 at Wiehenstephan, Bavaria. Broccoli was grown in plots with a black beltic peat substrate. The typical nutrient deficiency symptoms of nitrogen, phosphorus and pot as are under supply were described. Over supply of nutrients produced necrotic spores on old leave. No deficiency symptoms were found for magnesium, iron. The Copper and manganese, Boron and Molybdenum deficiency and sodium chloride ,boron, zinc and manganese over supplied caused severe damage.

Singh (2003) studied the effect of B on the growth and yield of cauliflower cv. Musa Synthetic in Chiplima, Orissa, India during the rabi season of 1998-99, The treatments consisted of borax applied at various rates : 10 kg/ha as soil treatment, 5 kg/ha as soil treatment + 0.25% as spray at 45 and 65 days after planting (DAP), 5 kg /ha as soil treatment + 0.5% as foliar spray at 45 and 60 DAP, 0.25 or 0.56% as foliar spray at 30, 45 and 60 DAP. B significantly improved the negative growth and quality parameter of cauliflower, the greatest stalk length (6.78 cm) was obtained with borax applied at 10kg/ha as soil treatment. Borax applied at 5 kg/ha as soil treatment + 0.2% as foliar spray at 45 and 60 DAP resulted in the highest number of leaves per plant (17.4), leaf area (374.6 cm), curd weight (510.0 g), curd width (1568 cm), curd length (8.48 cm), curd yield per plot (16.23. cm), curd yield per ha (140.8 quintal), net profit (51,203 rupees/ha) and benefit cost ratio (4.20). [1 quintal= kg].

The effects of molybdenum (0.5 and 1 kg sodium molibdate/ha) and boron (10 and 20 kg borax/ha), applied alone or in combination with 25 tons farm yard manure (FYM)/ha, on the yield and yield components of cauliflower cv. Pusa snowball-I were determined by Kumar *et al.* (2002) 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. Borax at 10kg/ha and molybdenum at 0.5 kg/ha increased the yield by 32 and 14% respectively. Application of FYM in addition to 10% recommended NPK enhanced the yield of cauliflower by 27% compared to application of NPK alone.

Sharma *et al*. (2002) conducted field experiments in kandaghat, Himachal Pradesh, India, during 1993-94 and 1994-95 on a sandy loam soil to determine the response of cauliflower cv. Pusa Snowball k-1 to different level of B (5, 15 and 25 kg horax/ha) and Mo (1.0, 1.5 and 2.0 kg ammonium molibdate/ha) through soil application. Maximum plant height, number of branches per plant, number of seeds per pod, seed yield per plant (32.67g) and per hectare (9.80q/ha), 1000-seed weight and percent seed germination were obtained when 25 kg borax/ha was applied through soil application.

Jana and Mukhopadhaya (2002) conducted an experiment on the effect of boron, molybdenum and zinc on yield and quality of cauliflower seed. They reported that higher seed yield and seed quality were observed by applying boron at the rate of 20 kg borax per hectare as compared to no boron application. The combined effect of boron, molybdenum and zinc showed significant increase in number in primary inflorescence stalks (8.7 per plant), pods per plant (1085.7) and seed yield (489.3kg/ha).

Yang *et al.* (2000) studied the effects of 8 B-Mo treatments on curd yield and active oxygen metabolism in broccoli. When the concentrations of B were the same, catalase (CAT) activity and antiscorbutic (ASA) content increased with increases in Mo concentration. Similar increased in CAT activity and ASA content were obtained with increases in B concentration at uniform Mo concentrations. The combination of B and Mo at 6 and 5 g/litre, respectively increased superoxide dismutase (SOD), peroxide (POD), and nitrate rductase (NR) activity,oxidation rate, inhibited membrane lipid peroxidation and increased curd yield.

Katur (1998) conducted a field experiment on cauliflower cv. snowball 1 and reported that soil/foliar application of boric acid B (1.5 kg B/ha or 0.1% boric acid) and Mo (1.5 kg B/ha or 0.1% ammonium molybdate) significantly increased curd yield and the respective nutrient contents in leaf tissue compare with the control. Combined application of B+Mo on soil synergistically increased curd yield by 12% and 17% compare with single application of B and Mo respectively. While the increase was significantly higher (17 and 27%) when applied through foliar sprays.

The effects of 3 rates of N. Mg and B on cauliflower yield, average curd mass, and hollow stem disorder were evaluated on sandy and clay loam soils in Georgis (Batal *et al.*, 1997). They found that maximum mean curd mass and maximum yields were obtained with the highest N rates (269 and 381 kg ha 1) applied to sandy loam and clay loam soils, respectively. Yield response to increased N rate varied with rate varied with cultivar, The

Mg effect on curd was influenced by N and B rates. On both soil types, the higher Mg and B rates reduced the incidence of hollow stem, but the Mg effect depended on N rate. On clay loam soil, increasing B from 22 to 8.8 kg /ha reduced hollow stem but had no effect on yield or curd mass.

Gosh and Hassan (1997) reported that application of B as borax at 15 kg/ha on the cauliflower cv. Early Kunwari significantly produced plants with the highest number of leaves/plant (27.2), the largest curds (1048g) and the highest yield (524 q/ha).

Katur (1992) determined the effects of boron and lime application during 2 seasonal cultivation Sequences (winter-rainy-winter seasons and winter-rainy seasons, WRW and RWR, respectively) with cultivars Pusa Snowball-1 (winter seasons) and Pusa Kunwari (rainy seasons). The soil were a sandy loam (Haplustalf), B application (0-3.75 kg/ha) significantly increased yield at up to 1.5 kg/ha. With 1.5 kg B/ha, the yield from the WRW sequence was 84% higher than the control, whereas the yield from the RWR sequence was 65% higher than the control. The B concentration in leaved was increased.

Broccoli (*Brassicao leracea* var. Italica) cultivar response to B deficiency were studied by Shelp *et al.* (1992) and found that all cultivars showed visible symptoms of B deficiency (leaf midrib cracking, stem corkiness, necrotic lesions and hollowing of in the stem pith) and reductions in shoot fresh weight with the zero B treatment. The variety Commander less affected. When B was removed from the nutrient solution at initiation of inflorescence development, the B concentrations of the florets and young leaves of all cultivars were higher than in the zero B treatment. Compared to the 0.5 mg/L treatment, the B concentrations of old leaves from all cultivars were reduced, but only in Premium Crop was the floret B significantly decreased. These cultivars exhibited a consistent trend for high and low susceptibility to the hollow stem disorder respectively. The variety commander was the least susceptibility to B deficiency. The apparent insensitivity of commander was unrelated to the maturation time because it matured more rapidly than Premium Crop. For the tested, the internal stein browning, necrotic lesions and gap and hollow formation resembled symptoms seen previously for glasshouse-grown broccoli (Shelp, 1988) and may reflect initial stages of the hollow stem disorder under field conditions. Premium Crop exhibited a significant decline in floret B with the removal of B after a period of adequate supply.

Mishra (1992) carried out a study on cauliflower cv. Patna Main during 1984-85 and 1985-86 on a sandy loam soil. Four rates of N (90,120, 150 or 180 kg/ha) were applied in 3 or 4 equal split doses. B was applied at 10 or 15 kg/ha before transplanting. Of the N treatments, application of 150 kg/ha resulted in the highest 1000-seed weight and seed yield. For B, application of 10 kg/ha resulted in the highest 1000-seed weight and seed yield.

Sharma and Tanuja (1991) induced boron deficiency in 60-day-old cauliflower cv. Pusa plants growing in sand by withholding B from the nutrient solution. Leaf water potential, stomatal opening and conductance, transpiration rate, hill reaction activity, net photosynthesis and intercellular CO_2 concentration were greatly reduced by B deficiency. Relative water content and sugar, starch and proline contents increased, but total N, chlorophyll and chloroplast proteins decreased. Resupplying B reversed these effects to some extent, although recovery was generally slow. A rapid and significant recovery occurred in transpiration rate, stomatal conductance and intercellular CO_2 concentration, suggesting the involvement of B in stomatal regulation. The decrease in net photosynthesis with b deficiency was, however, a non-stomatal effect largely due to decreased hill reaction activity.

In field trials during the winter seasons of 1985-86 and 1986-87, Thakur *et al.* (1991) studied the effects of 5 rates of N application (80,120,160,200 and 240 kg/ha), 4 rates of P application (100, 150, 200 and 250 kg/ha) and 2 rates of B application (0 and 20 kg/ha) on cauliflower cv. Pusa Snowball-1 and reported that application of boron increased the number of leaves/plant, DM content and curd yield, and reduced leaf area, stalk length and incidence of stalk rot.

Shelp (1990) reported that broccoli (cv. Premium Crop) seeds were germinated in soil, and the seedlings were transferred to vermiculite 3 weeks later and grown in a greenhouse; they were supplied continuously with B at concentrations ranging from 0.0 to 12.5 mg/l. At commercial maturity, the partitioning of N into soluble (nitrate. ammonium. amino acids) and insoluble components of the foliage (young and old leaves) and the florets was investigated. Both B deficiency and toxicity increased the % soluble N, particularly as nitrate, Boron toxicity, but not deficiency, consistently affected the concentration and relative composition was dependent upon the developmental stage of the plant organs concerned, and upon whether B was present in deficient or toxic levels.

In field and pot trials of rape speed (*Brassica campestris*) with B, N and K Yang *et al*. (1989) reported that boron application increased plant boron content in all plant parts, but especially leaves. Seed yield was positively correlated with soil the especially leaf B content. Applying B, N and K promoted growth, CO_2 assimilation; nitrate reductase activity in leaves and DM accumulation.

Prasad and Singh (1988) screened eight genotypes of the Snowball group during 1985-86 of response of B using boric acid applied at the rate of 15 kg/ha to half the plots white no B was applied to the other half. Under B application Pusa Snowball K1 gave the highest yield (15.4 t/ha) followed by Sel 5 (14.7 kg/ha) with lowest yield observed in K_9 (8.8 t/ha). Application of B significantly increased the yield (by 133%), curd weight, curd diameter; number of marketable curds and total plant weight. Yields from the control plots (without B) were highest in Sel 5 (10.2 t/ha) and Pusa Snowball (10.1 t/ha) while Sel 7 recorded the lowest yields (5.1 t/ha). There were significant differences between genotypes in response to B.

Petracek and Sams (1987) supplied broccoli (*Brassica oleracea* var. Italic) plants grown in perlite with nutrient solutions containing 0.08, 0.41, 0,61, 0.81 , 4.06 or 8,11 ppm boron and observed that plants grown in either low (0.08 ppm) or high (8.11 ppm) boron concentrations developed at slower rates than plans in the other boron concentrations. The reduction in stomata conductance on boron deficient plants coincided with the early signs of leaf thickening and chlorosis. Chlorophyll levels and net photosynthetic (Pn) rates of plants in 0.08 ppm boron were significantly less than those in 0.41, 0.61 and 0.81 ppm boron. Heads produced by plants in 0.08 ppm had small, chlorotic buds, scale-covered stalls and high levels of total phenols and fiber. Plants grown in 4.06 and 8.11 mm boron had slightly chlorotic leaves throughout their life cycle and chlorotic leaf margins. Stomatal conductance and transpiration rate were affected by boron toxicity. Although the chlorophyll content and Pn rates were lower for plants in 4.06 and 8.1 ppm boron than for those in 0.41, 0.61 and 0.81 ppm boron. Leave size was slightly larger. This finding suggests that high boron concentrations which induce boron toxicity symptoms in leaves may stimulate head development.

An experiment was conducted to see the effect of B at different N levels on the hollow stem disorder in broccoli (Shattuck and Shelp, 1987) and found that soil and foliar applications of B significantly enhanced the B levels. Hollow stem was not related to tissue or soil B. Broccoli variety, Premium Group grown in the absence of B in the greenhouse showed only initial signs of hollow stem which was alleviated by adding B. They found that the N and B treatment had little effect on the elemental composition of head tissue. At Since, the Mo and K concentration of variety Stolto were increased by increasing N and B treatment of the variety Emperor was enhanced by higher N. They suggested that B nutrition may in some case be involved induction of hollow stem in broccoli but additional factors such as cultivar and environment may be of greater importance in the field.

Dutta (1984) reported that application of B (1 kg/ha) increase leaf area index (LAI), crop growth rate (CGR), number of branches/plant, number of pods/plant, seed weight/pod and decrease in chlorophyll content, net assimilation rate, other growth attributes of broccoli were unaffected.

An increase in the size and yield of curd by B spray might be due to increase cell division and its enlargement (Mishra and Singh, 1984). Such increase in the size of curd and yield were also observed by Mehrotra *et al.* (1975) and Antonova *et al.* (1975).

Four doses of N (90, 12, 150 and 180 kg/ha) and two doses of B (Borax 10 and 15 kg/ha) were evaluated for cauliflower seed production in calcarious soil by Mishra (1952) and found that application of B as borax 10 kg/ha resulted in the highest 1000 seed weight and net yield. There was a significant interaction between the effect of N and B with the high-test seed yield (515 kg/ha) obtained with 150 kg N and 10kg B/ha.

CHAPTER III

MATERIALS AND METHODS

3.1 Location of the experimental field

The research work was conducted at the Horticulture Farm, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, during the period from October, 2014 to January 2015. The location of the site was 23.714°N Latitude and 90.335° E Longitude with the elevation of 8.2 meter from the sea level (Anon., 1989) and the location of the experimental field is presented in Appendix I.

3.2 Soil of the experimental field

The experimental plot belongs to the Modhupur Tract which was under the Agro Ecological Zone-28. The analytical data of the soil, collected from the experimental area were determined in Soil Research and Development Institute (SRDI), Soil Testing Laboratory, Khamarbari, Dhaka and presented in Appendix II.

3.3 Climate of the experimental area

The experimental site is situated in subtropical zone, the macro climate is characterized by heavy rainfall during the months from April to September (Kharif season) and scantly rainfall during the rest month of the year (Rabi season). Information regarding average monthly the maximum and minimum temperature, rainfall and relative humidity and sunshine hour as recorded by the weather yard, Bangladesh Meteorological Department (Climate Division), Agargaon, during the period of study has been presented in Appendix III.

3.4 Plant materials used

The variety of broccoli used in the experiment was "Green Magic". The seeds were collected from a seed trader of China seed store, Dhaka.

3.5 Raising of Seedlings

Broccoli seedlings were raised in the seedbed of 3 m x 1 m size. The soil was well prepared and converted into loose friable condition to obtain good tilth. All weeds, stubbles and dead root were removed. Twenty grams of seeds were sown in two seed bed. The seeds were sown in the seed bed on 25 October, 2014. Seeds were then covered with finished light soil and shading was provided by polyethylene bags to protect the young seedlings from scorching sunshine and rainfall. Light watering, weeding and mulching were done as and when necessary to provide seedlings of a good condition for growth.

3.6 Treatments of the experiment

The experiment consisted of two factors as follows:-

Factor A: It included three different concentration of GA_3 (Gibberellic Acid) which are mentioned below with alphabetic symbol.

Levels of GA_3	**Alphabetic symbol**
Control	G_0
100 ppm	G_1
200 ppm	G_2

Factor B: It consisted of three levels of boron which are mentioned below with alphabetic symbol.

Levels of boron	**Alphabetic symbol**
Control	B_0
100 ppm	B_1
200 ppm	B_2

Total nine (9) treatment combinations were as follows: G_0B_0, G_0B_1, G_0B_2, G_1B_0, G_1B_1, G_1B_2, G_2B_0, G_2B_1 and G_2B_2.

3.7 Layout and design of the experiment

The two factor experiment was laid out in the Randomized Complete Block Design (RCBD) with three replications. An area of 19.4 m x 8.4 m was divided into three equal blocks. Each block consisted of nine (9) plots where nine (9) treatments combination of GA_3 and boron solution were assigned randomly as per design of the experiment. There were 27 unit plots altogether in the experiment. The size of the plot was 1.8 m x 1.6 m. Block to block distance was 1.0 m and plot to plot was 0.5 m. Seedlings were transplanted on the plots with 60 cm x 40 cm spacing.

3.8 Cultivation procedure

3.8.1 Land preparation

The selected plot was fallow at the time of period of land preparation. The land was opened on 02 November, 2014 with the help of the power tiller and then it was kept open to sun for seven days prior to further ploughing, cross ploughing followed by laddering. The weeds and stubbles were removed after each laddering. Simultaneously the clods were broken and the soil was made into good tilth for transplanting.

3.8.2 Application of manures and fertilizers

Fertilizers were applied at the rate of 15 ton cowdung, 240 kg urea, 150 kg TSP, 220 kg MOP, 5 kg zinc and 2 kg molybdenum per hectare. Cowdung, TPS, MOP, zinc and molybdenum were applied during final land preparation. Urea were applied as top dressing in three instalment at 10, 30 and 50 days after transplanting (DAT)'

3.8.3 Transplanting of seedlings

Thirty days old healthy and uniform sized seedlings were transplanted in the experimental plots on 25 November, 2014. The seedbed was watered one hour before uprooting the seedlings to minimize the damage to the roots of the seedlings. Transplanting was done in the afternoon. During transplanting of seedling, 60 cm x 45 cm spacing were followed. Eight plants were transplanted in each unit plot. The seedlings were watered immediately after transplanting. To protect from scorching sunshine and unexpected rain, banana leaf sheath pieces were used over the transplanted seedlings.

Shading and watering were continued until the seedlings were well established and it required for six days. A number of treated seedlings were planted on the border of the experimental plots for gap filling.

3.8.4 Gap filling

Very few seedlings were damaged after transplanting and such seedling were replaced by new seedlings from the same stock planted earlier on the border of the experimental plots. The seedlings were transplanted with a mass of root attached with soil ball to avoid transplanting shock.

3.8.5 Intercultural operations

The plants were kept under careful observation. Light watering was done every morning and afternoon following transplanting and was continued for 6 days for early and well establishment of the seedlings. Weeding and other intercultural operations were done as and when required. Earthing up was done on both sides of rows after 60 days of transplanting using the soil from the space between the rows.

3.8.6 Control of pest and disease

Insect attack was serious problem at the time of establishment of the seedling. Mole cricket, field cricket and cut warm attacked the young transplanted seedlings. Basudin was applied for controlling the soil born insects. Cut worms were controlled both mechanically and spraying by Dursban 20 EC @ 3%. Some of the plants were attacked by aphids and were controlled by spraying Diazinon 60 EC @ 560 ml/ha.

Few plants were infected by Alternaria leaf spot disease caused caused by *Alternaria brasicae*. To prevent the spread of disease Copper oxychloride (50%) was sprayed in the field at the rate of 1.35 kg per 450 liters of water.

3.8.7 Preparation and application of GA_3 and Boron

GA_3 in different concentrations viz. 0, 100, 200 ppm and boron in different concentrations viz. 0, 100, 200 ppm were prepared following the procedure mentioned below and spraying was done during the noon using hand sprayer. Spraying was done 10 days after transplanting.

100 ppm solution of GA_3 was prepared by dissolving 100 mg of it with distilled water. Then distilled water was added to make the volume 1 liter to prepare 100 ppm solution. In a similar way 200 ppm concentrations were made. An adhesive Tween-20 @ 0.1% was added to each solution according to (Roy *et al.,* 1991). Control plots were treated only with distilled water. Simillar methods were followed in preparing100 and 200 ppm solutions of boron.

3.8.8 Harvesting

The harvesting of the crop was not possible on a particular date because time required for curd initiation and curd maturity were not uniform in all the experimental plots. Only the compact and main curds were harvested with 2-4 cm stalk by a sharp knife using a slanted cut, so that rain water could not stay at the cut surface. The curds are recommended to be harvested in compact condition before the inflorescence stalk the flower buds open (Thompson and Kelly, 1988). Before harvesting of the broccoli head, compactness of the head was tested by pressing with thumbs. The crop was harvested during the period from 20 to 30 January, 2015 when the plants formed compacted heads. Harvesting was done plot wise after testing the compactness of the broccoli head by thumb. The compact head showed comparatively a hard feeling. Each head was collected by cutting at the base of the plant.

3.9 Parameters assessed

Five plants were selected at random at the time of collecting data from each plot and mean data on the following parameters were recorded:-

1) Plant height (cm)
2) Number of leaves per plant
3) Days to main and secondary curd formation
4) Days to main and secondary curd maturity
5) Stem length (cm)
6) Stem diameter (cm)
7) Curd length (cm)
8) Curd diameter (cm)
9) Leaf area (cm^2)
10) Canopy of plant (cm)
11) Percent dry matter of leaf
12) Percent dry matter of curd
13) Weight of main and secondary curd (g)
14) Main and secondary curd yield per plot (kg)
15) Main and secondary curd yield per hectare (ton)

3.10 Data collection

When the heads were well compact, the plants were harvested at random from each unit plot. Plants were randomly selected from each plot and data were recorded according to the characters were studied. However, for gross and marketable yield per plot, all plants of each unit plot were considered.

3.10.1 Plant height

The height of the plant was measured with meter scale from the ground level to the tip of the longest leaf and was recorded in centimeter (cm).

3.10.2 Number of leaves per plant

The number of leaves per plant was counted at 15, 30, 45 and 60 days after transplanting.

3.10.3 Days to main and secondary curd formation

Each plant of the experiment plot was kept under close observation to count days to main and secondary curd formation. Total number of days from the date of transplanting to the curd formation was recorded.

3.10.4 Days to main and secondary curd maturity

Each plant of the experimental plot was kept under close observation to count days to main and secondary curd maturity. Total number of days from the date of transplanting to the curd maturity was recorded.

3.10.5 Length of stem

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

3.10.6 Diameter of stem

The diameter of stem was measured in cm with a scale as the horizontal distance from one side of upper most level of the stem to another side after sectioning the stem longitudinally at the middle portion.

3.10.7 Diameter of curd

The harvested curd was placed on a table in flat position and the diameter was measured in (cm) with a meter scale.

3.10.8 Length of curd

Length of the curd was measured at the time of harvest with the help of a measuring scale and it was expressed in centimetre.

3.10.9 Leaf area

Leaf area was measured an interval of 15 days starting from 35 DAT till 65 DAT by non-destructive method using CL-202 Leaf Area Meter (USA). Mature leaf (from 4^{th} node) were measured all time and expressed in cm^2. Three mature plant of each plot were measured and then average it after mean was calculated.

3.10.10 Percent dry matter of leaves

The heads weighing 100g from randomly selected plants leaves were cut into very small pieces after well mixing and then sun dried for two days, sun dried samples were then put into envelopes and oven dried for 72 hours at 68 to 72^0 C in an oven. After oven drying, samples were weighted. An electric balance was used to record the dry weight of sample and it was calculated on percentage basis. The percentage of dry matter of leaves was calculated by the following formula:

$$\text{Dry matter content (\%)} = \frac{\text{Dry weight of the sample}}{\text{Fresh weight of the sample}} \text{X } 100$$

3.10.11 Percent dry matter of curd

The heads weighing 100g from randomly selected plants were cut into very small pieces after well mixing and then sun dried for two days, sun dried samples were then put into envelopes and oven dried for 72 hours at 68 to 72^0 C in an oven. After oven drying, samples were weighted. An electric balance was used to record the dry weight of sample and it was calculated on percentage basis. The percentage of dry matter was calculated by the following formula:

$$\text{Dry matter content (\%)} = \frac{\text{Dry weight of the sample}}{\text{Fresh weight of the sample}} \text{X } 100$$

3.10.12 Fresh weight of main and secondary curd

It was the weight of main and secondary curd excluding roots and outer leaves measured in (g).

3.10.18 Yield per plot

The yield per plot was measured by totalling the head yield of each unit plot separately during the period from first to final harvest and was recorded in kilogram (kg).

3.10.19 Yield per hectare

The yield per hectare was calculated from per plot yield data and their average was taken. It was measured by the following formula,

$$\text{Yield per hectare (ton)} = \frac{\text{Yield per plot (kg) x 10000}}{\text{Area of plot in square meter x 1000}}$$

3.11 Statistical analysis

The data obtained for different characters were statistically analyzed to find out the significance of the difference for gibberellic acid and boron nutrient on yield and yield contributing characters of broccoli. The mean values of all the recorded characters were evaluated and analysis of variance was performed by the 'F' (variance ratio) test. The significance of the difference among the treatment combinations of means was estimated by Least Significant Different Test (LSD) at 5% level of probability (Gomez and Gomez, 1984).

3.12 Economic analysis

The cost of production was analyzed in order to find out the most economic combination of different levels of gibberellic acid and boron. All input cost included the cost for lease of land and interests on running capital in computing the cost of production. The interests were calculated @ 14% in simple rate. The market price of broccoli was considered for estimating the cost and return. Analyses were done according to the procedure of Alam *et al*. (1989). The benefit cost ratio (BCR) was calculated as follows:

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

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to find out the effect of foliar application of different levels of GA_3 and boron on growth and yield of broccoli. The results obtained from the study have been presented, discussed and compared in this chapter through tables, figures and appendices.

4.1 Plant height (cm)

There was a significant variation observed in plant height of broccoli due to different levels GA_3 treatments (Figure 1 and Appendix IV). Plant height increased with increasing level of GA_3 at different days after transplanting of broccoli. The tallest plant at 15, 30, 45 and 60 DAT was observed from 200 ppm of GA_3 treatment (24.43, 39.75, 54.67 cm and 63.53 cm, respectively). On the other hand, the shortest plant of broccoli at 15, 30, 45 and 60 DAT was observed from control treatment (0 ppm) of GA_3 (21.82, 36.64, 52.20 and 58.40 cm, respectively). Reza *et al.* (2015) reported that the maximum plant height (31.5 cm) was found from the application of 50 ppm GA_3, while the minimum from control. Thara *et al.* (2013) stated that GA_3 30 ppm showed best result with respect to plant height. Vijay and Ray (2000) observed that GA_3 at 100 ppm produced the tallest plants of broccoli. Dhaarmender *et al.* (1996b) reported that the best growth parameter like plant height was observed from GA_3 at 50 ppm. Reddy (1989) reported that the greatest plant height (58.20 cm) over the control was obtained with application of GA_3. Mishra and Singh (1986) revealed that increase in plant height of broccoli due to GA_3 application.

Different levels of boron treatment significantly affected on plant height of broccoli at different days after transplanting (Figure 2 and Appendix IV). Plant height increased with increasing level of boron application. The longest plant at 15, 30, 45 and 60 DAT was observed from 200 ppm of boron treatment (24.14, 39.55, 54.60 and 62.07 cm, respectively). On the other hand, the smallest plant of broccoli at 15, 30, 45 and 60 DAT was observed from control treatment (0 ppm) of boron (22.17, 37.00, 52.60 and 59.53 cm, respectively). Singh (2003) reported that the highest plant height (55.87 cm) was observed the borax applied at 5 kg/ha. Sharma *et al.* (2002) suggested that the maximum plant height was obtained when 25 kg borax/ha was applied through soil application.

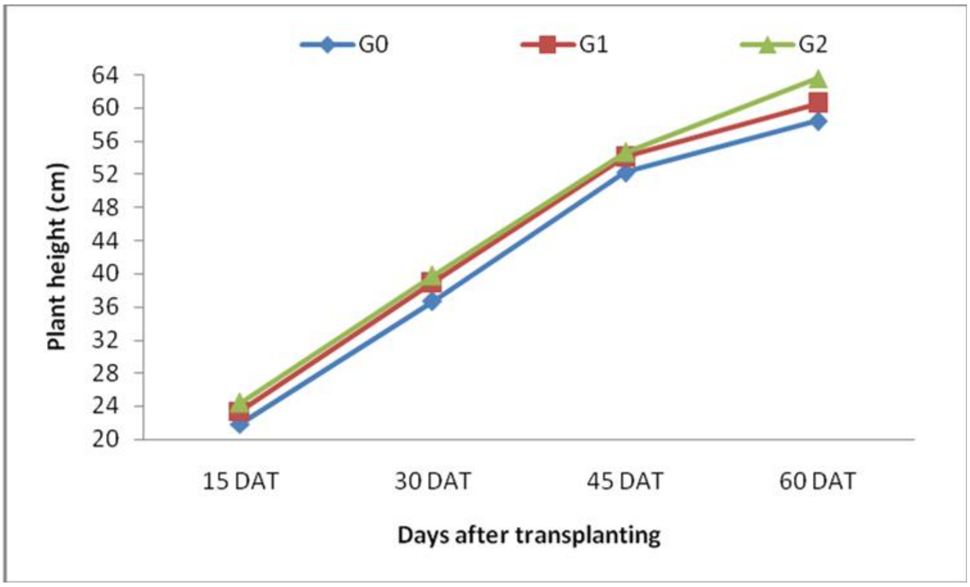


Figure 1. Effect of GA_3 on plant height (cm) of broccoli (LSD value = 0.37, 0.39, 0.46 and 0.45 at 15, 30, 45 and 60 DAT, respectively)

Note: G_0 – 0 ppm, G_1 –100 ppm and G_2 – 200 ppm

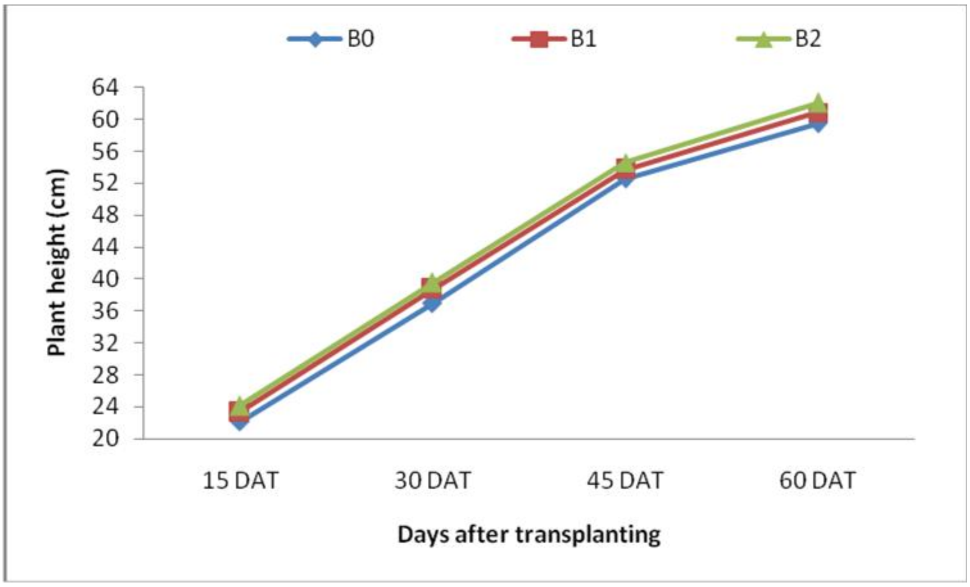


Figure 2. Effect of boron on plant height (cm) of broccoli (LSD value = 0.37, 0.39, 0.46 and 0.45 at 15, 30, 45 and 60 DAT, respectively)

Note: B_0 – 0 ppm, B_1 – 100 ppm and B_2 – 200 ppm

The combination of GA_3 and boron showed significant effect on plant height (cm) of broccoli at different days after transplanting (DAT) (Table 1 and Appendix IV). The tallest plant at 15 DAT (25.20 cm), 30 DAT (41.35 cm), 45 DAT (56.00 cm) and 60 DAT (64.40 cm) was recorded from the combination of 200 ppm GA_3 and 200 ppm of boron (G_2B_2). In comparison, the shortest plant at 15 DAT (20.30 cm), 30 DAT (34.30 cm), 45 DAT (50.40 cm) and 60 DAT (57.00) was observed from control treatment (G_0B_0).

Table 1. Interaction effect of GA_3 and boron on plant height (cm) of broccoli at different days after transplanting (DAT)

Treatment combination	Plant height (cm)			
	15 DAT	**30 DAT**	**45 DAT**	**60 DAT**
G_0B_0	20.30	34.30	50.40	57.00
G_0B_1	22.00	37.10	52.40	58.40
G_0B_2	23.16	38.51	53.80	59.80
G_1B_0	22.52	38.06	53.80	58.60
G_1B_1	23.60	39.74	54.40	61.00
G_1B_2	24.06	38.80	54.00	62.00
G_2B_0	23.70	38.64	53.60	63.00
G_2B_1	24.40	39.25	54.40	63.20
G_2B_2	25.20	41.35	56.00	64.40
$LSD_{(0.05)}$	0.37	0.39	0.46	0.45
CV (%)	3.93	3.60	4.50	3.46

Note: G_0 – 0 ppm, G_1 –100 ppm, G_2 – 200 ppm and B_0 – 0 ppm, B_1 – 100 ppm, B_2 – 200 ppm

4.2 Number of leaves per plant

There was a significant variation observed in number of leaves per plant in broccoli due to different levels GA_3 treatments (Figure 3 and Appendix V). Number of leaves per plant increased with the increasing level of GA_3 at different days after transplanting of broccoli. The maximum number of leaves per plant at 15, 30, 45 and 60 DAT was observed from 200 ppm of GA_3 treatment (7.47, 11.40, 16.27 and 17.40, respectively). On the other hand, the minimum number of leaves per plant at 15, 30, 45 and 60 DAT was observed from control treatment (0 ppm) of GA_3 (6.60, 10.60, 14.07 and 16.13, respectively). Dhaarmender *et al.* (1996b) suggested that the best growth parameter like number of leaves per plant was observed with GA_3 at 50 ppm. Mishra and Singh (1986) revealed that increase in number of leaves per plant of broccoli due to GA_3 application.

Different levels of boron treatment significantly affected on number of leaves per broccoli plant at different days after transplanting (Figure 4 and Appendix V). Number of leaves per plant increased with the increasing level of boron application. The maximum number of leaves per plant at 15, 30, 45 and 60 DAT was observed from 200 ppm of boron treatment (7.33, 11.27, 15.87 and 17.33, respectively). On the other hand, the minimum number of leaves per broccoli plant at 15, 30, 45 and 60 DAT was observed from control treatment (0 ppm) of boron (6.73, 10.60, 14.60 and 16.40, respectively). Singh (2003) found that the highest number of leaves per plant (17.40) was observed the borax applied at 5 kg/ha. Sharma *et al.* (2002) found that the maximum number of leaves per plant was obtained when 25 kg borax/ha was applied through soil application. Gosh and Hassan (1997) reported that application of B as borax at 15 kg/ha on the cauliflower cv. Early Kunwari significantly produced plants with the highest number of leaves/plant (27.2). Thakur *et al.* (1991) reported that application of boron increased the number of leaves/plant.

Interaction of GA_3 and boron showed significant effect on number of leaves plant^{-1} of broccoli at different days after transplanting (DAT) (Table 2 and Appendix V). The maximum number of leaves plant^{-1} at 15 DAT (8.00), 30 DAT (11.80), 45 DAT (16.80) and 60 DAT (17.80) was observed from the combination of 200 ppm GA_3 and 200 ppm of boron (G_2B_2). In comparison, the minimum number of leaves plant^{-1} at 15 DAT (6.00), 30 DAT (10.00), 45 DAT (13.40) and 60 DAT (15.20) was observed from control treatment (G_0B_0).

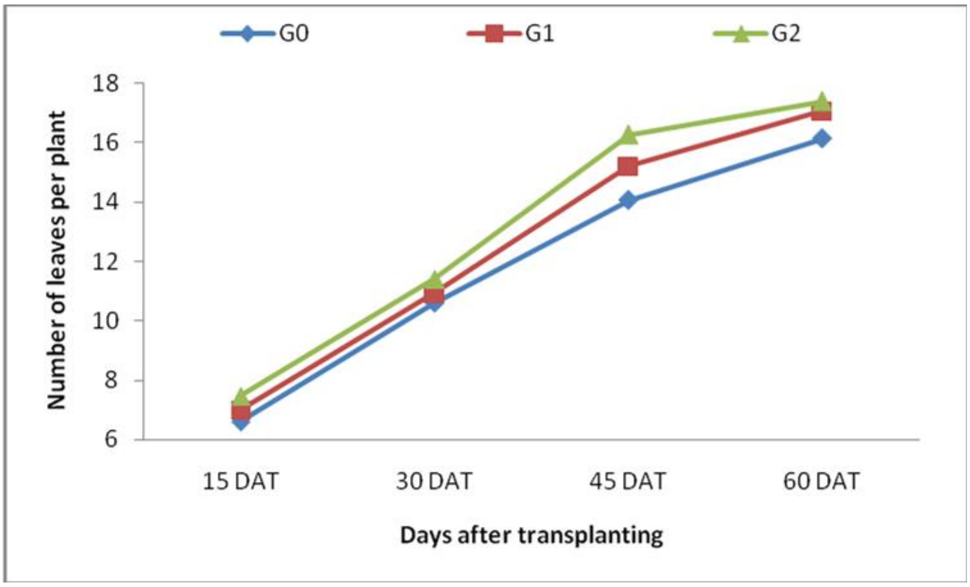


Figure 3. Effect of GA_3 on number of leaves per plant of broccoli (LSD value = 0.23, 0.28, 0.40 and 0.24 at 15, 30, 45 and 60 DAT, respectively)

Note: G_0 – 0 ppm, G_1 –100 ppm and G_2 – 200 ppm

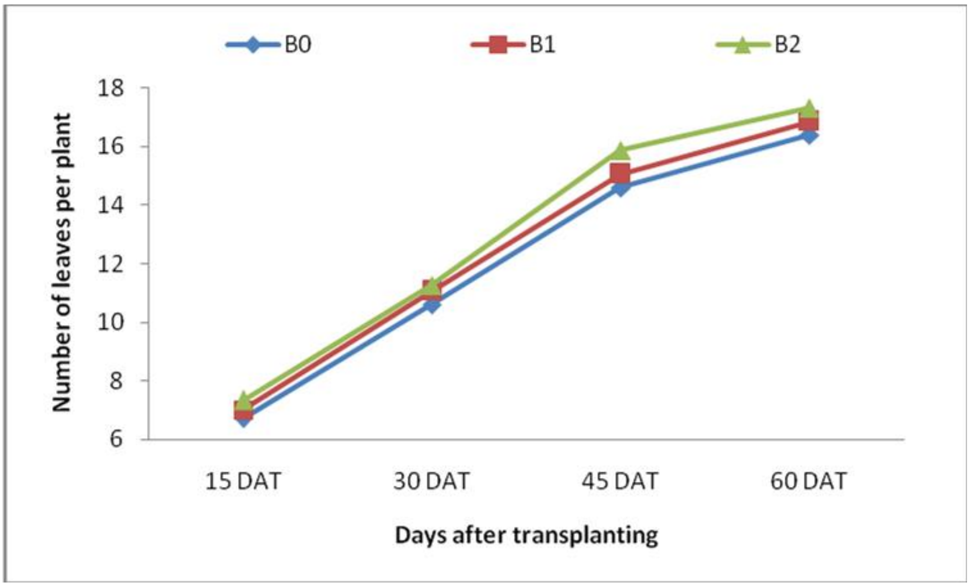


Figure 4. Effect of boron on number of leaves per plant of broccoli (LSD value = 0.23, 0.28, 0.40 and 0.24 at 15, 30, 45 and 60 DAT, respectively)

Note: B_0 – 0 ppm, B_1 – 100 ppm and B_2 – 200 ppm

Table 2. Interaction effect of GA_3 and boron on number of leaves plant^{-1} of broccoli at different days after transplanting (DAT)

Treatment combination	Number of leaves plant^{-1}			
	15 DAT	**30 DAT**	**45 DAT**	**60 DAT**
G_0B_0	6.00	10.00	13.40	15.20
G_0B_1	6.80	10.80	14.00	16.40
G_0B_2	7.00	11.00	14.80	16.80
G_1B_0	7.00	10.80	14.60	16.80
G_1B_1	7.00	11.00	15.00	17.00
G_1B_2	7.00	11.00	16.00	17.40
G_2B_0	7.20	11.00	15.80	17.20
G_2B_1	7.20	11.40	16.20	17.20
G_2B_2	8.00	11.80	16.80	17.80
$LSD_{(0.05)}$	0.23	0.28	0.40	0.24
CV (%)	4.90	2.47	3.51	2.83

Note: G_0 – 0 ppm, G_1 –100 ppm, G_2 – 200 ppm and B_0 – 0 ppm, B_1 – 100 ppm, B_2 – 200 ppm

4.3 Days to main curd formation

Different levels of GA_3 application had significant effect on days to main curd formation of broccoli (Table 3 and Appendix VI). The maximum days required to main curd formation

(45.89) was recorded from control treatment (0 ppm) of GA_3 whereas, the minimum days required to main curd formation (40.56) was recorded from 200 ppm of GA_3 treatment.

Different levels of boron application had significant effect on days to main curd formation of broccoli (Table 4 and Appendix VI). The highest days required to main curd formation (44.44) was recorded from control treatment (0 ppm) of boron and the minimum days required to main curd formation (41.78) was recorded from 200 ppm of boron treatment.

Interaction of GA_3 and boron showed significant effect on days to main curd formation of broccoli (Table 5 and Appendix VI). The Maximum days required to main curd formation (48.00) was recorded from control treatment combination (G_0B_0). In comparison, the minimum days required to main curd formation (38.69) was recorded from the combination of 200 ppm GA_3 and 200 ppm of boron (G_2B_2).

Table 3. Effect of GA_3 on days to main and secondary curd formation, days to main curd maturity and number of secondary curds plant^{-1} of broccoli

Treatment	Days to main curd formation (day)	Days to secondary curd formation (day)	Days to main curd maturity (day)	Number of secondary curds plant^{-1}
G_0	45.89	72.48	58.53	2.74
G_1	42.55	66.89	56.07	4.37
G_2	40.56	62.42	54.69	7.17
$LSD_{(0.05)}$	0.58	3.98	0.82	0.34
CV (%)	3.78	3.40	2.84	4.15

Note: G_0 – 0 ppm, G_1 –100 ppm and G_2 – 200 ppm

Table 4. Effect of boron on days to main and secondary curd formation, days to main curd maturity and number of secondary curds plant^{-1} of broccoli

Treatment	Days to main curd formation (day)	Days to secondary curd formation (day)	Days to main curd maturity (day)	Number of secondary curds plant^{-1}
B_0	44.44	68.78	57.73	4.02
B_1	42.78	67.93	56.53	4.76
B_2	41.78	66.08	55.02	5.50
$LSD_{(0.05)}$	0.58	NS	0.82	0.34
CV (%)	3.78	3.40	2.84	4.15

Note: B_0 – 0 ppm, B_1 – 100 ppm and B_2 – 200 ppm

4.4 Days to secondary curd formation

Different levels of GA_3 application had significant effect on days to secondary curd formation of broccoli (Table 3 and Appendix VI). The highest days required to secondary curd formation (72.48) was recorded from control treatment (0 ppm) of GA_3 while, the lowest days required to secondary curd formation (62.42) was recorded from 200 ppm of GA_3 treatment.
Different concentration of boron did not show any significant effect on days to secondary curd formation (Table 4 and Appendix VI).The highest days required to secondary curd formation (68.78) was recorded from control treatment (0 ppm) of boron. On the other hand, the minimum days required to secondary curd formation (66.08) was recorded from 200 ppm of boron treatment.

Interaction of GA_3 and boron showed significant effect on days to secondary curd formation of broccoli (Table 5 and Appendix VI). The maximum days required to secondary curd formation (76.23) was recorded from control treatment combination (G_0B_0) whereas, the minimum days required to secondary curd formation (60.17) was recorded from the combination of 200 ppm GA_3 and 200 ppm of boron (G_2B_2).

4.5 Days to main curd maturity

Different levels of GA_3 had significant effect on days to main curd maturity of broccoli (Table 3 and Appendix VI). The maximum days required to main curd maturity (58.53) was recorded from control treatment (0 ppm) of GA_3. In comparison, the minimum days required to main curd maturity (54.69) was recorded from 200 ppm of GA_3 treatment. Dharmender *et al.* (1996b) suggested that the best growth parameter like days of main curd maturity was observed GA_3 at 50 ppm.

Different levels of boron had significant effect on days to main curd maturity of broccoli (Table 4 and Appendix VI). The maximum days required to main curd maturity (57.73) was recorded from control treatment (0 ppm) of boron. In comparison, the minimum days required to main curd maturity (55.02) was recorded from 200 ppm of boron treatment.

Interaction of GA_3 and boron showed significant effect on days to main curd maturity of broccoli (Table 5 and Appendix VI). The maximum days required to main curd maturity (61.60) was recorded from control treatment combination (G_0B_0). In comparison, the minimum days required to main curd maturity (53.27) was recorded from the combination of 200 ppm GA_3 and 200 ppm of boron (G_2B_2).

4.6 Number of secondary curds plant^{-1}

Different levels of GA_3 had significant effect on number of secondary curds plant^{-1} of broccoli (Table 3 and Appendix VI). The highest number of secondary curds plant^{-1} (7.17) was recorded from 200 ppm of GA_3. In comparison, the lowest number of secondary curds plant^{-1} (2.74) was recorded from the control treatment (0 ppm).

Different levels of boron had significant effect on number of secondary curds plant^{-1} of broccoli (Table 4 and Appendix VI). The highest number of secondary curds plant^{-1} (5.50) was recorded from 200 ppm of boron. In comparison, the lowest number of secondary curds plant^{-1} (4.02) was recorded from of control treatment (0 ppm) of boron.

Interaction of GA_3 and boron showed significant effect on number of secondary curds plant^{-1} of broccoli (Table 5 and Appendix VI). The highest number of secondary curds plant^{-1} (8.33) was recorded from the combination of 200 ppm GA_3 and 200 ppm of boron (G_2B_2). In comparison, the lowest number of secondary curds plant^{-1} (2.07) was recorded from control treatment combination (G_0B_0).

Table 5. Interaction effect of GA_3 and boron on days to main and secondary curd formation, days to main curd maturity and number of secondary curds plant^{-1} of broccoli

Treatment combination	Days to main curd formation (day)	Days to secondary curd formation (day)	Days to main curd maturity (day)	Number of secondary curds plant^{-1}
G_0B_0	48.00	76.23	61.60	2.07
G_0B_1	45.33	72.13	57.40	3.00
G_0B_2	44.33	70.07	56.60	3.17
G_1B_0	43.33	66.00	56.40	4.00
G_1B_1	42.00	67.67	56.60	4.10
G_1B_2	42.33	67.00	55.20	5.00
G_2B_0	42.00	65.10	55.20	6.00
G_2B_1	41.00	64.40	55.60	7.17
G_2B_2	38.69	60.17	53.27	8.33
$LSD_{(0.05)}$	0.58	3.98	0.82	0.34
CV (%)	3.78	3.40	2.84	4.15

Note: G_0 – 0 ppm, G_1 –100 ppm, G_2 – 200 ppm and B_0 – 0 ppm, B_1 – 100 ppm, B_2 – 200 ppm

4.7 Stem diameter (cm)

Different levels of GA_3 had significant effect on stem diameter (cm) of broccoli (Table 6 and Appendix VII). The highest stem diameter (4.57 cm) was recorded from 200 ppm of GA_3 treatment. In comparison, the lowest stem diameter (3.81 cm) was recorded from control treatment (0 ppm) of GA_3. Mishar and Singh (1986) reported that increase in diameter of stem of broccoli due to GA_3 application.

Different levels of boron had significant effect on stem diameter (cm) of broccoli (Table 7 and Appendix VII). The maximum stem diameter (4.52 cm) was recorded from 200 ppm of boron treatment. On the other head, the minimum diameter (3.99 cm) was recorded from control treatment (0 ppm) of boron.

Interaction of GA_3 and boron showed significant effect on stem diameter (cm) of broccoli (Table 8 and Appendix VII). The maximum stem diameter (4.94 cm) was recorded from the combination of 200 ppm GA_3 and 200 ppm of boron (G_2B_2) and the minimum diameter (3.50 cm) was recorded from control treatment combination (G_0B_0).

4.8 Stem length (cm)

Different levels of GA_3 application had significant effect on stem length (cm) of broccoli (Table 6 and Appendix VII). The longest stem (24.10 cm) was recorded from 200 ppm of GA_3 treatment. In comparison, the shortest stem (21.77 cm) was recorded from control treatment (0 ppm) of GA_3. Reza *et al.* (2015) reported that the maximum main stem length (21.3 cm) was found from the application of 50 ppm GA_3, while the minimum from control.

Different levels of boron application had significant effect on stem length (cm) of broccoli (Table 7 and Appendix VII). The longest stem (25.50 cm) was recorded from 200 ppm of boron treatment. In comparison, the shortest stem (22.03 cm) was recorded from control treatment (0 ppm) of boron.

Interaction of GA_3 and boron showed significant effect on stem length (cm) of broccoli (Table 8 and Appendix VII). The maximum stem length (25.30 cm) was recorded from the combination of 200 ppm GA_3 and 200 ppm of boron (G_2B_2) whereas, the minimum stem length (21.60 cm) was recorded from the combination of 0 ppm GA_3 and 100 ppm of boron (G_0B_1).

4.9 Curd diameter (cm)

Different levels of GA_3 application had significant effect on curd diameter (cm) of broccoli (Table 6 and Appendix VII). The maximum curd diameter (15.23 cm) was recorded from 200 ppm of GA_3 treatment. In comparison, the minimum curd diameter (12.18 cm) was recorded from control treatment (0 ppm) of GA_3. Reza *et al.* (2015) reported that the maximum main curd diameter (19.3 cm) was found from the application of 50 ppm GA_3, while the minimum from control. Thara *et al.* (2013) suggested that GA_3 30 mg/l + NAA 30 mg/l treatment (T_{10}) showed best result with respect to head diameter. Reddy (1989) reported that the largest curd diameter (26.08 cm) over the control was obtained from application of GA_3.

Different levels of boron had significant effect on curd diameter (cm) of broccoli (Table 7 and Appendix VII). The largest curd diameter (14.93 cm) was recorded from 200 ppm of boron treatment. In comparison, the shortest curd diameter (12.70 cm) was recorded from control treatment (0 ppm) of boron. Singh (2003) stated that the highest curd diameter (13.23 cm) was observed with borax applied at 5 kg/ha. Prasad and Singh (1988) reported that the application of B significantly increased the curd diameter.

Interaction of GA_3 and boron showed significant effect on curd diameter (cm) of broccoli (Table 8 and Appendix VII). The largest curd diameter (16.40 cm) was recorded from the combination of 200 ppm GA_3 and 200 ppm of boron (G_2B_2). In comparison, the shortest curd diameter (11.00 cm) was recorded from control treatment combination (G_0B_0).

Table 6. Effect of GA_3 on stem diameter (cm), stem length (cm), curd diameter (cm), curd length (cm) and leaf area plant^{-1} (cm^2) of broccoli

Treatment	Stem diameter (cm)	Stem length (cm)	Curd diameter (cm)	Curd length (cm)	Leaf area plant^{-1} (cm^2)
G_0	3.81	21.77	12.18	12.60	878.40
G_1	4.29	22.47	13.77	14.07	1023.00
G_2	4.57	24.10	15.23	15.27	969.80
$LSD_{(0.05)}$	0.33	0.40	0.41	0.44	9.52
CV (%)	4.43	3.00	1.74	3.80	4.57

Note: G_0 – 0 ppm, G_1 –100 ppm and G_2 – 200 ppm

Table 7. Effect of boron on stem diameter (cm), stem length (cm), curd diameter (cm), curd length (cm) and leaf area plant^{-1} (cm^2) of broccoli

Treatment	Stem diameter (cm)	Stem length (cm)	Curd diameter (cm)	Curd length (cm)	Leaf area plant^{-1} (cm^2)
B_0	3.99	22.03	12.70	13.07	956.50
B_1	4.16	22.80	13.54	14.40	966.00
B_2	4.52	23.50	14.93	14.47	949.00
$LSD_{(0.05)}$	0.33	0.40	0.41	0.44	9.52
CV (%)	4.43	3.00	1.74	3.80	4.57

Note: B_0 – 0 ppm, B_1 – 100 ppm and B_2 – 200 ppm

4.10 Curd length (cm)

Different levels of GA_3 application had significant effect on curd length (cm) of broccoli (Table 6 and Appendix VII). The longest curd (15.27 cm) was recorded from 200 ppm of GA_3 treatment. In comparison, the shortest curd (12.60 cm) was recorded from control treatment (0 ppm) of GA_3. Reza *et al.* (2015) reported that the maximum main curd length (13.45 cm) was found from the application of 50 ppm GA_3, while the minimum from control. Vijay and Ray (2000) stated that GA_3 at 100 ppm produced the largest curd length.

Different levels of boron application had significant effect on curd length (cm) of broccoli (Table 7 and Appendix VII). The longest curd (14.47 cm) was recorded from 200 ppm of boron treatment. In comparison, the shortest curd (13.07 cm) was recorded from control treatment (0 ppm) of boron. Singh (2003) cited that the highest curd length (8.48 cm) was observed with borax applied at 5 kg/ha.

Interaction of GA_3 and boron showed significant effect on curd length (cm) of broccoli (Table 8 and Appendix VII). The longest curd (16.40 cm) was recorded from the combination of 200 ppm GA_3 and 200 ppm of boron (G_2B_2). In comparison, the shortest curd (12.00 cm) was recorded from control treatment combination (G_0B_0).

Table 8. Interaction effect of GA_3 and boron on stem diameter (cm), stem length (cm), curd diameter (cm), curd length (cm) and leaf area $plant^{-1}$ (cm^2) of broccoli

Treatment combination	Stem diameter (cm)	Stem length (cm)	Curd diameter (cm)	Curd length (cm)	Leaf area $plant^{-1}$ (cm^2)
G_0B_0	3.50	21.70	11.00	12.00	840.30
G_0B_1	3.74	21.60	11.83	12.80	864.80
G_0B_2	4.19	22.00	13.70	13.00	930.00
G_1B_0	4.16	21.80	12.70	13.40	1065.00
G_1B_1	4.28	22.40	13.90	14.80	1001.00
G_1B_2	4.42	23.20	14.70	14.00	1004.00
G_2B_0	4.32	22.60	14.40	13.80	964.30
G_2B_1	4.46	24.40	14.90	15.60	1032.00
G_2B_2	4.94	25.30	16.40	16.40	913.10
$LSD_{(0.05)}$	0.33	0.40	0.41	0.44	9.52
CV (%)	4.43	3.00	1.74	3.80	4.57

Note: G_0 – 0 ppm, G_1 –100 ppm, G_2 – 200 ppm and B_0 – 0 ppm, B_1 – 100 ppm, B_2 – 200 ppm.

4.11 Leaf area $plant^{-1}$ (cm^2)

Different levels of GA_3 application had significant effect on leaf area $plant^{-1}$ (cm^2) of broccoli (Table 6 and Appendix VII). The maximum leaf area $plant^{-1}$ (1023.00 cm^2) was recorded from 100 ppm of GA_3 treatment. In comparison, the minimum leaf area $plant^{-1}$ (878.40 cm^2) was recorded from control treatment (0 ppm) of GA_3. Dharmender *et al.* (1996b) reported that the best growth parameter like leaf area was observed with GA_3 at 50 ppm.

Different levels of boron application had significant effect on leaf area $plant^{-1}$ (cm^2) of broccoli (Table 7 and Appendix VII). The maximum leaf area $plant^{-1}$ (966.00 cm^2) was recorded from 100 ppm of boron treatment. In comparison, the minimum leaf area $plant^{-1}$ (949.00 cm^2) was recorded from 200 ppm of boron treatment. Singh (2003) stated that the highest leaf area (374.60 cm) was observed from the borax applied at 5 kg/ha.

Interaction of GA_3 and boron showed significant effect on leaf area $plant^{-1}$ (cm^2) of broccoli (Table 8 and Appendix VII). The maximum leaf area $plant^{-1}$ (1065.00 cm^2) was recorded from G_1B_0 (100 ppm GA_3 and 0 ppm boron) treatment combination while minimum leaf area $plant^{-1}$ (840.30 cm^2) was recorded from control treatment combination (G_0B_0).

4.12 Canopy of plant (cm)

Different levels of GA_3 application had significant effect on canopy of broccoli plant (Table 9 and Appendix VIII). The highest canopy of plant (67.07 cm) was recorded from control treatment of GA_3 while the lowest canopy of plant (59.93 cm) was recorded from 200 ppm of GA_3.

Different levels of boron application had significant effect on canopy of broccoli plant (Table 10 and Appendix VIII). The highest canopy of plant (64.67 cm) was recorded from 100 ppm of boron while the lowest canopy of plant (63.67 cm) was recorded from 200 ppm of boron.

Interaction of GA_3 and boron showed significant effect on canopy of broccoli plant (Table11 and Appendix VIII). The highest canopy of plant (68.20 cm) was recorded from the combination of control GA_3 and 200 ppm of boron (G_0B_2) which was statistically similar with G_1B_1 (68.00 cm) while the lowest canopy of plant (59.00 cm) was recorded from the combination of 200 ppm of GA_3 and 100 ppm of boron (G_2B_1).

4.13 Leaf dry matter (%)

Different levels of GA_3 had significant effect on leaf dry matter(%) of broccoli (Table 9 and Appendix VIII). The highest leaf dry matter (12.60%) was recorded from 200 ppm of GA_3. In comparison, the lowest leaf dry matter (9.67%) was recorded from control treatment of GA_3.

Different levels of boron application had significant effect on leaf dry matter (%) of broccoli (Table 10 and Appendix VIII). The highest leaf dry matter (13.00 %) was recorded from 200 ppm of boron. In comparison, the lowest leaf dry matter (10.00 %) was recorded from control treatment of boron. Thakur *et al.* (1991) reported that application of boron increased the DM content.

Interaction of GA_3 and boron showed significant effect on leaf dry matter (%) of broccoli (Table11 and Appendix VIII). The highest leaf dry matter (15.00 %) was recorded from the combination of 200 ppm of GA_3 and 200 ppm of boron (G_2B_2). In comparison, the lowest leaf dry matter (8.00 %) was recorded from control treatment combination (G_0B_0).

Table 9. Effect of GA_3 on canopy of plant (cm), leaf and curd dry matter (%) and average weight of main and secondary curd (g) of broccoli

Treatment	Canopy of plant (cm)	Leaf dry matter (%)	Curd dry matter (%)	Average weight of main curd (g)	Average weight of secondary curd (g)
G_0	67.07	9.67	9.00	276.70	61.31
G_1	65.47	11.33	9.67	407.60	102.50
G_2	59.93	12.67	10.00	469.10	130.30
$LSD_{(0.05)}$	0.72	0.87	0.87	13.55	4.33
CV (%)	5.56	4.46	5.23	2.04	2.55

Note: G_0 – 0 ppm, G_1 –100 ppm and G_2 – 200 ppm

Table 10. Effect of boron on canopy of plant (cm), leaf and curd dry matter (%) and average weight of main and secondary curd (g) of broccoli

Treatment	Canopy of plant (cm)	Leaf dry matter (%)	Curd dry matter (%)	Average weight of main curd (g)	Average weight of secondary curd (g)
B_0	64.13	10.00	8.67	344.70	76.47
B_1	64.67	10.67	9.67	385.40	100.40
B_2	63.67	13.00	10.33	407.30	109.60
$LSD_{(0.05)}$	0.72	0.87	0.87	13.55	4.33
CV (%)	5.56	4.46	5.23	2.04	2.55

Note: B_0 – 0 ppm, B_1 – 100 ppm and B_2 – 200 ppm

4.14 Curd dry matter (%)

Different levels of GA_3 application had significant effect on curd dry matter (%) of broccoli (Table 9 and Appendix VIII). The highest curd dry matter (10.00 %) was recorded from 200 ppm of GA_3. In comparison, the lowest curd dry matter (9.00 %) was recorded from control treatment of GA_3.

Different levels of boron application had significant effect on curd dry matter (%) of broccoli (Table 10 and Appendix VIII). The maximum curd dry matter (10.33 %) was recorded from 200 ppm of boron. In comparison, the minimum curd dry matter (8.67 %) was recorded from control treatment of boron.

Interaction of GA_3 and boron showed significant effect on curd dry matter (%) of broccoli (Table11 and Appendix VIII). The highest curd dry matter (11.00 %) was recorded from the combination of 200 ppm of GA_3 and 200 ppm of boron (G_2B_2). In comparison, the lowest curd dry matter (8.00 %) was recorded from control treatment combination (G_0B_0).

4.15 Average weight of main curd (g)

Different levels of GA_3 application had significant effect on average weight of main curd (g) of broccoli (Table 9 and Appendix VIII). The highest average weight of main curd (469.10 g) was recorded from 200 ppm of GA_3. In comparison, the lowest average weight of main curd (276.70 g) was recorded from control treatment of GA_3. Reza *et al.* (2015) reported that the maximum main curd weight (668.0 g/plant) was found from the application of 50 ppm GA_3, while the minimum from control. Thara *et al.* (2013) stated that GA_3 30 mg/l showed best result with respect to head weight.

Different levels of boron application had significant effect on average weight of main curd of broccoli (Table 10 and Appendix VIII). The highest average weight of main curd (407.30 g) was recorded from 200 ppm of boron. In comparison, the lowest average weight of main curd (344.70 g) was recorded from control treatment of boron. Singh (2003) cited that the highest curd weight (510.00 g) was observed from the borax applied at 5 kg/ha. Gosh and Hassan (1997) reported that application of B as borax at 15 kg/ha on the cauliflower cv. Early Kunwari significantly produced plants with the largest curds (1048g). Prasad and Singh (1988) reported that the application of B significantly increased the curd weight.

Interaction of GA_3 and boron showed significant effect on average weight of main curd (g) of broccoli (Table11 and Appendix VIII). The highest average weight of main curd (492.20 g) was recorded from the combination of 200 ppm of GA_3 and 200 ppm of boron (G_2B_2). While the lowest average weight of main curd (250.00 g) was recorded from control treatment combination (G_0B_0).

4.16 Average weight of secondary curd (g)

Different levels of GA_3 application had significant effect on average weight of secondary curd of broccoli (Table 9 and Appendix VIII). The highest average weight of secondary curd (130.30 g) was recorded from 200 ppm of GA_3.Whereas the lowest average weight of secondary curd (61.31 g) was recorded from control treatment of GA_3. Mishar and Singh (1986) reported that increase in secondary curd weight of broccoli due to GA_3 application.

Different levels of boron application had significant effect on average weight of secondary curd of broccoli (Table 10 and Appendix VIII). The highest average weight of secondary curd (109.60 g) was recorded from 200 ppm of boron. On the other hand, the lowest average weight of secondary curd (76.47 g) was recorded from control treatment of boron.

Interaction of GA_3 and boron showed significant effect on average weight of secondary curd of broccoli (Table11 and Appendix VIII). The highest average weight of secondary curd (149.10 g) was recorded from the combination of 200 ppm of GA_3 and 200 ppm of boron (G_2B_2). While the lowest average weight of secondary curd (55.19 g) was recorded from control treatment combination (G_0B_0).

Table 11. Interaction effect of GA_3 and boron on canopy of plant (cm), leaf and curd dry matter (%) and average weight of main and secondary curd (g) of broccoli

Treatment combination	Canopy of plant (cm)	Leaf dry matter (%)	Curd dry matter (%)	Average weight of main curd (g)	Average weight of secondary curd (g)
G_0B_0	66.00	8.00	8.00	250.00	55.19
G_0B_1	67.00	9.00	9.00	280.00	62.07
G_0B_2	68.20	12.00	10.00	300.00	66.67
G_1B_0	66.00	12.00	9.00	350.00	77.78
G_1B_1	68.00	10.00	10.00	443.00	116.60
G_1B_2	62.40	12.00	10.00	429.80	113.00
G_2B_0	60.40	10.00	9.00	434.00	96.44
G_2B_1	59.00	13.00	10.00	471.10	140.30
G_2B_2	60.40	15.00	11.00	492.20	149.10
$LSD_{(0.05)}$	0.72	0.87	0.87	13.55	4.33
CV (%)	5.56	4.46	5.23	2.04	2.55

Note: G_0 – 0 ppm, G_1 –100 ppm, G_2 – 200 ppm and B_0 – 0 ppm, B_1 – 100 ppm, B_2 – 200 ppm

4.17 Yield plot^{-1} (kg) of main curd

Different levels of GA_3 treatment showed significant difference on yield per plot of main curd of broccoli (Figure 5 and Appendix IX). Increase in GA_3 concentration produced more yield per plot of main curd. The highest yield per plot of main curd was produced from 200 ppm of GA_3 application (5.63 kg) and the lowest yield per plot was observed from control (0 ppm) treatment of GA_3 (3.32 kg).

Different levels of boron treatment showed significant difference on yield per plot of main curd of broccoli (Figure 6 and Appendix IX). Increase in boron concentration produced more yield per plot. The highest yield per plot of main curd was produced from 200 ppm of boron application (4.89 kg) and the lowest yield per plot was recorded from control (0 ppm) treatment of boron (4.14 kg). Singh (2003) stated that the highest curd yield per plot (16.23 kg) was observed from the borax applied at 5 kg/ha.

Interaction of GA_3 and boron showed significant effect on yield $plot^{-1}$ (kg) of main curd of broccoli (Table 12 and Appendix IX). The highest yield $plot^{-1}$ of main curd (5.91 kg) was recorded from the combination of 200 ppm of GA_3 and 200 ppm of boron (G_2B_2). Whereas the lowest yield $plot^{-1}$ of main curd (3.00 kg) was recorded from control treatment combination (G_0B_0).

4.18 Yield $plot^{-1}$ (kg) of secondary curd

Different levels of GA_3 treatment showed significant difference on yield per plot of secondary curd of broccoli (Figure 5 and Appendix IX). Increase in GA_3 concentration produced more yield per plot. The highest yield per plot of secondary curd was found from 200 ppm of GA_3 application (1.56 kg) and the lowest yield per plot was observed from control (0 ppm) treatment of GA_3 (0.74 kg).

Different levels of boron treatment showed significant differences on yield per plot of secondary curd of broccoli (Figure 6 and Appendix IX). Increase in boron concentration produced more yield per plot. The highest yield per plot of secondary curd was observed from 200 ppm of boron application (1.32 kg) and the lowest yield per plot was observed from control (0 ppm) treatment of boron (0.92 kg).

Interaction of GA_3 and boron showed significant effect on yield per plot of secondary curd of broccoli (Table 12 and Appendix IX). The highest yield $plot^{-1}$ of secondary curd (1.79 kg) was recorded from the combination of 200 ppm of GA_3 and 200 ppm of boron (G_2B_2). On the other hand, the lowest yield $plot^{-1}$ of secondary curd (0.66 kg) was recorded from control treatment (G_0B_0).

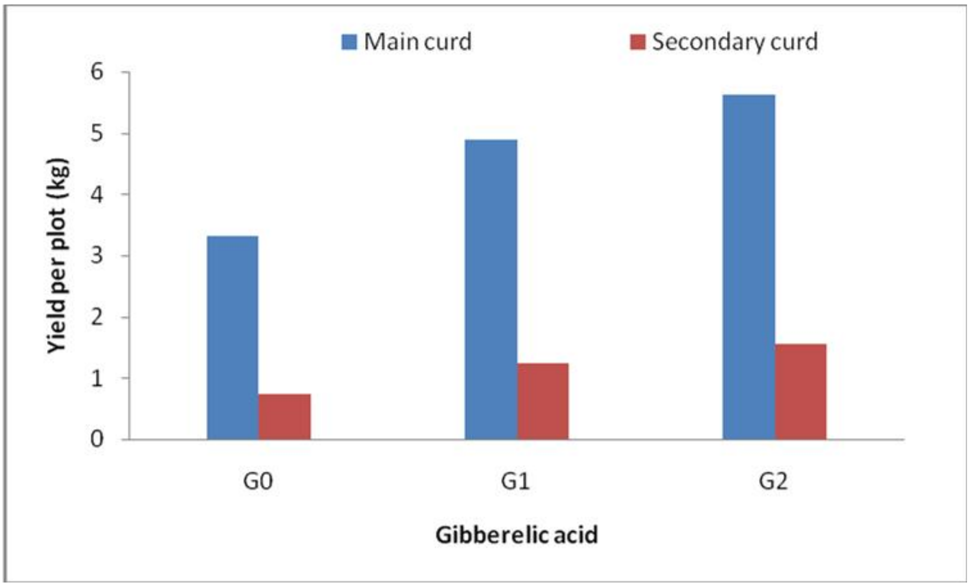


Figure 5. Effect of GA_3 on yield per plot (kg) of main and secondary curd of broccoli
(LSD value = 0.16 and 0.05 at main and secondary curd, respectively)

Note: G_0 – 0 ppm, G_1 –100 ppm and G_2 – 200 ppm

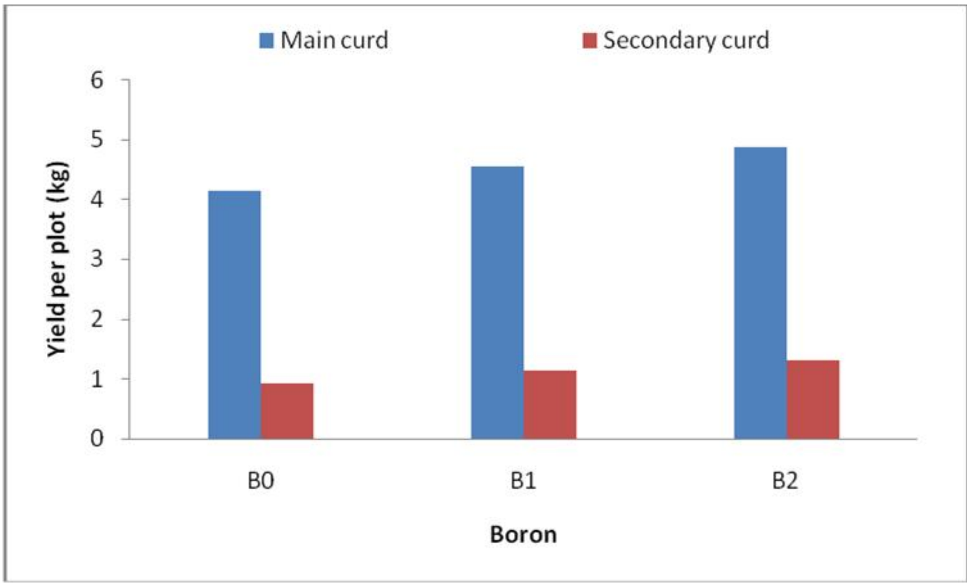


Figure 6. Effect of boron on yield per plot (kg) of main and secondary curd of broccoli
(LSD value = 0.16 and 0.05 at main and secondary curd, respectively)

Note: B_0 – 0 ppm, B_1 – 100 ppm and B_2 – 200 ppm

4.19 Yield ha^{-1} (ton) of main curd

Significant difference with different concentration of GA_3 treatment was observed on main curd yield of broccoli (Figure 7 and Appendix IX). Increase in GA_3 concentration produced more yield. In case of main curd, the highest yield was produced from 200 ppm of GA_3 application (19.55 t ha^{-1}) and the lowest yield was observed from control (0 ppm) treatment of GA_3 (11.53 t ha^{-1}). Reza *et al.* (2015) reported that the maximum main curd yield (24.5 t/ha) was found from the application of 50 ppm GA_3, while the minimum from control. Thara *et al.* (2013) stated that GA_3 30 mg/l showed best result with respect to head yield. Vijay and Ray (2000) mentioned that GA_3 at 100 ppm produced the highest curd yields of broccoli. Reddy (1989) reported that the increase yield over the control (164 %) was obtained application of GA_3. Mishra and Singh (1986) revealed that increase in yield of broccoli due to GA_3 application.

Different concentration of boron application showed significant difference on main curd yield of broccoli (Figure 8 and Appendix IX). Increase in boron concentration produced more yield for main curd. The highest yield was found from 200 ppm of boron application (16.97 t ha^{-1}) and the lowest yield was observed from control (0 ppm) treatment of boron (14.36 t ha^{-1}). Gosh and Hassan (1997) reported that application of B as borax at 15 kg/ha on the cauliflower cv. Early Kunwari significantly produced plants with the highest yield (524 q/ha). Thakur *et al.* (1991) reported that application of boron increased the curd yield. Prasad and Singh (1988) reported that the application of B significantly increased the yield (by 133 %) over control treatment.

Interaction of GA_3 and boron showed significant effect on yield per ha of main curd of broccoli (Table 12 and Appendix IX). The highest yield ha^{-1} of main curd (20.51 ton) was recorded from the combination of 200 ppm of GA_3 and 200 ppm of boron (G_2B_2). In comparison, the lowest yield ha^{-1} of main curd (10.42 ton) was recorded from control treatment combination (G_0B_0).

4.20 Yield ha^{-1} (ton) of secondary curd

Different concentration of GA_3 significantly influences on secondary curd yield of broccoli (Figure 7 and Appendix IX). Increase in GA_3 concentration produced more yield. The highest yield for secondary curd was observed from 200 ppm of GA_3 application (5.43 t ha^{-1}) and the lowest yield was recorded from control (0 ppm) treatment of GA_3 (2.55 t ha^{-1}). Different concentration of boron application showed significant difference on yield of secondary curd of broccoli (Figure 8 and Appendix IX). Increase in boron concentration produced more yield for secondary curd. The highest yield for secondary curd was produced from 200 ppm of boron application (4.57 t ha^{-1}) and the lowest yield was recorded from control (0 ppm) treatment of boron (3.19 t ha^{-1}). Singh (2003) reported that the highest secondary yield (1.40 t ha^{-1}) was observed from the borax applied at 5 kg/ha.

Interaction of GA_3 and boron showed significant effect on yield/ha of secondary curd of broccoli (Table 12 and Appendix IX). The highest yield ha^{-1} of secondary curd (6.21 ton) was recorded from the combination of 200 ppm of GA_3 and 200 ppm of boron (G_2B_2). In comparison, the lowest yield ha^{-1} of secondary curd (2.30 ton) was recorded from control treatment combination (G_0B_0).

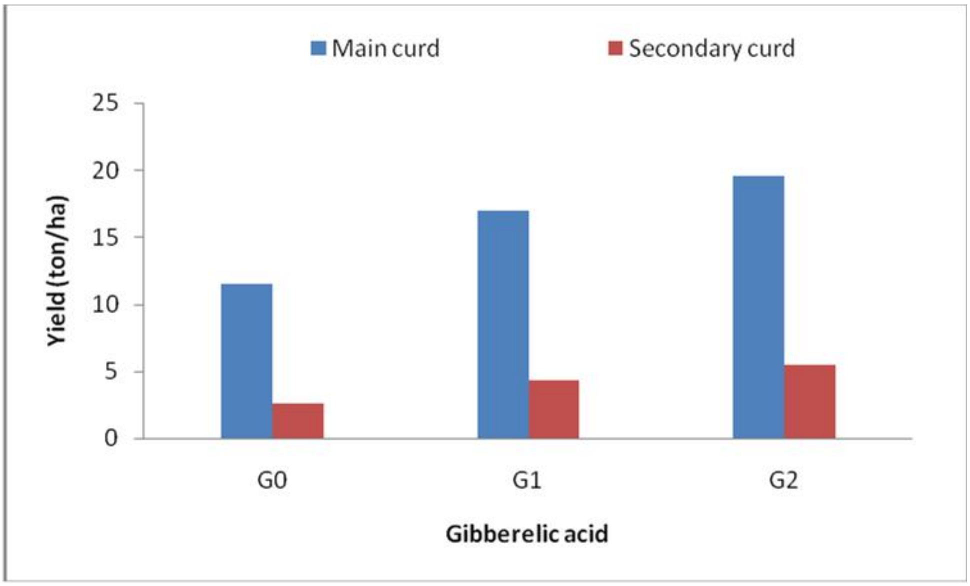


Figure 7. Effect of GA_3 on yield (ton/ha) of main and secondary curd of broccoli (LSD value = 0.56 and 0.18 at main and secondary curd, respectively)

Note: G_0 – 0 ppm, G_1 –100 ppm and G_2 – 200 ppm

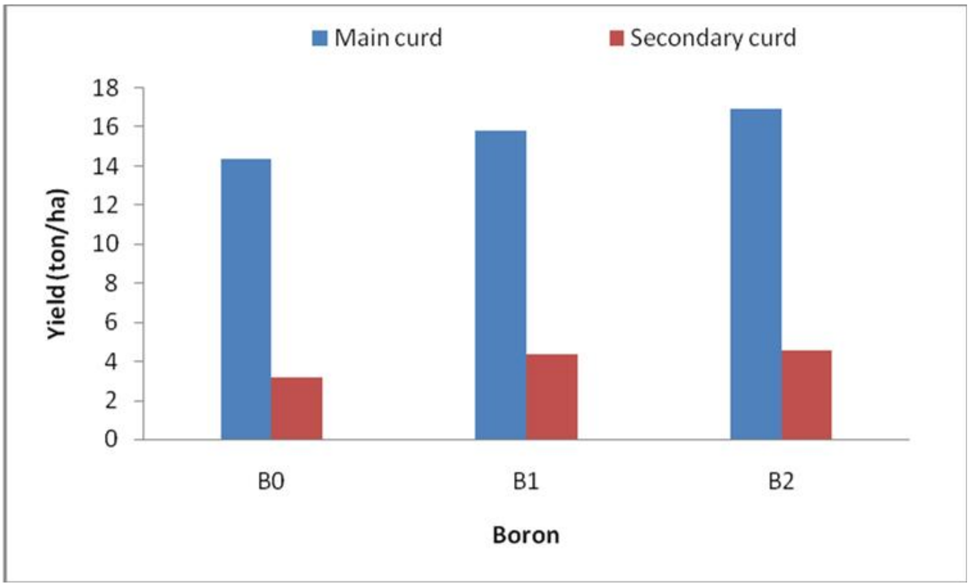


Figure 8. Effect of boron on yield (ton/ha) of main and secondary curd of broccoli (LSD value = 0.56 and 0.18 at main and secondary curd, respectively)

Note: B_0 – 0 ppm, B_1 – 100 ppm and B_2 – 200 ppm

Table 12. Interaction effect of GA_3 and boron on yield of main and secondary curd of broccoli

Treatment combination	Yield plot^{-1} (kg)		Yield ha^{-1} (ton)	
	Main curd	Secondary curd	Main curd	Secondary curd
G_0B_0	3.00	0.66	10.42	2.30
G_0B_1	3.30	0.75	11.27	2.59
G_0B_2	3.60	0.80	12.50	2.78
G_1B_0	4.20	0.93	14.58	3.24
G_1B_1	5.32	1.32	18.46	4.86
G_1B_2	5.00	1.36	17.91	4.71
G_2B_0	5.21	1.16	18.08	4.02
G_2B_1	5.50	1.60	19.05	5.46
G_2B_2	5.91	1.79	20.51	6.21
$LSD_{(0.05)}$	0.16	0.05	0.56	0.18

CV (%)	2.03	2.56	2.04	2.57

Note: G_0 – 0 ppm, G_1 –100 ppm, G_2 – 200 ppm and B_0 – 0 ppm, B_1 – 100 ppm, B_2 – 200 ppm

4.21 Economic analysis

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

4.21.1 Gross return

The combination of different levels of gibberellic acid and boron showed different value in terms of gross return under the trial (Table 13). The highest gross return (Tk. 2,83,380) was obtained from the treatment combination G_2B_2 and the second highest gross return (Tk. 2,61,360) was found in $G_2B_{1.}$ The lowest gross return (Tk. 1,38,840) was obtained from G_0B_0.

4.21.2 Net return

In case of net return, different levels of gibberellic acid and boron showed different levels of net return under the present trial (Table 13). The highest net return (Tk. 1,64,123) was found from the treatment combination G_2B_2 and the second highest net return (Tk. 1,46,409) was obtained from the combination $G_2B_{1.}$ The lowest (Tk. 35,411) net return was obtained from G_0B_0.

4.21.3 Benefit cost ratio

The highest benefit cost ratio (2.38) was noted from the combination of G_2B_2 and the second highest benefit cost ratio (2.27) was estimated from the combination of $G_2B_{1.}$ The lowest benefit cost ratio (1.34) was obtained from G_0B_0 (Table 13). From economic point of view, it was apparent from the above results that the combination of G_2B_2 was better than rest of the combination. Singh (2003) reported that the highest benefit cost ration (4.20) was observed from the borax applied at 5 kg/ha.

Table 13. Cost and return of broccoli cultivation as influenced by different levels of gibberellic acid and boron

Treatment combination	Cost of production (Tk./ha)	Main curd yield (t/ha)	Secondary curd yield (t/ha)	Gross Return (ton/Tk.)	Net return (Tk./ha)	Benefit cost ratio
G_0B_0	1,03,429	10.42	2.3	1,38,840	35,411	1.34
G_0B_1	1,05,951	11.27	2.59	1,50,780	44,829	1.42
G_0B_2	1,10,257	12.5	2.78	1,66,680	56,423	1.51
G_1B_0	1,07,929	14.58	3.24	1,94,400	86,471	1.80
G_1B_1	1,10,451	18.46	4.86	2,50,680	1,40,229	2.27
G_1B_2	1,14,757	17.91	4.71	2,43,180	1,28,423	2.12
G_2B_0	1,12,429	18.08	4.02	2,41,080	1,28,651	2.14
G_2B_1	1,14,951	19.05	5.46	2,61,360	1,46,409	2.27
G_2B_2	1,19,257	20.51	6.21	2,83,380	1,64,123	2.38

Price of main curd of broccoli @ Tk. 12000/ton and secondary curd of broccoli @ Tk. 6000/ton

Note: G_0 – 0 ppm, G_1 –100 ppm, G_2 – 200 ppm and B_0 – 0 ppm, B_1 – 100 ppm, B_2 – 200

CHAPTER V
SUMMARY AND CONCLUSION

The field experiment was conducted in the Horticultural farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207 during the period from October 2014 to January 2015 to find out the effect of GA_3 and boron on the growth and yield of broccoli. The experiment consisted of two factors, Factor A: Different doses of GA_3 such as G_0: Control, G_1: 100 ppm and G_2: 200 ppm; Factor B: Different doses of boron such as B_0: control, B_1: 100 ppm and B_2: 200 ppm. Data on different growth and yield contributing characters were recorded.

Plant height and number of leaves per plant increased with the increasing level of GA_3 at different days after transplanting of broccoli. At 60 DAT, the maximum plant height (63.53 cm) and number of leaves per plant (17.40) was observed from 200 ppm of GA_3 treatment whereas, the minimum plant height (58.40 cm) and number of leaves per plant (16.13) was observed from control treatment (0 ppm) of GA_3. The highest days required to main curd formation (45.89), days required to secondary curd formation (72.48), days required to main curd maturity (58.53), number of secondary curds plant^{-1} (7.17), stem diameter (4.57 cm), stem length (24.10 cm), curd diameter (15.23 cm), curd length (15.27 cm), leaf area plant^{-1} (1023.00 cm^2), canopy of plant (67.07 cm), leaf dry matter (12.60 %), curd dry matter (10.00 %), average weight of main curd (469.10 g), average weight of secondary curd (130.30 g), main curd yield per plot (5.63 kg plot^{-1}), main curd yield per plot (3.32 kg), main curd yield (19.55 t ha^{-1}) and secondary curd yield (5.43 t ha^{-1}) was recorded from 200 ppm of GA_3 application. On the other hand, the minimum days required to main curd formation (40.56), days to required secondary curd formation (62.42), days required to main curd maturity (54.69), number of secondary curds plant^{-1} (2.74), stem diameter (3.81 cm), stem length (21.77 cm), curd diameter (12.18 cm), curd length (12.60 cm), leaf area plant^{-1} (878.40 cm^2), canopy of plant (59.93 cm), leaf dry matter (9.67 %), curd dry matter (9.00 %), average weight of main curd (276.70 g), average weight of secondary curd (61.31 g), main curd yield (11.53 t ha^{-1}) and secondary curd yield (2.55 t ha^{-1}) were recorded from control (0 ppm) treatment of GA_3.

Plant height and number of leaves per plant increased with the increasing level of boron application. At 60 DAT, The maximum plant height (62.07 cm) and number of leaves per plant (17.33) was observed from 200 ppm of boron treatment whereas, the minimum plant height (59.53 cm) and number of plant height (16.40) was observed from control treatment (0 ppm) of boron. The maximum days required to main curd formation (44.44), number of secondary curds plant^{-1} (5.50), stem diameter (4.52 cm), stem length (24.10 cm), curd diameter (14.93 cm), curd length (14.47 cm), leaf area plant^{-1} (966.00 cm^2), leaf dry matter (13.00 %), curd dry matter (10.33 %), average weight of main curd (407.30 g), main curd yield (16.97 t ha^{-1}) and secondary curd yield (4.57 t ha^{-1}) were recorded from 200 ppm of boron treatment. On the other hand, the minimum days required to main curd formation (41.78), number of secondary curds plant^{-1} (4.02), stem diameter (3.99 cm), stem length (21.77 cm), curd diameter (12.70 cm), curd length (13.07 cm), leaf area plant^{-1} (949.00 cm^2), leaf dry matter (10.00 %), curd dry matter (8.67 %), average weight of main curd (344.70 g), main curd yield (14.36 t ha^{-1}) and secondary curd yield (3.19 t ha^{-1}) were recorded from control treatment (0 ppm) of boron.

At 60 DAT, the tallest plant (64.40 cm) and number of leaves plant^{-1} (17.80) was recorded from the combination of 200 ppm GA_3 and 200 ppm of boron (G_2B_2) whereas, the shortest plant at (57.00 cm) and number of leaves plant^{-1} (15.20) was observed from control treatment (G_0B_0). The maximum days required to main curd formation (48.00) was recorded from control treatment combination (G_0B_0). In comparison, the minimum days required to main curd formation (38.69) was recorded from the combination of 200 ppm GA_3 and 200 ppm of boron (G_2B_2). The maximum days required to main curd maturity (61.60) was recorded from control treatment combination (G_0B_0). In comparison, the minimum days required to main curd maturity (53.27) was recorded from the combination of 200 ppm GA_3 and 200 ppm of boron (G_2B_2). The highest number of secondary curds plant^{-1} (8.33) was recorded from the combination of 200 ppm GA_3 and 200 ppm of boron (G_2B_2). In comparison, the lowest number of secondary curds plant^{-1} (2.07) was recorded from control treatment combination (G_0B_0). The longest stem diameter (4.94 cm) was recorded from the combination of 200 ppm GA_3 and 200 ppm of boron (G_2B_2). In comparison, the shortest stem diameter (3.50 cm) was recorded from control treatment combination (G_0B_0). The longest stem length (25.30 cm) was recorded from the combination of 200 ppm GA_3 and 200 ppm of boron (G_2B_2). In comparison, the shortest stem length (21.60 cm) was recorded from the combination of 0 ppm GA_3 and 100 ppm of boron (G_0B_1). The longest curd diameter (16.40 cm) was recorded from the combination of 200 ppm GA_3 and 200 ppm of boron (G_2B_2). In comparison, the shortest curd diameter (11.00 cm) was recorded from control treatment combination (G_0B_0). The longest curd length (16.40 cm) was recorded from the combination of 200 ppm GA_3 and 200 ppm of boron (G_2B_2). In comparison, the shortest curd length (12.00 cm) was recorded from control treatment combination (G_0B_0). The maximum leaf area plant^{-1} (1065.00 cm^2) was recorded from G_1B_0 (100 ppm GA_3 and 0 ppm boron) treatment combination while minimum leaf area plant^{-1} (840.30 cm^2) was recorded from control treatment combination (G_0B_0). The highest leaf dry matter (15.00 %) was recorded from the combination of 200 ppm of GA_3 and 200 ppm of boron (G_2B_2). In comparison, the lowest leaf dry matter (8.00 %) was recorded from control treatment combination (G_0B_0). The highest curd dry matter (11.00 %) was recorded from the combination of 200 ppm of GA_3 and 200 ppm of boron (G_2B_2). In comparison, the lowest curd dry matter (8.00 %) was recorded from control treatment combination (G_0B_0). The highest average weight of main curd (492.20 g) was recorded from the combination of 200 ppm of GA_3 and 200 ppm of boron (G_2B_2). In comparison, the lowest average weight of main curd (250.00 g) was recorded from control treatment combination (G_0B_0). The highest yield ha^{-1} of secondary curd (6.21 ton) was recorded from the combination of 200 ppm of GA_3 and 200 ppm of boron (G_2B_2). In comparison, the lowest yield ha^{-1} of secondary curd (2.30 ton) was recorded from control treatment combination (G_0B_0).

Conclusion

The present study revealed that on the basis of growth, yield and economic point, 200 ppm of GA_3 and 200 ppm of boron (G_2B_2) is suitable for broccoli cultivation.

REFERENCES

Abdalla, I.M., Helal, R.M. and Zaki, M.E. 1980. Studies on the effect of some growth regulators on yield and quality of cauliflower. *Ann. Agric. Sci.* **12**: 199-208.

Adity, N. and Fordham, S.E. 1995. Effects of cold exposure and GA_3 during early growth stages on the date of flowering of the tropical broccoli. *Indian J. Plant Physiol.* **32**(2): 11-115.

Agarwala, S.C., Shama, C. Chatterjee, M.N.A. and Sharma, C.P. 1981. Development and enzymatic changes during pollen development in boron deficient maize plants. *J. Plant Nutr.* **3**: 329-336.

Alam, M.S. Iqbal,, T.M.T. Amin, M. and Gaffar, M.A. 1989. Krishitattic Fasaler Utpadan O Unnayan (in Bengali). T. M. Jubair Bin Iqbal, Sirajgonj. pp. 231-239.

Anderson, et al, 1984. Plant response to Mo as a fertilizer. Mo and symbiotic nitrogen fixation. *Aust. Count. Sci. Indt. Res. Bull.* **18**(9): 7-24.

Anneser, K. Fischer, P. and Seling, S. 2004. Nutritional disorders in broccoli. *Gemuse Munchen.* **40**(12): 24-27.

Anonymous. 1989. The specific location of the site, and latitude and longitude of the experimental site.

Antonova, K.G. Jun, X.U. Ren, Z.U. Ping, C.Y. and Yan, M. 1975. Study on features of nutrient absorption and dry matter accumulation in broccoli. *Acta Agric. Shanghai.* **13**(4): 47-50.

Babik, S.P. and Elkner, W. 1999. Effect of nitrogen and phosphorous and boron on the growth and yield of sprouting broccoli (*Brassicao leracea L. var. italica*) cv. Green Head. *Hort. J.* **15**(20): 87-90.

Badawi, M.A. and Sahhar, K.F.E. 1979. Influence of some growth substance on different charaters of cabbage. *Egypt J. Hort.* **6**(2): 221-223.

Batal, K.M. Granberry, D.M. and Mullnix, B.G. 1997. Nitrogen, magnesium and boron application effect on cauliflower yield, curdmass and hollow stem disorder. *Hort. Sci.* **32**(1): 75-78.

Brahrma, S. Phookan, D.B., Gautamand, B.P. and Bora, D.K. (2002). Effect of nitrogen., phosphorus arid. potassium on growth and yield of broccoli (*Brassica oleracea* L.) cv. KSTS-1. *Veg. Sci.* **29**(2): 154-156.

Chauhan, K.S., and Bordia, N.S. 1971. Effcet of gibberellic acid, beta-napthoacetic acid and 2,4-D as per sowing seed treatment on growth and yield of broccoli. *Indian J. Hort.* pp. 57-63.

Chhonkar, V.S., and Jha, R.N. 1963. The use of starters and plant growth regulators in transplanting of broccoli and their response on growth and yield. *Indian J. Hort.* **20**(2): 122-128.

Chhonkar, V.S., and Singh, R. 1965. Effect of NAA and 2,4-D on growth, yield and quality of broccoli. *Indian J. Hort.* **22**: 322-329.

Denisova, A.Z., and Luponovich, I.S. 1962. The effect of GA_3 on the mineral nutrient of plant. *Soil Sci. Ins. BSSR Agri. Minsk. USSR.* **8**(4): 360-364.

Dharmender, K. Hujar, K.D. Paliwal, R. And Kumar, D. 1996a. Yield and yield attributes of broccoli as influenced by GA_3 and NAA. *Crop Res. Hisar.* **12**(1): 120-122.

Dharmender, K. Hujar, K.D. Paliwal, R. And Kumar, D. 1996b. Yield and yield attributes of cabbage as influenced by GA_3 and NAA. *Crop Res. Hisar.* **15**(7): 86-93.

Dutta, J. P. 1984. Crop growth attributes and seed quantity, chlorophyll content and net assimilation rate response of broccoli to different levels of boron under North Bank Plain Zone conditions. *Assam J. Agric. Sci. Soc.* **15**(2) 105-107.

Gomez, K.A. and Gomez, A.A. 1984. Statistical Procedure for Agricultural Research (2nd ed.). *Int. Rice Res. Inst. A Willey Int. Sci*., pp. 28-192.

Gosh, S.K. and Hassan, M.A. 1997. Effect of boron on growth and yield of cauliflower. *Ann. Agric. Res.* **18**(3): 391-392.

Guo, D.P Shah, G.A. Zeng, G.W. and Zheng, S. 2004. The interaction of plant growth regulators and vernalization on the growth and flowering of cauliflower. *Plant Growth Res.* **43**(2): 163-171.

Islam, M.A. Diddiqua, A. and Kashem, M.A. 1993. Effect of PGR on growth, yield and quality of cabbage. *Bangladesh J. Agril. Sci.* **20**(1): 21-27.

Islam, M.T. 1985. The effect of some growth regulators on yield and biomass production of cabbage. *Punjab Veg. Grower.* **20**: 11-16.

Jana, J.C and Mukhopadhyay, T.P. 2002. Effect of nitrogen and phosphorus on seed production of cauliflower var. Agrhani in Terai Zone of West Bengal. *Seed Res.* **30**(2): 253-257.

Jiang, J. 2005. Cornish Cauliflowers. *Agriculture.***70**(5): 217.

Katyal, S.L. 1977. Vegetable Growing in India Mohan Primiani, Oxford and IBH publishing Company., Janapath, New Delhi-110001. p. 45.

Katur, S.C. 1992. Effect of season and boron and lime application on curd yield, curd rot and utilization of boron by cauliflower (Brassica oleracea, var. botrytis) in an Alfisol. *Indian J. Agric. Sci.* **62**(4): 286-289.

Katur, S. C. 1998. Synergetic interaction of lime, boron and molybdenum on curd rot and curd yield of cauliflower (*Brassica oleracea* var. botrytis) on an Alfisol. *Indian J. Agric. Sci.* **68**(5): 268-270.

Kim, M.S. Hujar, K.D. Paliwal, R. and Kumar, D. 2009. Yield and yield attributes of cabbage as influenced by GA_3 and NAA. *Crop Res. Hisar.* **15**(7): 86-93.

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

Lu, H. Jun, X.U. Ren, Z.U. Ping, C.Y. and Yan, M. 1997. Study on features of nutrient absorption and dry matter accumulation in broccoli. *Acta Agric. Shanghai.* **13**(4): 47-50.

Meshrotra, P.L.M, Sharma, P.P. and Singh, K.K. 1975. Effect of nitrogen and phosphorous with and without boron curd yield and stalk rot incidence in cauliflower. *Veg. Sci.* **18**(2): 115-121.

Mishra, 1952. Effect of nitrogen, its time of application and boron on cauliflower seed production in calcareous soil. *Indian J. Hort.* **49**(1): 83-86.

Mishra, H.P. and Singh, B.P. 1986. Studies on nutrients and PGR interaction in 'Snowball-6' cauliflower. *Prog. Hort.* **18**(1&2): 77-82.

Mishra. H.P. and Singh, B.P. 1984. Influence of foliar application of nitrogen, boron and Gibberellic acid on the yield contributing characters and yield of cauliflower. *Bangladesh Hort. J.* **12**: 21-25.

Muthoo, A.K. Kmar, S. And Manuya, A.N. 1987. Studies on the effect of foliar application of GA_3, NAA and Mo on growth and yield of broccoli. *Haryana J. Hort. Sci.* **16**(1&2): 115-120.

Nonnecke, I.L. 1989. Vegetable Production. Vein Nostrand. New York.

Pandey, S.N. and Sinha, B.K. 1987. Physiology revised edition. Vikas Publishing house Pvt. Ltd. New Delhi-110014. pp.444-445.

Pandhawa, K.S. and Bhali, A.S. 1976. Growth, yield and quality of cauliflower (*Brassicaa oleracea* var. botrytis) as influenced by nitrogen, phosphorus and boron. *Indian. J. Hort.* **33**(1): 83-91.

Patil, A.A. Maiur, S.M. and Nalwadi, U.G. 1987. Effect of GA3 and NAA on growth and yield of cabbage. *South Indian Hort.* **35**(5): 393-394.

Petraeek, P.D. and Sams, C.E. 1987. The influence of boron on the development of broccoli plants. *J. Plant Nutri.* **10**(9): 2095-2107.

Pizzeta, L.C. Ferreira, M.E. Cruz, M.C.P.O. and Barbosa, J.C. 2005. Response of boron fertilization on broccoli, cauliflower and cabbage planted in sandy soil. *USA J. Plant Nutri.* **26**(12): 2537-2549.

Prasad, S. and Kumar, U. 1999. Principles of Horticulture.Agrobotanica, 4E 176 J.N. Vyas Nagar, India. p. 6.

Prasad, M.B.N.V. and Singh, D.P. 1988. Varietal screening in cauliflower against boron deficiency. *Indian J. Hort.* **45**(3): 307-311.

Qarim, K. Reza, S.K. Prasad, M.B.N.V. and Singh, D.P. 2010. Effect of different level of GA_3 and lines on the growth, yield of cauliflower. *J. Soil Nature.* **3**(1): 16-19.

Rana, M.M. 2011. Sabji Bijnan. Text Book Division, Bangla Academy, Dhaka. Bangladesh . p.217.

Rashid, M.M. 1976. Vegetable of Bangladesh (In Bengaliu), First edition.Bangla Academy, Dhaka. p.283.

Reza, S.K. Prasad, M.B.N.V. and Singh, D.P. 2015. The effect of IAA and foliar nitrogen on wheat. *Ecosistema.* **12**: 123-126.

Reddy, S.A. 1989. Effect of foliar application of urea and GA_3 on cauliflower. *J. Res. APAU.* **17**(1): 79-83.

Roy, D.S.K. Kabir, J. Chatterjee, R. and Mitra, S.K. 1991. Effect of post harvest foliar spray of some chemicals on storage behavior of onion. *Indian Hort. J.,* **3**: 23-25.

Shabbir, V.P.S. Sing, G.D. and Keshwa, D.L. 2015. Synergetic interaction of lime, boron and molybdenum on curd rot and curd yield of cauliflower (*Brassica oleracea* var. botrytis) on an Alfisol. *Indian J. Agric. Sci.* **68**(5): 268-270.

Sharma, S.K. and Mishra, R.C. 1989. The influence of boron on the development of broccoli plants. *J. Plant Nutri.* **10**(9): 2095-2107.

Sharma, P.N. and Tanuja, R. 1991. Effects of boron deficiency and recovery on water relations and photosynthesis in cauliflower. *Indian J. Expl. Boil.* **29**(10): 967-970.

Sharma, S.K. Rajender, S. Korla, B.N. and Sharma, R. 2002. Effect of nitrogen and phosphorous and boron on the growth and yield of sprouting broccoli (*Brassicao leracea L. var. italica*) cv. Green Head. *Hort. J.* **15**(20): 87-90.

Shatuck, V.I and B.J. Shelp, B.J. 1987. Effect of Boron nutrition on hollow stem in Broccoli (*Brassica olceracea* var. Italica). *Can. J. Plant Sci.* **67**:1221-1225.

Shattuck, V.I. and Shelp, B.J. 1985. Hollow stem in broccoll. OMAF Pactsheer, Ontario Ministry of Agriculture and Food .Toronto, Ont. Pp.2-5.

Shelp, B. J. 1990. The influence of boron nutrition on nitrogen partitioning broccoli plants. Com. *Soil Sci. Plant Anal.* **21**(1-2): 49-60.

Shelp, B.J.V.I. Shatuck, D. and Liu, L. 1992. Boron nutrition and the composition of gluconsinolates and soluble nitrogen compounds in two broccoli (*Brassica oleracea* var. italica) cultivars. *Canadian J. plant Sci*. **72**:889-899.

Shelp, B.J. 1988. Boron mobility and nutrition in broccoli (*Breassicao leracea* var. Ltalica). *Ann. Bit.* **61**:83-91.

Singh, D.N. 2003. Effects of boron on the growth and yield of cauliflower inlateratic soil on western Orissa. *India J. Hort. Sci.* **60**(3): 283-286.

Singh, S.K. Shelp B.J.V.I. Shatuck, D. and Mishra, R.C. 2001. Effect of PGR on flower morphometrics with reference to insect pollinators. *Indian J. Agril. Sci.* **59**(3): 546-557.

Singh, S, Shelp B.J.V.I., Shatuck, D. and Husain, A. 2011. Effect of nitrogen and phosphorous and boron on the growth and yield of sprouting broccoli (*Brassicao leracea L. var. italica*) cv. Green Head. *Hort. J.* **15**(20): 87-90.

Thakur, O.P, Sharma, P.P. and Singh, K.K. 1991. Effect of nitrogen and phosphorous with and without boron curd yield and stalk rot incidence in cauliflower. *Veg. Sci.* **18**(2): 115-121.

Thara, N.L, Shelp B.J.V.I, Shatuck, D. And kokazov, N.I. 2013. Effect of nitrogen. phosphorus and potassium on growth and yield of broccoli (*Brassica oleracea* L.) cv. KSTS-1. *Veg. Sci.* **29**(2): 154-156.

Thompson, H.C. and Kelly, W.C. 1988. Vegetable Crops. 5th ed., Tata McGraw Hill Publishing Company Ltd. New Delhi. India. p.611.

Vijay, K. and Ray, N. 2000. Effect of plant growth regulators on broccoli. *Orissa J. Hort.* **28**(1): 56-59.

Watt. B.K. 1963. Nutritive Value of fruits and vegetables. USAID, Hand Bool No. 8 [cited in Nonnecke, I.L. 1989. Vegetable Production. An Avi Book Published by Van Nostrand Reinhold, New York].

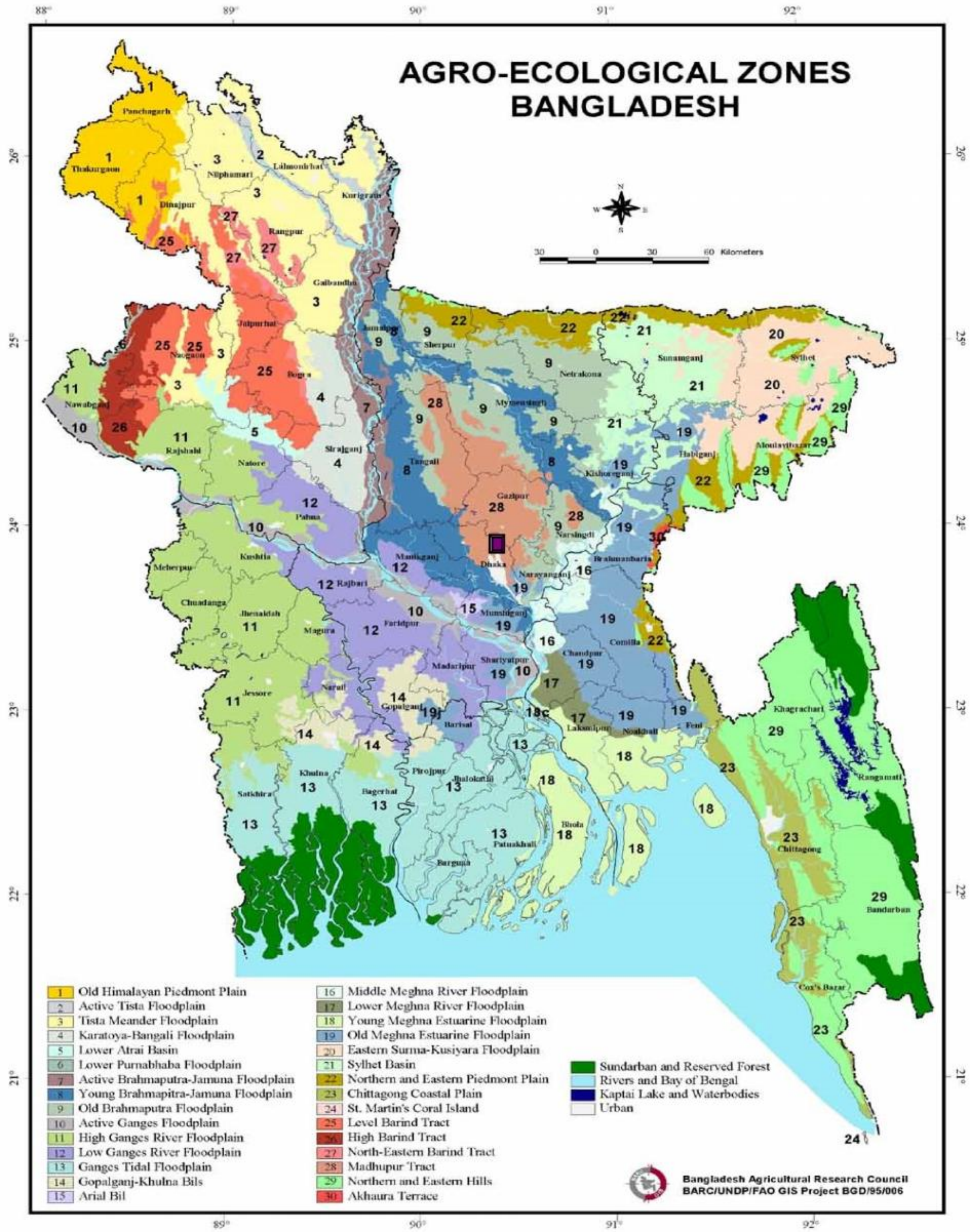
Yabuta, R.P, Joshi, R.P, Singh, R.D. and Adhikari, K.S. 1981. Effect of GA_3 on the performance of broccoli plants varieties. *Prog. Hort.* **5**(1): 35-38.

Yang, 2000. Yield and yield attributes of cabbage as influenced by GA_3 and NAA. *Crop Res. Hisar.* **15**(7): 86-93.

Yang, Y.A, Xu, H.K, Jie, Z.Q. and Wang, B.Y. 1989. Influence of B, N and P nutritional level on B uptake, quality and yield of rape seed. *Agril. Sci.* **22**(1): 44-51.

APPENDICES

Appendix I. Map showing the experimental sites under study



■ **The experimental site under study**

Appendix II. Physical characteristics and chemical composition of soil of the experimental plot

Soil characteristics	Analytical results
Agrological Zone	Madhupur Tract
PH	6.45
Organic matter	0.84
Total N (%)	0.46
Available phosphorous	21 ppm
Exchangeable K	0.41 meq / 100 g soil

Source: Soil Resource and Development Institute (SRDI), Dhaka

Appendix III. Monthly average record of air temperature, rainfall, relative humidity and Sunshine of the experimental site during the period from October 2014 to January 2015.

Month	Air temperature (ºc)		Relative humidity (%)	Total rainfall (mm)	Sunshine (hr)
	Maximum	Minimum			
October, 2014	31.6	23.8	78	172.3	5.2
November, 2014	29.6	19.2	77	34.4	5.7
December, 2014	26.4	14.1	69	12.8	5.5
January, 2015	25.4	12.7	68	7.7	5.6

Source: Bangladesh Meteorological Department (Climate & Weather Division) Agargoan, Dhaka – 1212.

Appendix IV: Error mean square values for plant height of broccoli at different days after transplanting (DAT)

Source of variation	Degrees of freedom	Plant height			
		15 DAT	30 DAT	45 DAT	60 DAT
Replication	2	0.512	6.929	6.929	70.355
GA_3 (A)	2	61.214*	258.021*	258.021*	262.010*
Boron (B)	2	5.027*	121.587*	55.037**	79.470*
A × B	4	0.716**	6.669**	6.669*	3.795*
Error	16	1.949	15.077	15.077	36.725

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

Appendix V: Error mean square values for number of leaves plant^{-1} of broccoli at different days after transplanting (DAT)

Source of variation	Degrees of freedom	Number of leaves plant^{-1}			
		15 DAT	30 DAT	45 DAT	60 DAT
Replication	2	0.008	0.612	0.401	0.737
GA_3 (A)	2	3.909**	8.810*	12.801*	6.418**
Boron (B)	2	0.268*	13.934**	9.808*	7.435*
A × B	4	0.087*	0.679*	0.368**	0.081*
Error	16	0.185	0.350	0.481	0.522

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

Appendix IV: Error mean square values for days to main and secondary curd formation, days to main curd maturity and number of secondary curds plant^{-1} of broccoli

Source of variation	Degrees of freedom	Days to main curd formation	Days to secondary curd formation	Days to main curd maturity	Number of secondary curds plant^{-1}

Replication	2	0.054	0.054	2.406	0.944
GA_3 (A)	2	0.700*	2.633*	68.689*	1340.745*
Boron (B)	2	4.104*	5.378*	4.726*	1623.569*
A × B	4	0.049*	0.106*	0.063*	35.573*
Error	16	0.017	0.017	0.513	1.447

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

Appendix VII: Error mean square values for stem diameter (cm), stem length (cm), curd diameter (cm), curd length (cm) and leaf area plant^{-1} (cm^2) of boccoli

Source of variation	Degrees of freedom	Stem diameter	Stem length	Curd diameter	Curd length	Leaf area plant^{-1}
Replication	2	0.003	0.016	0.054	0.200	0.083
GA_3 (A)	2	0.694*	19.888*	3.298*	2.300*	46.829*
Boron (B)	2	6.185*	184.347**	11.310*	1.867**	41.675**
A × B	4	1.130**	3.123*	1.238*	1.033*	9.744**
Error	16	0.083	0.078	0.123	0.057	0.046

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

Appendix VIII: Error mean square values for canopy of plant (cm), leaf and curd dry matter (%) and average weight of main and secondary curd (g) of boccoli

Source of variation	Degrees of freedom	Canopy of plant	Leaf dry matter	Curd dry matter	Average weight of main curd	Average weight of secondary curd
Replication	2	0.003	0.046	0.054	0.401	70.355
GA_3 (A)	2	0.464*	23.845*	2.633*	12.801*	262.010*
Boron (B)	2	4.895*	168.336*	5.378*	9.808*	79.470*
A × B	4	1.30**	5.123*	0.106*	0.368**	3.795*
Error	16	0.083	0.2678	0.017	0.481	36.725

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

Appendix IX: Error mean square values for yield of main and secondary curd of boccoli

Source of variation	Degrees of freedom	Yield $plot^{-1}$ (kg)		Yield ha^{-1} (ton)	
		Main curd	Secondary curd	Main curd	Secondary curd
Replication	2	0.005	0.029	0.057	0.944
GA_3 (A)	2	1.247*	3.108**	0.518*	1340.745*
Boron (B)	2	0.595**	8.374*	4.547*	1623.569*
A × B	4	0.031*	0.156**	0.250**	35.573*
Error	16	0.002	0.007	0.008	1.447

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