YIELD AND QUALITY OF GROUNDNUT SEED AS INFLUENCED BY LIGHT AND BORON

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YIELD AND QUALITY OF GROUNDNUT SEED AS INFLUENCED BY LIGHT AND BORON

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CERTIFICATE

This is to certify that the thesis entitled **"Yield and Quality of Groundnut Seed as Influenced by Light and Boron"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (M.S.)** in **AGRONOMY,** embodies the results of a piece of *bona fide* research work carried out by **Md. Quamruzzaman,** Registration. No. **09-03439** under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.

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

Dated:

Place: Dhaka, Bangladesh

(Prof. Dr. Md. Jafar Ullah)
Supervisor

Dedicated
to
My Beloved Parents

LIST OF ACRONYMS

Abbreviation	Full word
AEZ	Agro Ecological Zone
AOAC	Analyses of Association of Analytical Chemist
BARC	Bangladesh Agricultural Research Council
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
BCSIR	Bangladesh Council of Scientific and Industrial Research
CV	Coefficient of Variance
DAP	Days After Planting
meq	Milli-equivalent
NS	Non-Significant
SE	Standard Error
SRDI	Soil Resource Development Institute
USDA	United States Department of Agriculture

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LIST OF CONTENTS

LIST OF CONTENTS (Cont'd)

LIST OF CONTENTS (Cont'd)

LIST OF CONTENTS (Cont'd)

LIST OF CONTENTS (Cont'd)

LIST OF TABLES

LIST OF TABLES (Cont'd)

LIST OF FIGURES

LIST OF APPENDICES

LIST OF PLATES

YIELD AND QUALITY OF GROUNDNUT SEED AS INFLUENCED BY LIGHT AND BORON

ABSTARCT

Boron is an important micronutrient that enhances vegetative and reproductive growth as well as yield and quality of crops, like groundnut. Light also plays an important role for pegging of groundnut. There has been little information on the application of boron and light in groundnut in Bangladesh. Therefore, a field experiment was conducted to study the effects of light and boron on the yield and quality of groundnut at the central experimental farm, Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh during March to July, 2014. Treatments consisted of two groundnut varieties (V_1 =Dhaka 1 and V_2 = BARI Chinabadam 8), three levels of boron (B_0= Control, B_1 = 1-kg boron ha^{-1} and B_2 = 2-kg boron ha^{-1}), and two levels of light, viz., normal day light (L_0) and normal day light + 6-h extended red light at night (L). Result revealed that yield of groundnut was significantly influenced by variety, boron and light where L_0, B_2, V_2 and $L_0B_2V_2$ gave the highest seed yield (1.37, 1.53, 1.39 and 1.82 t ha^{-1}, respectively). The highest seed yield of the interaction treatment was attributed to the highest number of pods $plant^{-1}$ (120.67), pod weight $plant^{-1}$ (59 g) and 100 seed weight (59.58 g). Number of branches $plant^{-1}$ had a positive relationship with pod yield (R^2=0.255). Although imposition of light did not increase seed yield, it increased seed protein content (39.98 %), oil content (50.94 %) and vitamin E content (10.61 mg/100 g seed) in V_2 under highest boron dose.

Chapter 1

Introduction

CHAPTER 1

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is one of the most important oil seed crops throughout the world (Onemli, 2012). It contains so many bio-constituents for human betterment; among these, protein, oil (Linoleic Acid, and Oleic Acid, also a good source of Omega-6 fatty acids and minimal amount of Omega-3 fatty acids) and vitamin E (∞-tocopherol) are the most important.

Boron is an important micronutrients required by plants in a very small quantity (El-Wahab, 2008) which are rapidly becoming deficient in soils (Tahir *et al*., 2009). Boron is an essential element needed for normal growth and development of peanut plant (Gascho and Davis, 1995; Harris and Brolman, 1966a, 1966b, 1966c). Application of boron in soil significantly increase the growth and yield of groundnut (Kabir *et al*., 2013 and Singaravel *et al*., 2006). It has a special importance in retaining flower and fruit setting of legume crops (Zhang, 2001); it regulates carbohydrate metabolism and keeps role in seed formation (BARC, 2005). This element also influences on flowering in peanut (Singh *et al*., 2009) because boron is the important micro-nutrient that makes the stigma receptive, sticky and making pollen grain fertile and enhance the pollination (Kaisher *et al*., 2010). As a result, boron helps to increase number of pegs, pods in groundnut (Naiknaware *et al*., 2015). Application of boron along with NPK also increase the total number of pods in peanut (Luo *et al*., 1990) and finally increased the pod yield (Jena *et al*., 2009).

Oil and protein content in groundnut increase with the application of B (Jena *et al.*, 2009) and combine application of boron and sulphur helps to increase the protein and oil content of groundnut seed (Naiknaware *et al*., 2015). Boron also helps to uptake the highest value of N, P, K, Fe and Mn (Nasef *et al*., 2006) and K helps to increase Vitamin E (α-tocopherol) content in Tomato (Caretto *et al*., 2008). Boron (B) deficiency problem for crop production have been identified in Bangladesh (Ahmed & Hossain, 1997) and application of boron in crops is limited at farmer's field (Nasreen *et al*., 2015). Even farmers are not aware of the importance of boron on groundnut.

Light plays an important role for the vegetative and reproductive growth in groundnut. The quantity, quality and direction of light are perceived by several different photosensory systems that together regulate nearly all stages of plant development, presumably in order to maintain photosynthetic efficiency (Hangarter, 1997). However, the number of flowers markedly reduce if less light is received by the peanut plants (Cox, 1978). Total numbers of pegs, pods and thereby yield become lower in long day photoperiods but vegetative production is higher in long day photoperiod (Bagnall and King, 1991, Stalker and Wynne, 1983). In groundnut, for light supplementation peg to pod conversation rate and yield is lower (Nigam *et al*., 1998) but light stress can lead to ROS (Reactive Oxygen Species) accumulation and antioxidant enzymes activation in plant (Mittler, 2002). With the supplementation of light helps to reduce the seed protein content and higher oil content than that of normal day length in leguminous crops (Han *et al*., 1996). In Bangladesh, groundnut is grown in both winter and summer. As in winter, there is no shortage of light supply to crops. But during summer, light supply is interrupted by clouds leading to lower yields. This situation should be taken under consideration as groundnut seed crop is grown in summer. There is evidence that abundant supply of light helps to increase yield. Increasing seed yield is also important as the price of seed is very high especially when compared to non-seed kernel. Further, influence of Boron and light on the quality of seed to be examined. However, little or no experiment was conducted in Bangladesh to find out the impact of light on groundnut. Therefore, it is important to study the effect of boron and light supplementation for better growth, reproductive development, yield and quality of groundnut.

Keeping all points in minds mentioned above, the present study was undertaken with the following objectives-

- To observe the influence on yield and quality of groundnut seeds by the application of boron.
- To find out the impact on yield and quality of groundnut seeds by increasing light duration.
- To evaluate the interaction effect of light and boron on yield and quality of groundnut seeds.

Chapter 2

Review of literature

CHAPTER 2

REVIEW OF LITERATURE

This chapter represents a comprehensive review of the works which have been done in Bangladesh and many other countries of the world with regards to the yield and quality of groundnut seed as influenced by light and boron.

2.1 Effect of boron and light

2.1.1 Growth parameters

2.1.1.1 Days to emergence

Roekkasem (1994) conducted an experiment to investigate the boron deficiency in food legumes in Northern Thailand. They reported that low boron was responsible for poor seed germination and/or seedling establishment in peanut.

Rerkasem and Loneragan (1990) conducted a field study to investigate the effect of seed B (boron) on early seedling growth in cool season plantings of black and green gram at Chiang Mai, Thailand. They reported that B helped on early seedling growth.

2.1.1.2 Days to flowering

Ansari *et al*. (2014) conducted an experiment to find out the efficacy of boron sources on groundnut production under North East Hill Regions and stated that application of boron reduced days to 50% flowering by 4-5 days in groundnut.

Singh and Misra (2009) stated that application of boron in peanut caused 2-3 days early flowering.

2.1.1.3 Plant height

Kabir *et al*. (2013) conducted an experiment to observe the effect of Phosphorus (P), Calcium (Ca) and Boron (B) on the growth and yield of groundnut cv. BARI Cheenabadam 7. They found that the combine application of P, Ca and B helped to increase the plant height of groundnut.

Jing *et al*. (1994) reported that the application of B promotes the absorption of N by groundnut and increases the plant height, plant dry weight and the total number of pods.

Wynne and Emery (1974) conduced an experiment to identify the response of intersubspecific peanut hybrids to photoperiod. They reported that long day photoperiod produced tallest plant than short day photoperiod.

2.1.1.4 Leaf area

Kabir *et al*. (2013) conducted an experiment to observe the effect of Phosphorus (P), Calcium (Ca) and Boron (B) on the growth and yield of groundnut cv. BARI Cheenabadam 7. They found that the combine application of P, Ca and B help to increase the leaf area index (LAI) of groundnut.

Nigam *et al*. (1998) conducted an experiment to find out the effects of temperature and photoperiod on vegetative and reproductive growth of groundnut (*Arachis hypogaea* L.) and stated that with the supplementation of light leaf area of groundnut increased.

2.1.2 Yield and yield contributing characters

2.1.2.1 Number of branches

Kabir *et al*. (2013) conducted an experiment to observe the effect of Phosphorus (P), Calcium (Ca) and Boron (B) on the growth and yield of groundnut cv. BARI Cheenabadam 7. They found that the combine application of P, Ca and B help to increase the number of branches plant^{-1} of groundnut.

Luo *et al*. (1990) carried out field trials in 1987-88 on boron-deficient soils. Sodium borate was applied to the soils along with NPK fertilizers and found increased number of breaches plant^{-1} in groundnut.

Wynne (1973) carried out an experiment to identify the photoperiodic response of peanut. They reported that vegetative growth of the plants was reduced by short day treatments.

2.1.2.2 Shoot dry weight

Kabir *et al*. (2013) conducted an experiment to observe the effect of Phosphorus (P), Calcium (Ca) and Boron (B) on the growth and yield of groundnut cv. BARI Cheenabadam 7. They found that the combine application of P, Ca and B helped to increase the shoot dry weight of groundnut.

Nigam *et al*. (1998) conducted an experiment to find out the effects of temperature and photoperiod on vegetative and reproductive growth of groundnut (*Arachis hypogaea* L.) and stated that total dry matter of groundnut increased in long day photoperiod.

2.1.2.3 Number of flowers

Kabir (2007) conducted a pot culture experiment at the Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh to study the effect of different level of boron (B) on yield of three different groundnut varieties. He observed that the number of flower plant^{-1} increased with the application of Boron.

Cox (1978) carried out an experiment to study the effect of quantity of light on the early growth and development of the peanut. He reported that, the number of flowers was markedly reduced as less light was received by the peanut plants.

2.1.2.4 Number of pegs

Naiknaware *et al*. (2015) carried out the field trial to study the varying levels of boron and sulphur on growth, yield and quality of summer groundnut (*Arachis hypogea* L.). They found that the number of pegs plant^{-1} increased with the application of B.

Kabir (2007) conducted a pot culture experiment at the Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh to study the effect of different level of boron (B) on yield of three different groundnut varieties and observed that the number of pegs plant^{-1} increased with the application of Boron.

Stalker and Wynne (1983) stated that total numbers of pegs produced in short-day treatments were generally greater than in long-day treatments.

2.1.2.5 Number of pods

Naiknaware *et al*. (2015) carried out the field trial to study the varying levels of boron and sulphur on growth, yield and quality of summer groundnut (*Arachis hypogea* L.). They found that the number of pods plant^{-1} increased with the application of B.

Kabir *et al*. (2013) conducted an experiment to observe the effect of Phosphorus (P), Calcium (Ca) and Boron (B) on the growth and yield of groundnut cv. BARI Cheenabadam 7. They found that the combine application of P, Ca and B helped to increase the number of pods plant^{-1} of groundnut.

Bagnall and King (1991) conducted an experiment to study the response of peanut (*Arachis hypogaea*) to temperature, photoperiod and irradiance 1. They reported that number pods enhanced significantly in short day photoperiod.

Golakiya & Patel (1986) found that the application of Boron produced maximum number of mature pods in groundnut.

2.1.2.6 Pods dry weight

Ansari *et al.* (2013) found that significantly higher dry pod yield and haulm yield were recorded with solubor (Soil Application) (3.5 and 4.72 t/ha), which was 29 and 24% higher than control (2.71 and 3.82 t/ha).

Rashid *et al*. (1997) reported that the rainfed soils of peanut (*Arachis hypogaea* L.) growing fields in the Potohar planteau of Pakistan are alkaline and calcareous with low organic matter contents and the peanut crop grown on such soils was suspected to suffer from boron (B) deficiency. In a field experiment on an alkaline calcareous Typic Hapludalfs, B fertilization at 0.5 to 1.0 kg B/ha increased pod yield of rainfed peanut by 10%.

Bagnall and King (1991) conducted an experiment to study the response of peanut (*Arachis hypogaea*) to temperature, photoperiod and irradiance 1. They reported that pod weight enhanced significantly in short day photoperiod.

2.1.2.7 The 100 seed weight

Kabir *et al*. (2013) conducted an experiment to observe the effect of Phosphorus (P), Calcium (Ca) and Boron (B) on the growth and yield of groundnut cv. BARI Cheenabadam 7. They found that the combine application of P, Ca and B help to increase the 100 pods weight plant^{-1} of groundnut.

Nigam *et al*. (1998) conducted an experiment to find out the effects of temperature and photoperiod on vegetative and reproductive growth of groundnut (*Arachis hypogaea* L.) and stated that pod weight of groundnut increased in short day photoperiod.

Luo *et al*. (1990) carried out field trials in 1987-88 on boron-deficient soils. Sodium borate was applied to the soils along with NPK fertilizers and found increased the 100 seeds weight in groundnut.

2.1.2.8 Shelling percentage

Naiknaware *et al*. (2015) carried out the field trial to study the varying levels of boron and sulphur on growth, yield and quality of summer groundnut (*Arachis hypogea* L.) and found that the shelling% increased with the application of B.

Kabir *et al*. (2013) conducted an experiment to observe the effect of Phosphorus (P), Calcium (Ca) and Boron (B) on the growth and yield of groundnut cv. BARI Cheenabadam 7. They found that the combine application of P, Ca and B helped to increase the shelling percentage of groundnut.

Sharma *et al.* (2012) stated that during stress condition plant made a defense mechanism on itself.

Golakiya & Patel (1986) conducted a pot experiment, with the application of boron, peanut produced maximum number of mature pods, shelling percentage, minimum number of pops and highest pod yield.

2.1.2.9 Pod yield

Jena *et al.* (2009) conducted an experiment to observe the effects of boron and boron enriched organic manure on yield and quality of groundnut in boron deficient Alfisol. Boron at 1 kg/ha and B enriched cow dung increased groundnut pod yield by 57 and 62%.

Chitdeshwari & Poongothai (2003) conducted front line demonstration in the farmers field on the response of groundnut to the application of multi micronutrients to soil and also used as a seed treatment. They indicated that the soil application of Zn, B and S significantly increased the pod yield.

Rashid *et al*. (1997) carried out an experiment in the rainfed soils with low organic matter contents and the crop is grown without adequate fertilization. The peanut crop grown on such soils was suspected to suffer from boron (B) deficiency. B fertilization at 0.5 to 1.0 kg B/ha increased pod yield of rainfed peanut by 10% over control.

Ketring, 1979) conducted a light experiment to find out the light effects on development of an indeterminate plant. He stated that long photoperiod produced the largest amount of vegetative, but least number of reproductive components.

2.1.2.10 Seed yield

Kabir *et al*. (2013) conducted an experiment to observe the effect of Phosphorus (P), Calcium (Ca) and Boron (B) on the growth and yield of groundnut. They found that the combine application of P, Ca and B helped to increase the seed weight of groundnut.

Jena *et al.* (2009) conducted an experiment to observe the effects of boron and boron enriched organic manure on yield and quality of groundnut in boron deficient Alfisol. They observed that application of boron and B enriched cow dung increased groundnut yield.

2.1.2.11 Stover yield

Naiknaware *et al*. (2015) carried out the field trial to study the varying levels of boron and sulphur on growth, yield and quality of summer groundnut (*Arachis hypogea* L.). They found that the haulm yield increased with the application of B.

Ansari *et al.* (2013) found that significantly higher dry pod yield and haulm yield of groundnut were recorded with solubor (Soil Application) (3.5 and 4.72 t/ha), which was 29 and 24% higher than control (2.71 and 3.82 t/ha).

Wynne (1973) carried out an experiment to identify the photoperiodic response of peanut. He reported that vegetative growth of the plants was reduced by short day treatments.

2.1.3 Quality contributing characters

2.1.3.1 Protein content

Naiknaware *et al*. (2015) carried out the field trial to study the varying levels of boron and sulphur on growth, yield and quality of summer groundnut (*Arachis hypogea* L.). They found that the protein content in groundnut increased with the application of B.

Jena *et al.* (2009) conducted an experiment to observe the effects of boron and boron enriched organic manure on yield and quality of groundnut in boron deficient Alfisol. They found protein content in groundnut increased by 1-4 and 3-13%, respectively over control due to B application.

Han *et al*. (1996) reported that when plant is exposed to the long photoperiod produced lower seed protein than that in short photoperiod.

2.1.3.2 Oil content

Naiknaware *et al*. (2015) carried out the field trial to study the varying levels of boron and sulphur on growth, yield and quality of summer groundnut (*Arachis hypogea* L.). They found that the oil content in groundndut increased with the application of B.

Jena *et al.* (2009) conducted an experiment to observe the effects of boron and boron enriched organic manure on yield and quality of groundnut in boron deficient Alfisol. They found oil content and oil content in groundnut increased by 1-4 and 3-13%, respectively over control due to B application.

Han *et al*. (1996) reported that when plant is exposed to the long photoperiod had seed higher oil content than that in short photoperiod.

2.1.3.3 Vitamin E content

Nasef *et al*. (2006) found that boron helps to uptake the highest value of N, P, K, Fe and Mn and Caretto *et al*., (2008) reported that K helped to increase Vitamin E (α-tocopherol) content in Tomato.

Mittler (2002) reported that light stress can lead to ROS (Reactive Oxygen Species) accumulation and antioxidant enzymes activation.

Demmig-Adams and Adams (1992). Stated that plants exposed to excessive light can suffer photo-inhibition, serious damage to the photosynthetic apparatus, and degradation of photosynthetic proteins.

2.1.3.4 Germination percentage

Gupta and Solanki (2012) reported that B concentration of 15 ppm and 5ppm were more suitable for seeds as 15 ppm gave highest seed germination, while seeds of 5 ppm treatment were the highest length, fresh weight and dry weight of seedlings over control in Brinjal.

Roekkasem (1994) stated that boron deficiency on peanut induce the reduction of seed yield and lowering of seed quality. Sowing low boron seeds may result in poor germination and/or poor seedling establishment in the peanut. Low boron in the seed is associated with physical damages which may lead to other problems of poorer quality.

Chapter 3

Materials and Methods

CHAPTER 3

MATERIALS AND METHODS

In this Chapter different materials and methodologies followed during the experimental period are described as follows:

3.1 Description of the experimental site

3.1.1 Location

The experiment was conducted at the Agronomy Field, Sher-e-Bangla Agricultural University (SAU), Dhaka-1207, during the period of March 17 to July 10, 2014 to study the yield and quality of groundnut seed as influenced by light and boron. The experimental filed is located at 23^0 41' N latitude and 90^0 22' E longitude at a height of 8.6 m above the sea level belonging to the Agro-ecological Zone “AEZ-28” of Madhupur Tract (BBS, 2013).

3.1.2 Soil

The soil of the research field is slightly acidic in reaction with low organic matter content. The selected research plot was above flood level and sufficient sunshine was available and was also available irrigation and drainage system during the experimental period. Soil sample from 0-15 cm depth were collected from experimental field and the soil analysis were done from Soil Resources Development Institute (SRDI), Dhaka. The experimental plot was high land having pH 5.9. The physical properties and nutritional status of soil of the experimental plot are given in Appendix I.

3.1.3 Climate

The experimental field was suited under the sub-tropical climate, usually the rainfall is heavy during *Kharif* season, (April to September) and scanty in *Rabi* season (October to March). In *Robi* season temperature is generally low and there is plenty of sunshine. The temperature tends to increase from February as the season proceed towards *Kharif* and temperature was so high during April to July in spite of having sometimes rainfall. Rainfall was scanty during March to April 2014, but increase from May to July. The monthly total rainfall, average temperature during the study period (March to July) has been presented in Appendix II.

3.2 Crops

Two groundnut verities were used for this experiment viz., Maischor Badam (Dhaka-1) and BARI Chinabadam-8. Seeds were provided by Bangladesh Agricultural Research Institute (BARI), Gazipur. Average plant height of these verities ranged from 30-42 cm. Average yield in *Kharip* season 1.6-1.8 ton/ha (Dhaka-1) and 2.5 ton/ha (BARI Chinabadam-8). Both verities require about 120-142 days for completing its life cycle in *Kharif* season.

3.3 Experimental treatment

The experiment consisted of 3 factors:

Factors A: Levels of Light

(a) L_0 = normal day light (≈12-h light)
(b) L = normal day light + 6-h extended red light at night (≈18-h light)

Factors B: Levels of Boron [Source: boric acid (16.5% boron)]

There were three level of Boron. There were-

(a) B_0 = 0 (Control)
(b) B_1 = 1 kg ha^{-1}
(c) B_2 = 2 kg ha^{-1}

Factors C: Groundnut Verities

There were two varieties under study and they were-

(a) V_1 = Dhaka-1 (Maizchar Badam)
(b) V_2= BARI Chinabadam-8

Treatment: Boron-variety interaction under light and dark at night (6x2=12)

LB_0V_1, $L_0B_0V_1$, LB_1V_1, $L_0B_1V_1$, LB_2V_1, $L_0B_2V_1$, LB_0V_2, $L_0B_0V_2$, LB_1V_2, $L_0B_1V_2$, LB_2V_2, $L_0B_2V_2$

To extent the photoperiod, one month after seed sowing (after seedling emergence) artificial lightening was used by florescence bulb from 1800-h 2400 @30-50,000 lux, measured by lux meter.

3.4 Details of the field operation

3.4.1 Land preparation

Repeated ploughing by power tiller was done on 10 March and Final Land was prepared on 16 March. Ploughing was followed by laddering in order to break clods as well as level the land. All weeds, stubbles and crop residues were removed from the experimental field. The layout of the experiment was done as per as statistical design.

3.4.2 Experimental design

The experiment was laid out in a split-split plot design with three replications. Light was imposed in the main plots while Boron in the sub-plot and variety in the sub-sub plot. Each experimental unit was divided into three blocks each of which representing a replication. There were altogether 36 units of plots, each plot was measuring $4m^2$ (2m x 2m). Inter-plot and inter–block spacing was 0.5 m and 0.5 m, respectively. Spacing was maintained 30 cm x 15 cm with 6 lines in a plot having 1,24,800 plants ha^{-1}.

3.4.3 Light structure:

Electricity wires, 18 bulbs 200W (Normal Bulb), holder, 18 blub covers (Dhakna), black polythene, rope, net, bamboo stick etc.

3.4.4 Fertilizer application

The following doses of manure and fertilizer were used

Urea	:	25 kg ha^{-1}
TSP	:	160 kg ha^{-1}
MP	:	75 kg ha^{-1}
Gypsum	:	170 kg ha^{-1}
Zinc sulphate	:	4 kg ha^{-1}
Boric Acid	:	0 kg ha^{-1}, 5 kg ha^{-1}, 10 kg ha^{-1}

Half dose of urea and all others fertilizer were applied during final land preparation and incorporated in each plot. Rest amount of urea was applied during flowering of plants.

3.4.5 Collection of seeds

As per treatment seeds of different groundnut varieties were collected from Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur.

3.4.6 Test for seed germination

Germination test was performed in the laboratory before sowing the seeds in the main plot. For laboratory test petridishs and pots were used. Three layers of filter paper were placed on petridishes and the filter papers were soaked with water. Sand and normal soil was used in different pots to check whether soil or sand is good for seed germination. Separately 10 seeds were distributed in each petridishe and pot. Days to emergence were calculated in percentage basis by using the following formula:

$$\%Germination = \frac{Number\ of\ seeds\ germinated}{Number\ seeds\ set\ for\ germination} \text{ X } 100$$

3.4.7 Sowing of seeds

The Seeds were sown on 17 March 2014. As a good tilth condition, furrows were made with hand rakes for sowing. Before sowing seeds were treated with Provax-200 Ec @ 2.5 g powder kg^{-1} seed. After providing slight water in each line, 26 seeds were sown in a line maintaining plant to plant distance 15 cm (2 seeds in a hole) in 2-3 cm depth @110 kg seeds ha^{-1}(with shell).

3.4.8 Intercultural operations

The following intercultural operations were done for the better growth and development of the plants during the period of the experiment:

3.4.8.1 Irrigation

Threes level of irrigation were applied, the first irrigation was done after 20 days of planting, the second during flowering stage, and the third irrigation was done at pegging and pod formation stage.

3.4.8.2 Weeding and earthing up

Weeding was accomplished as and when necessary to keep the crop field free from weeds and to break the soil crust. Two level of earthing up were done, the first just before flowering and the second one during pegging stage.

3.4.8.3 Disease and insect control

To prevent the plant from fungal infection, Rovral @ 2 g L^{-1} was applied at 15 days of interval. To control sowing seeds from Ant Sevin 85 Ec was applied. To prevent plants from insect's appropriate insecticides was sprayed in the experimental field.

3.4.9 Harvesting

Harvesting was done at 8 and 9 July 2014. The plants were carefully uprooted from each plots with the help of khurpi. The plants were taken to the threshing floor and washed with running tap water. After washing leaf, stem, roots, pegs and pods were separated and data were recorded.

3.5 Parameter studies

3.5.1 Growth parameter

1. Days to emergence
2. Days to flowering
3. Plant height (cm)
4. Leaf area (cm^2)

3.5.2 Yield and yield contributing characters

1. Number of branches $plant^{-1}$
2. Shoot dry weight (g)
3. Number of flowers $plant^{-1}$
4. Number of pegs $plant^{-1}$
5. Number of pods $plant^{-1}$
6. Pod dry weight $plant^{-1}$ (g)
7. 100 seed weight (g)
8. Shelling percentage
9. Pod yield (t/ha)
10. Seed yield (t/ha)
11. Stover yield (t/ha)

3.5.3 Seed quality contributing characters

1. Protein content (%)
2. Oil content (%)
3. Vitamin E content (mg/100 g seed)
4. Germination Percentage

3.6 Procedures of data collection

3.6.1 Growth Parameter

3.6.1.1 Days to emergence

Days to emergence of seedling was calculated by checking every day for first and last emergence. Then days to first and last emergence days was recorded.

3.6.1.2 Days to flowering

Days to flowering in plant was recorded by checking every day for first and 50% flowering. Then days to first and last flowering was recorded.

3.6.1.3 Plant height

Plant height was measured from the ground level to top of the plant at 30, 60, 90, and during harvesting. From each plot, 3 plants were measured and averaged in centimeter.

3.6.1.4 Leaf area

The leaf area was calculated by leaf area meter. It was starting from 30 days after planting (DAP) to harvest.

3.6.2 Yield and yield components

3.6.2.1 Number of branches

Three plants were selected from each plot randomly. The number of total branches from 3 plants were counted and averaged then to have a total numbers of branches palnt^{-1}.

3.6.2.2 Shoot dry weight

Three plants were uprooted from each field and washed with a running tap water then cut root and shoot, shoot was kept for oven drying maintaining temperature 80^{0}C for 72 hours until a constant weight was obtained. Then data were recorded as shoot dry weight plant^{-1}.

3.6.2.3 Number of flowers

The number of flowers from selected three uprooted plants were counted and averaged into flowers plant^{-1} at 60 DAP, 90 DAP and at harvest.

3.6.2.4 Number of pegs

The number of pegs from selected three uprooted plants were counted and averaged into pegs plant^{-1} at 60 DAP, 90 DAP and at harvest.

3.6.2.5 Number of pods

The number of pods from selected three uprooted plants were counted and averaged into pods plant^{-1} at 60 DAP, 90 DAP and at harvest.

3.6.2.6 Pod dry weight

The number of pods from selected three uprooted plants were oven dried and dried pods were weight recorded in gram. Then averaged into pod weight for 60 DAP, 90 DAP and at harvest.

3.6.2.7 100-seed weight

Weight of 100 sun dried seeds (g) were taken using an electric balance.

3.6.2.8 Shelling percentage

Shelling percentage was calculated as (seed dry weight of 100 pods/ 100 pod weight × 100)

3.6.2.9 Pod yield

Finally, total pod yield of the experimental plot was calculated as ton ha^{-1}.

3.6.2.10 Seed yield

Seed yield of the experimental plot was calculated as ton ha^{-1}.

3.6.2.11. Stover yield

Stover yield of the experimental field was calculated as ton ha^{-1}.

3.6.3 Quality parameters

Seed protein content, oil content and vitamin E content were analyzed at Bangladesh Council of Scientific and Industrial Research (BCSRI)

3.6.3.1 Protein content

The protein content was evaluated by the multiplication of total nitrogen with 6.25 (Kaishar *et al.,* 2010), which was determined by following the Micro-Kjeldahl's method (Devani *et al.,* 1989).

3.6.3.2 Oil content

In order to determine the oil content of groundnut seed, the soxhlet extraction method (AOAC, 1990) which was used by Inuwa *et al.,* (2011).

3.6.3.3 Vitamin E content

Ejoh and Ketiku (2013) used a procedure to analysis the vitamin E content of groundnut seed and in the present study we also followed the same procedure to determine the vitamin E content of groundnut seed.

3.6.3.4 Germination percentage

After harvesting pods were stored in a natural condition and seeds were taken for germination test. Then 25 seeds dish for each treatment were taken in each petri to evaluate the percentage of seed germination. The number of germinated seeds was counted and finally germination percentage was recorded.

3.7 Statistical analysis

The data were analyzed through a statistical computer software IBM-SPSS (Version 20.0) and the means were adjusted by Tukey's Test at 0.05% level of significance.

Chapter 4

Results and Discussion

CHAPTER 4

RESULTS AND DISCUSSION

This chapter represent the result and discussions of the present study. Summary of mean square values at different parameters are also given in the appendices from IV to XII.

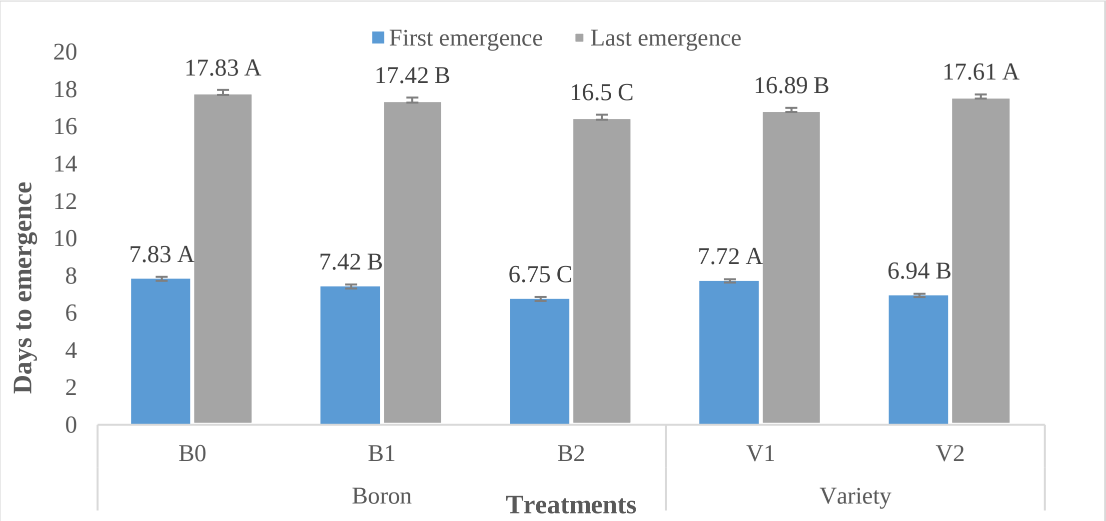
4.1 Effect of boron and light on growth of groundnut

4.1.1 Days to emergence

4.1.1.1 Effect of boron and variety

Boron had a significant impact on days to groundnut seedling emergence. When B was applied at 2 kg ha^{-1} seed took shorter times for days to 1st (6.75 days) and last emergence (16.50 days) in both the varieties compared to control (7.83 and 17.83 days) (Figure 1 and appendix III). BARI Chinabadam-8 took shorter time to first emergence and in case of last emergence it took more time than Dhaka-1. This might be due to that B helped early germination and faster growth of hypocotyl (Rerkasem *et al*. 1990). Roekkasem (1994) reported that low boron is responsible for poor seed germination and/or seedling establishment in peanut.

We applied light just after 30 days of seed sowing, so in our present study we couldn't study the effect of light on days to seedling emergence.



B= Boron; V= Variety; B_0= 0 Kg B ha^{-1}, B_1= 1 Kg B ha^{-1}, B_2= 2 Kg B ha^{-1}; V_1= Dhaka-1, V_2= BARI Chinabadam-8 Means were separated by Tukey's test at $P \leq 0.05$. Vertical bars represent the standard error of the means

Figure 1. Effect of boron and variety on days to emergence of two groundnut varieties

4.1.1.2 Effect of boron-variety interaction

From data (Table 1 and appendix III) it was found that V_1B_2 gave the best result compared to other interactions. This interaction took 6.33 days for first emergence and for last emergence V_1B_2 and V_1B_0 gave the similar result (16.50 days and 16.17 days, respectively).

Table 1. Effect boron-variety interaction on days to emergence of groundnut

Treatment	Days to emergence	
	first	last
Boron (B)×Variety(V)		
B_0V_1	8.83 a^z	16.17 c
B_1V_1	8.00 b	18.00 a
B_2V_1	6.33 d	16.50 c
B_0V_2	6.83 cd	16.83 bc
B_1V_2	6.83 cd	17.67 ab
B_2V_2	7.17 c	18.33 a
SE (±)	0.152	0.192
CV	5.08 %	2.90 %
Significance (*P*)		
B×V	**	**

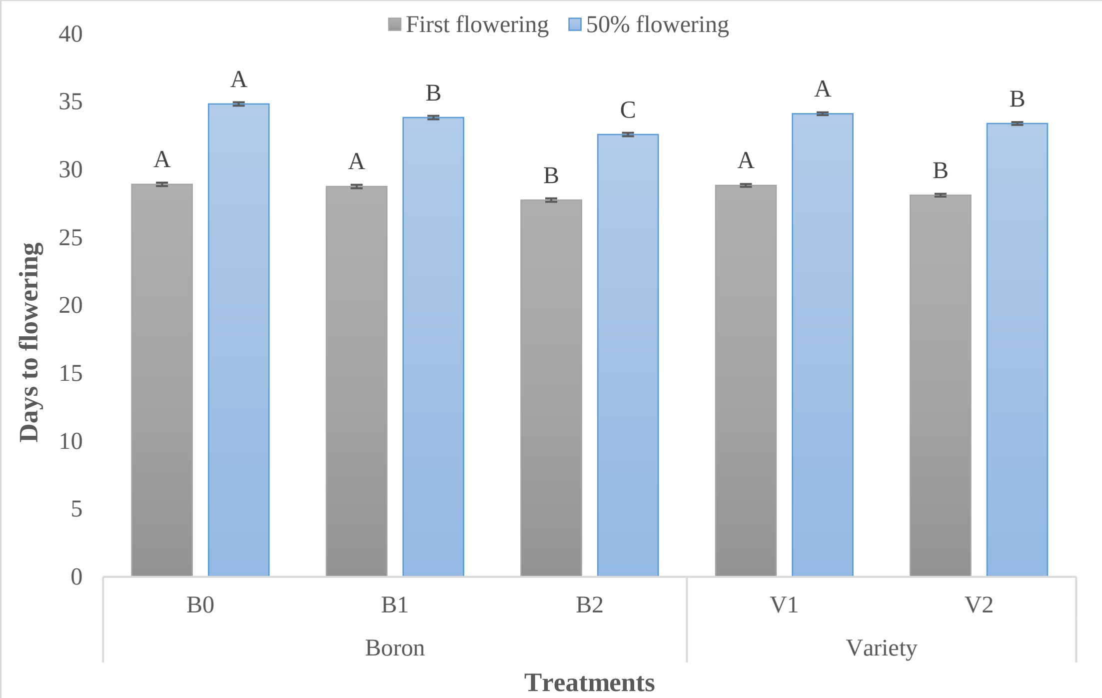
B= Boron; V= Variety; ^{z}means column having same letter (s) are insignificant and different later (s) statistically significant, P= Probability. Means were separated by Tukey's test at $P \leq 0.05$, **means significant at $p \leq 0.01$, B_0= 0 kg B ha^{-1}, B_1= 1 kg B ha^{-1}, B_2= 2 kg B ha^{-1}, V_1= Dhaka-1, V_2= BARI Chinabadam-8

4.1.2 Day to flowering

4.1.2.1 Effect of boron and variety

Boron applied at 2 kg ha^{-1} facilitated 2 days to 1st flowering (27.75 days) and 3 days early 50% of flowering (32.58 days) than the control (28.91 and 34.83 days, respectively) (Figure 2 and appendix III). Because, application of B had pronounced influence on flowering (Singh *et al*., 2009). Singh *et al*. (2009) reported that B application caused 2-3 days early flowering even application of boron reduced days to 50% flowering by 4-5 days over control in groundnut (Ansari *et al*., 2016).

Though light treatment showed 1 days early in days to 50% flowering, in spite of light treatment we couldn't report any findings, because light treatment was imposed after 30 days of seed sowing.



B= Boron; V= Variety; B_0= 0 kg B ha^{-1}, B_1= 1 kg B ha^{-1}, B_2= 2 kg B ha^{-}1. V_1=Dhaka-1, V_2= BARI Chinabadam-8. Means were separated by Tukey's test at $P \leq 0.05$. Vertical bars represent the standard error of the means.

Figure 2. Effect of boron and variety on days to flowering of two groundnut varieties

4.1.2.2 Effect of boron-variety interaction

Boron-variety interaction had no significant impact on days to first flowering but for days to 50% flowering it had a significant impact. Result showed that B_2V_2 interaction showed the earlier flowering over other interactions (Table 2 and appendix III).

Table 2. Effect of boron-variety interaction on days to flowering of groundnut

Treatment	Days to flowering	
	first	50%
Boron (B) × Variety (V)		
B_0V_1	29.17	34.83 a[z]
B_1V_1	29.17	34.33 a
B_2V_1	28.17	33.17 b
B_0V_2	28.67	34.83 a
B_1V_2	28.33	33.33 b
B_2V_2	27.33	32.00 c
SE (±)	-	0.180
CV	1.43 %	0.99 %
Significance (*P*)		
B×V	NS	**

B= Boron; V= Variety; [z]means column having same letter (s) are insignificant and different later (s) statistically significant, P= Probability. Means were separated by Tukey's test at $P \leq 0.05$, ** means significant at $p \leq 0.01$, NS=Non Significant, B_0= 0 kg B ha^{-1}, B_1= 1 kg B ha^{-1}, B_2= 2 kg B ha^{-1}, V_1= Dhaka-1, V_2= BARI Chinabadam-8

4.1.3 Plant height (cm)

4.1.3.1 Effect of light

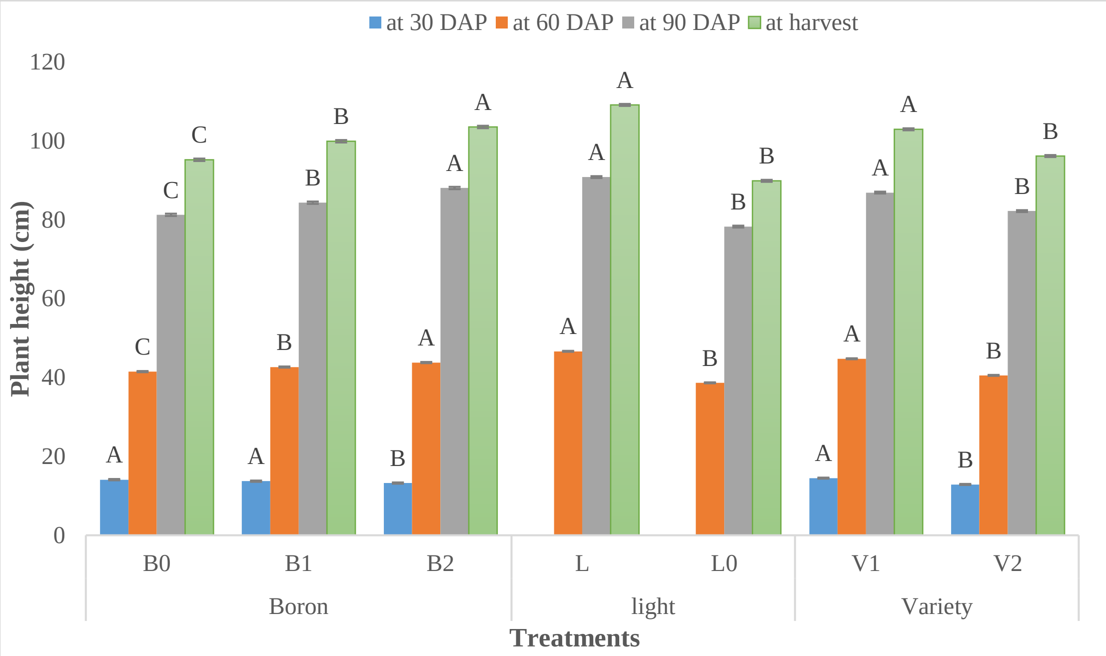
Plant height of both varieties increased gradually with the advancement of growth stage and up to harvest. The highest plant height was obtained from the light treatment (L) (13.74, 46.63, 90.79 and 109.08 cm at 30, 60, 90 DAP and during harvest, respectively) over the control (L_0) (13.63, 38.64, 78.24 and 89.84 cm at 30, 60, 90 DAP and during harvest time respectively) (Figure 3 and appendix IV). The fact that plant growth rate was significantly influenced by light in groundnut (Nigam *et al*., 1994). Wynne and Emery (1974) stated that long day photoperiod produced taller plants than the short day photoperiod.

4.1.3.2 Effect of boron

Plant height showed significant variations with the application of different doses of boron. Data revealed that 2 kg ha^{-1} B produced the highest plant height over the control at 30, 60, 90 DAP and during harvest time (Figure 3 and appendix IV). This might be due to that boron helped to cell elongation and meristematic tissue development in plant (Mengel and Kirkby, 1982). It was also reported that plant height increased with the application of boron in groundnut (Kabir *et al*., 2013).

4.1.3.3 Effect of variety

Dhaka-1 produced the highest plant height (14.48, 44.74, 86.86 and 102.90 cm) while BARI Chinabadam-8 showed the lowest and identical plant height (12.88, 40.53, 82.17 and 96.12 cm) at 30, 60, 90 DAP and during harvest time respectively (Figure 3 and appendix IV). This might be due to genetic variation among the varieties. The present finding is not consisted with the findings of Singh *et al*. (2007).



DAP= Days after planting, B= Boron; L=Light; V= Variety; B_0= 0 kg B ha^{-1}, B_1= 1 kg B ha^{-1}, B_2= 2 kg B ha^{-1}, L= normal day light + 6-h extended red light at night (≈18-h light), L_0= normal day light (≈12-h light), V_1=Dhaka-1, V_2= BARI Chinabadam-8. Means were separated by Tukey's test at $P \leq 0.05$. Vertical bars represent the standard error of the means.

Figure 3. **Effect of boron and light on the plant height of two groundnut varieties**

4.1.3.4 Effect of boron-variety interaction

Plant height showed significant variations with the application of different doses of boron. Data revealed that 2 kg boron ha^{-1} produced the highest plant height over the control at 90 DAP and during harvest time but at 30 DAP and 60 DAP there was no significant variations among the treatment interactions (Table 3 and appendix IV). Tallest plant was observed from V_1B_2 (Dhaka-1 and B at 2 kg ha^{-1}) treatment interaction at all sampling dates except at 30 DAP. Jiang *et al.* (1994) reported that the application of boron promoted the absorption of N by groundnuts and increased the plant height.

Table 3. Effect of boron-variety interaction on the plant height of groundnut

Treatment	Plant height (cm) at			
	30 DAP	60 DAP	90 DAP	Harvest
Boron (B) × Variety (V)				
B_0V_1	15.02	43.73	82.52 d^z	98.00 cd
B_1V_1	14.58	44.54	87.26 b	103.22 b
B_2V_1	13.84	45.96	90.81 a	107.47 a
B_0V_2	13.19	39.23	79.92 e	92.35 e
B_1V_2	12.84	40.74	81.35 de	96.52 d
B_2V_2	12.63	41.61	85.23 c	99.50 c
SE (±)	-	-	0.416	0.438
CV	4.94 %	1.26 %	1.15 %	1.05 %
Significance (*P*)				
B×V	NS	NS	**	*

DAP= Days After Planting, B= Boron; V= Variety; ^{z}means column having same letter (s) are insignificant and different later (s) statistically significant, P= Probability. Means were separated by Tukey's test at $P \leq 0.05$, ** means significant at $p \leq 0.01$, *means significant at $p \leq 0.05$, NS=Non Significant, B_0= 0 kg B ha^{-1}, B_1= 1 kg B ha^{-1}, B_2= 2 kg B ha^{-1}, V_1= Dhaka-1, V_2= BARI Chinabadam-8

4.1.3.5 Interaction effect of light, boron and variety

Interaction between light, boron and variety was observed a positive effect on plant height at 90 DAP. But data showed that there were no significant differences among the treatment interactions on plant height of groundnut at other sampling dates (Table 4 and appendix IV). Tallest plant was observed from LB_2V_1 treatment interaction at the growth stage of 90 DAP and at harvest.

Table 4. Interaction effect of light, boron and variety on the plant height of groundnut

Treatment	Plant height (cm) at		
	60 DAP	90 DAP	Harvest
Light(L)×Boron(B)×Variety(V)			
LB_0V_1	47.59	89.51 b^z	108.40
$L_0B_0V_1$	39.87	75.52 h	87.60
LB_1V_1	48.57	95.90 a	114.80
$L_0B_1V_1$	40.51	78.61 fg	91.64
LB_2V_1	49.82	98.45 a	118.54
$L_0B_2V_1$	42.11	83.17 de	96.39
LB_0V_2	43.26	85.30 cd	100.92
$L_0B_0V_2$	35.21	74.54 h	83.77
LB_1V_2	44.98	86.30 c	104.47
$L_0B_1V_2$	36.50	76.40 gh	88.57
LB_2V_2	45.59	89.28 b	107.34
$L_0B_2V_2$	37.62	81.17 ef	91.66
SE (±)	-	0.588	-
CV	1.26 %	1.15 %	1.05 %
Significance (*P*)			
L×B×V	NS	*	NS

DAP= Days After Planting, B= Boron; L= light; V= Variety; ^{z}means column having same letter (s) are insignificant and different later (s) statistically significant, P= Probability. Means were separated by Tukey's test at $P \leq 0.05$, *means significant at $p \leq 0.05$, NS=Non Significant, B_0= 0 kg B ha^{-1}, B_1= 1 kg B ha^{-1}, B_2= 2 kg B ha^{-}1, L= normal day light + 6-h extended red light at night (≈18-h light), L_0= normal day light (≈12-h light), V_1= Dhaka-1, V_2= BARI Chinabadam-8

4.1.4 Leaf area (cm^2)

4.1.4.1 Effect of light

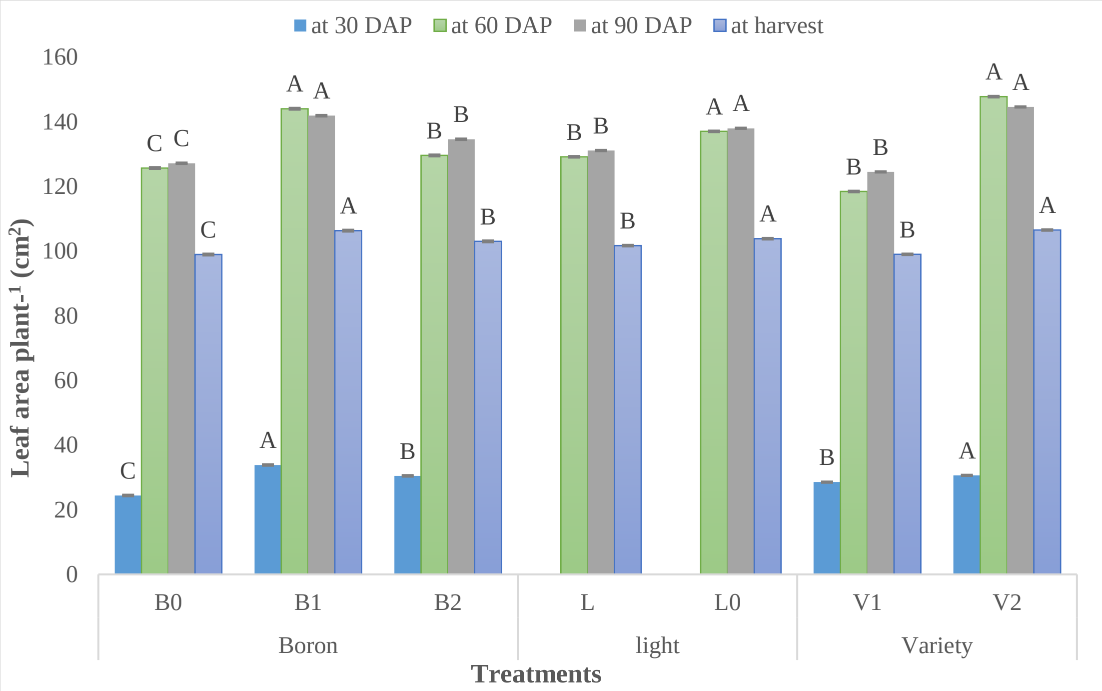
Leaf area of both varieties increased gradually with the advancement of growth stage up to certain days and then showed decreasing trend. The highest leaf area was obtained from the control treatment (L_0) over the light control (L) at 60, 90 DAP and during harvest (Figure 4 and appendix V). The result is not supported by that of Nigam *et al.* (1998). Imposition of light did not increase the leaf area, probably photosynthates increased leaf thickness instead of leaf area. In this study leaf thickness was not monitored.

4.1.4.2 Effect of boron

Leaf area of groundnut varied significantly among the varieties due to the effect of different doses of boron (Figure 4 and appendix V). The data revealed that 1 kg B ha^{-1} produced the highest leaf area and control plant produced the lowest leaf area. Probably boron deficiency inhibited the leaf expansion in groundnut (Dell & Huang, 1997). Kabir *et al*. (2013) also reported that the leaf area was increased with the application of boron.

4.1.4.3 Effect of variety

Among the two varieties BARI Chinabadam-8 (V_2) produced the highest leaf area over the Dhaka-1 (V_1) at 30 DAP, 60 DAP, 90 DAP and during harvest (Figure 4 and appendix V). This might be due to genetic variation among the varieties. Singh *et al*. (2007) reported that, in recent years, improved genotypes has increased the productivity of groundnut.



DAP= Days after planting, B= Boron; L=Light; V= Variety; B_0= 0 kg B ha^{-1}, B_1= 1 kg B ha^{-1}, B_2= 2 kg B ha^{-1}, L= normal day light + 6-h extended red light at night (≈18-h light), L_0= normal day light (≈12-h light), V_1=Dhaka-1, V_2= BARI Chinabadam-8. Means were separated by Tukey's test at $P \leq 0.05$. Vertical bars represent the standard error of the means.

Figure 4. **Effect of boron and light on leaf area of two groundnut varieties**

4.1.4.4 Effect of boron-variety interaction

Leaf area of groundnut varieties varied significantly with the application of different doses of boron. Boron-variety interaction produced the significant effect at leaf area plant^{-1} (Table 5 and appendix V). Data revealed that the V_2B_1 interaction gave the highest result at all sampling dates.

The findings of present study are in agreement with the findings of Kabir *et al*. (2013), they observed that leaf area was increased with the application of boron.

Table 5. **Effect of boron-variety interaction on leaf area of groundnut**

Treatment	Leaf area (cm^2) at			
	30 DAP	60 DAP	90 DAP	Harvest
Boron (B) × Variety (V)				
B_0V_1	25.99 d^z	107.48 e	113.97 f	94.46 e
B_1V_1	30.64 b	134.19 c	132.71 d	103.51 c
B_2V_1	28.96 c	113.64 d	126.80 e	99.04 d
B_0V_2	22.84 e	143.90 b	140.35 c	103.42 c
B_1V_2	37.05 a	153.85 a	151.03 a	109.13 a
B_2V_2	31.98 b	145.56 b	142.38 b	107.00 b
SE (±)	0.349	0.419	0.345	0.417
CV	1.54 %	0.99 %	0.42 %	0.97 %
Significance (*P*)				
B×V	**	**	**	**

DAP= Days After Planting, B= Boron; V= Variety; ^{z}means column having same letter (s) are insignificant and different later (s) statistically significant, P= Probability. Means were separated by Tukey's test at $P \leq 0.05$, ** means significant at $p \leq 0.01$, B_0= 0 kg B ha^{-1}, B_1= 1 kg B ha^{-1}, B_2= 2 kg B ha^{-1}, V_1= Dhaka-1, V_2= BARI Chinabadam-8

4.1.4.5 Interaction effect of light, boron and variety

Interaction between light, boron and variety had a great effect on leaf area. Data showed that the significant differences was observed in leaf area of groundnut at all sampling dates (Table 6 and appendix V). Highest leaf area was observed from $L_0B_1V_2$ treatment interaction compared to others interactions.

Table 6. Interaction effect of light boron and variety on leaf area of groundnut

Treatment	Leaf area plant^{-1} (cm^2) at		
	60 DAP	90 DAP	Harvest
Light(L)×Boron(B)×Variety(V)			
LB_0V_1	104.94 g^z	113.42 i	92.88 e
$L_0B_0V_1$	110.02 f	114.52 i	96.05 d
LB_1V_1	126.25 d	126.61 g	99.87 c
$L_0B_1V_1$	142.13 c	138.82 e	107.15 a
LB_2V_1	110.34 f	119.39 h	98.66 cd
$L_0B_2V_1$	116.93 e	134.21 f	99.42 c
LB_0V_2	140.44 c	138.80 e	103.20 b
$L_0B_0V_2$	147.35 b	141.90 cd	103.64 b
LB_1V_2	149.93 b	147.90 b	108.77 a
$L_0B_1V_2$	157.77 a	154.18 a	109.49 a
LB_2V_2	143.09 c	140.53 de	106.76 a
$L_0B_2V_2$	148.02 b	144.24 c	107.24 a
SE (±)	0.592	0.489	0.590
CV	0.99 %	0.42 %	0.97 %
Significance (*P*)			
L×B×V	**	**	**

DAP= Days After Planting, B= Boron; L= light; V= Variety; ^{z}means column having same letter (s) are insignificant and different later (s) statistically significant, P= Probability. Means were separated by Tukey's test at $P \leq 0.05$, ** means significant at $p \leq 0.01$, B_0= 0 kg B ha^{-1}, B_1= 1 kg B ha^{-1}, B_2= 2 kg B ha^{-1}, L= normal day light + 6-h extended red light at night (≈18-h light), L_0= normal day light (≈12-h light), V_1= Dhaka-1, V_2= BARI Chinabadam-8

4.2 Effect of boron and light on yield and yield attributes of groundnut

4.2.1 Number of branches plant^{-1}

4.2.1.1 Effect of light

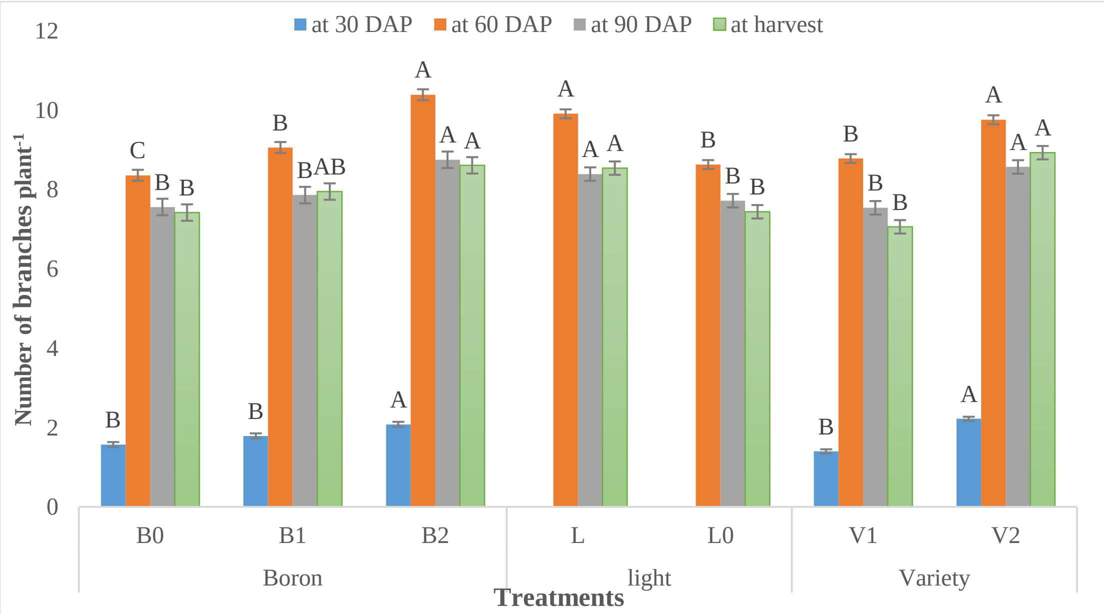
Number of branches plant^{-1} of groundnut showed statistically significant variations at 30 DAP, 60 DAP, 90 DAP and during harvest (Figure 5 and appendix VI). From the experiment it was observed that additional light helped to produce highest number of branches plant^{-1} of groundnut. Probably light helped to increase the vegetative growth in groundnut (Nigam *et al.*, 1998). Wynne *et al.* (1973) also reported that vegetative growth increased in long day treatment.

4.2.1.2 Effect of boron

Number of branches plant^{-1} showed significant variation due to different levels of boron application (Figure 5 and appendix VI). The data revealed that 2 kg B ha^{-1} produced the highest number of branches plant^{-1} and control plant produced the lowest number of branches plant^{-1} at all sampling dates in both of varieties. The possible reason behind the finding might be that B helps to promote the vegetative growth of groundnut (Singaravel *et al*., 2006). Similar result was obtained from other studies (Kabir *et al*., 2013 and Luo *et al*., 1990).

4.2.1.3 Effect of variety

Mean number of branch showed a wide range of variations among the two varieties. BARI Chinabadam-8 produced highest number of branch plant^{-1} at all the sampling dates whereas, Dhaka-1 produced lowest number of branch plant^{-1} (Figure 5 and appendix VI). This might be due to the genetic variation among the varieties. Singh *et al*. (2007) reported that, in recent years, improved genotypes showed increased productivity of groundnut.



DAP= Days after planting, B= Boron; L=Light; V= Variety; B_0= 0 kg B ha^{-1}, B_1= 1 kg B ha^{-1}, B_2= 2 kg B ha^{-1}, L= normal day light + 6-h extended red light at night (≈18-h light), L_0= normal day light (≈12-h light), V_1=Dhaka-1, V_2= BARI Chinabadam-8. Means were separated by Tukey's test at $P \leq 0.05$. Vertical bars represent the standard error of the means.

Figure 5. Effect of boron and light on the number of branches plant^{-1} of two groundnut varieties

4.2.1.4 Effect of boron-variety interaction

Number of branches palnt^{-1} was not significantly influenced by the interaction of boron doses and verities at different days after planting (DAP) (Table 7 and appendix VI). Result showed that maximum number of branches plant^{-1} was obtained from V_2B_2 at 30 DAP, 60 DAP, 90 DAP and during harvest.

Table 7. Effect of boron-variety interaction on the number of branches plant^{-1} in groundnut

Treatment	Number of branches plant^{-1} at			
	30 DAP	60 DAP	90 DAP	Harvest
Boron (B) × Variety (V)				
B_0V_1	1.24	7.72	7.00	6.45
B_1V_1	1.30	8.56	7.28	7.06
B_2V_1	1.67	10.06	8.33	7.67
B_0V_2	1.90	9.00	8.11	8.39
B_1V_2	2.28	9.56	8.45	8.83
B_2V_2	2.49	10.72	9.17	9.56
SE (±)	-	-	-	-
CV	12.67 %	5.28 %	10.21 %	8.85 %
Significance (*P*)				
B×V	NS	NS	NS	NS

DAP= Days After Planting, B= Boron; V= Variety; P= Probability. Means were separated by Tukey's test at $P \leq 0.05$, NS=Non Significant, B_0= 0 Kg B ha^{-1}, B_1= 1 Kg B ha^{-1}, B_2= 2 Kg B ha^{-1}, V_1= Dhaka-1, V_2= BARI Chinabadam-8

4.2.1.5 Interaction effect of light, boron and variety

Interaction effect of light boron-variety of groundnut showed insignificant differences on number of branches palnt^{-1} at all sampling dates (Table 8 and appendix VI). Mean number of branches plant^{-1} varied from B doses to doses. Though, LB_2V_2 produced the height number of branches plant^{-1} at all growth stages, there had no significant variation among the treatment interactions.

Table 8. Interaction effect of light-boron-variety on the number of branches plant^{-1} of groundnut

Treatment	Number of branches plant^{-1} at		
	60 DAP	90 DAP	Harvest
Light(L)×Boron(B)×Variety(V)			
LB_0V_1	8.11	7.33	7.00
$L_0B_0V_1$	7.33	6.67	5.89
LB_1V_1	9.11	7.67	7.67
$L_0B_1V_1$	8.00	6.89	6.44
LB_2V_1	9.78	8.33	8.33
$L_0B_2V_1$	10.33	8.33	7.00
LB_0V_2	10.33	8.33	9.22
$L_0B_0V_2$	7.67	7.89	7.56
LB_1V_2	11.00	8.78	9.33
$L_0B_1V_2$	8.11	8.11	8.33
LB_2V_2	11.11	9.89	9.67
$L_0B_2V_2$	10.33	8.45	9.44
SE (±)	-	-	-
CV	5.28 %	10.21 %	8.85 %
Significance (*P*)			
L×B×V	NS	NS	NS

DAP= Days After Planting, B= Boron; L= light; V= Variety; P= Probability. Means were separated by Tukey's test at $P \leq 0.05$, NS=Non Significant, B_0= 0 Kg B ha^{-1}, B_1= 1 Kg B ha^{-1}, B_2= 2 Kg B ha^{-1}, V_1= Dhaka-1, V_2= BARI Chinabadam-8

4.2.2 Shoot dry weight plant^{-1} (g)

4.2.2.1 Effect of light

Significant variation for shoot dry weight plant^{-1} of groundnut at 60, 90 DAP and at harvest were observed due to the effect of light (Figure 6 and appendix VII). Light treatment produced highest shoot dry weight during at all sampling dates over control. The reason behind the result might be due to that extended photoperiod helped to increase the vegetative growth (Ketring, 1979). The present finding is consisted with the finding of Nigam *et al*. (1998).

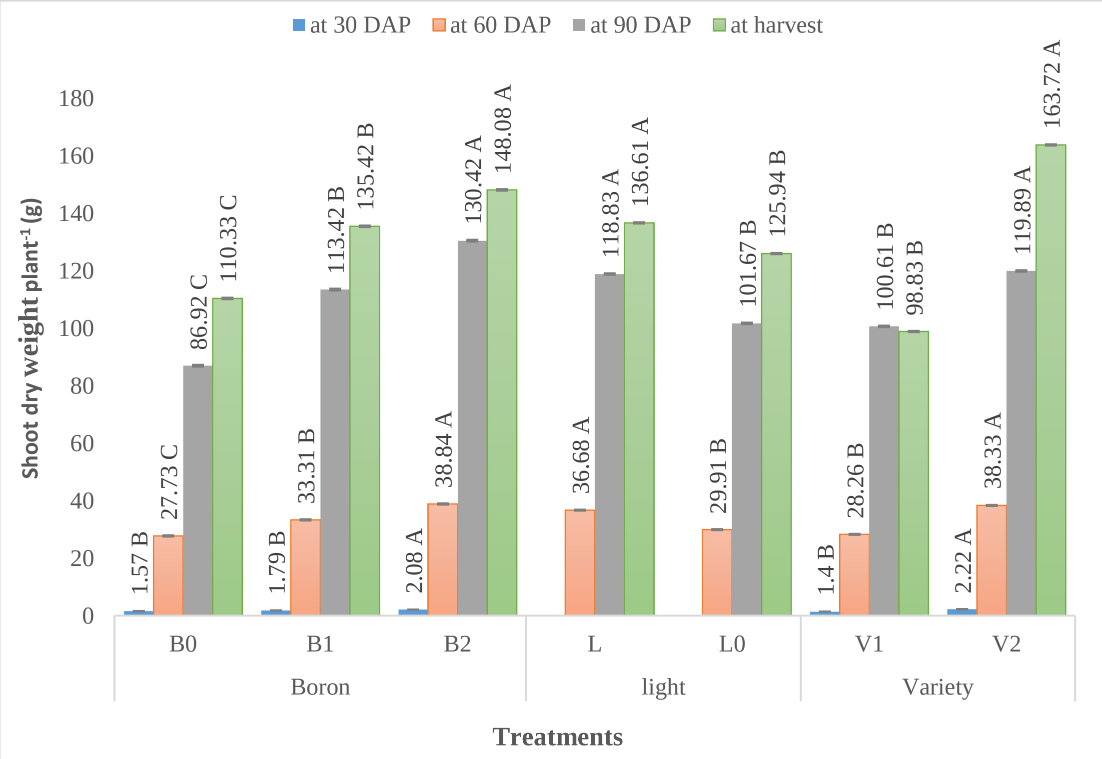
4.2.2.2 Effect of boron

The shoot dry weight of groundnut at 30, 60, 90 DAP and at harvest was influenced significantly due to different levels of boron application (Figure 6 and appendix VII). The highest shoot dry weight produced from 2 kg boron ha^{-1} and the lowest shoot dry weight palnt^{-1} was observed from control treatment. This might be due to that boron helped to increase the dry weight of groundnut plant (Kabir *et al*., 2013). Harris &

Brolmann, (1966) also reported that shoot dry weight increased with the application of boron in groundnut.

4.2.2.3 Effect of variety

Shoot dry weight of both varieties of groundnut increased as the age of the plants was increased up to the harvest. From the present study, significant variation was observed in terms of shoot dry weight plant^{-1} at all growth stages (Figure 6 and appendix VII). BARI chinabadam-8 produced the highest shoot dry weight whereas, Dhaka-1 produced the lowest shoot dry palnt^{-1}. The fact that genetic variations among the varieties. Singh *et al*. (2007) reported that, in recent years, improved genotypes had increased the productivity of groundnut.



DAP= Days After Planting, B= Boron; L=Light; V= Variety; B_0= 0 Kg B ha^{-1}, B_1= 1 Kg B ha^{-1}, B_2= 2 Kg B ha^{-1}, L= normal day light + 6-h extended red light at night (≈18-h light), L_0= normal day light (≈12-h light), V_1=Dhaka-1, V_2= BARI Chinabadam-8. Means were separated by Tukey's test at $P \leq 0.05$. Vertical bars represent the standard error of the means.

Figure 6. Effect of boron and light on shoot dry weight (g) plant^{-1} of two groundnut varieties

4.2.2.4 Effect of boron-variety interaction

The shoot dry weight of groundnut influenced significantly by the interaction of boron variety interaction except 30 DAP (Table 9 and appendix VII). B_2V_2 interaction produced the highest shoot dry weight plant^{-1} and B_0V_1 produced lowest shoot dry weight plant^{-1}.

Table 9. Effect of boron-variety interaction on shoot dry weight of groundnut

Treatment	Shoot dry weight plant^{-1} (g) at			
	30 DAP	60 DAP	90 DAP	Harvest
Boron (B) × Variety (V)				
B_0V_1	1.24	23.29 e^z	76.17 e	78.33 f
B_1V_1	1.30	29.44 d	110.67 c	105.50 e
B_2V_1	1.67	32.06 c	115.00 b	112.67 d
B_0V_2	1.90	32.18 c	97.67 d	142.33 c
B_1V_2	2.28	37.19 b	116.17 b	165.33 b
B_2V_2	2.49	45.61 a	145.83 a	183.50 a
SE (±)	-	0.338	0.466	0.404
CV	12.67 %	2.53 %	1.13 %	0.55 %
Significance (*P*)				
B×V	NS	**	**	**

DAP= Days After Planting, B= Boron; V= Variety; ^{z}means column having same letter (s) are insignificant and different later (s) statistically significant, P= Probability. Means were separated by Tukey's test at P ≤ 0.05, ** means significant at p ≤ 0.01, NS=Non Significant, B_0= 0 Kg B ha^{-1}, B_1= 1 Kg B ha^{-1}, B_2= 2 Kg B ha^{-1}, V_1= Dhaka-1, V_2= BARI Chinabadam-8

4.2.2.5 Interaction effect of light, boron and variety

Interaction effect of light, boron and variety showed the range of significant variation at all sampling dates except during 30 DAP (Table 10 and appendix VII). BARI Chinabdam-8 and light produced the highest shoot dry weight at all sampling dates with 2 kg B ha^{-1} compared than that of others interactions.

Table 10. Interaction effect of light-boron-variety on shoot dry weight of groundnut

Treatment	Shoot dry weight plant^{-1} (g) at		
	60 DAP	90 DAP	Harvest
Light(L)×Boron(B)×Variety(V)			
LB_0V_1	26.30 g	88.00 g	88.67 j
$L_0B_0V_1$	20.27 h	64.33 i	68.00 k
LB_1V_1	33.74 de	107.00 f	106.33 hi
$L_0B_1V_1$	25.14 g	114.33 de	104.67 i
LB_2V_1	34.90 cd	113.00 e	117.00 g
$L_0B_2V_1$	29.22 f	117.00 cd	108.33 h
LB_0V_2	31.47 ef	114.67 de	144.33 e
$L_0B_0V_2$	32.89	80.67 h	140.33 f
LB_1V_2	39.29 b	119.67 bc	168.33 c
$L_0B_1V_2$	35.09 cd	112.67 e	162.33 d
LB_2V_2	54.39 a	170.67 a	195.00 a
$L_0B_2V_2$	36.83 bc	121.00 b	172.00 b
SE (±)	0.477	0.659	0.571
CV	2.53 %	1.13 %	0.55 %
Significance (*P*)			
L×B×V	**	**	**

DAP= Days After Planting, B= Boron; L= light; V= Variety; [z]means column having same letter (s) are insignificant and different later (s) statistically significant, P= Probability. Means were separated by Tukey's test at $P \leq 0.05$, ** means significant at $p \leq 0.01$, NS=Non Significant, B_0= 0 kg B ha^{-1}, B_1= 1 kg B ha^{-1}, B_2= 2 kg B ha^{-1}, L= normal day light + 6-h extended red light at night (≈18-h light), L_0= normal day light (≈12-h light), V_1= Dhaka-1, V_2= BARI Chinabadam-8

4.2.3 Number of flowers plant^{-1}

4.2.3.1 Effect of light

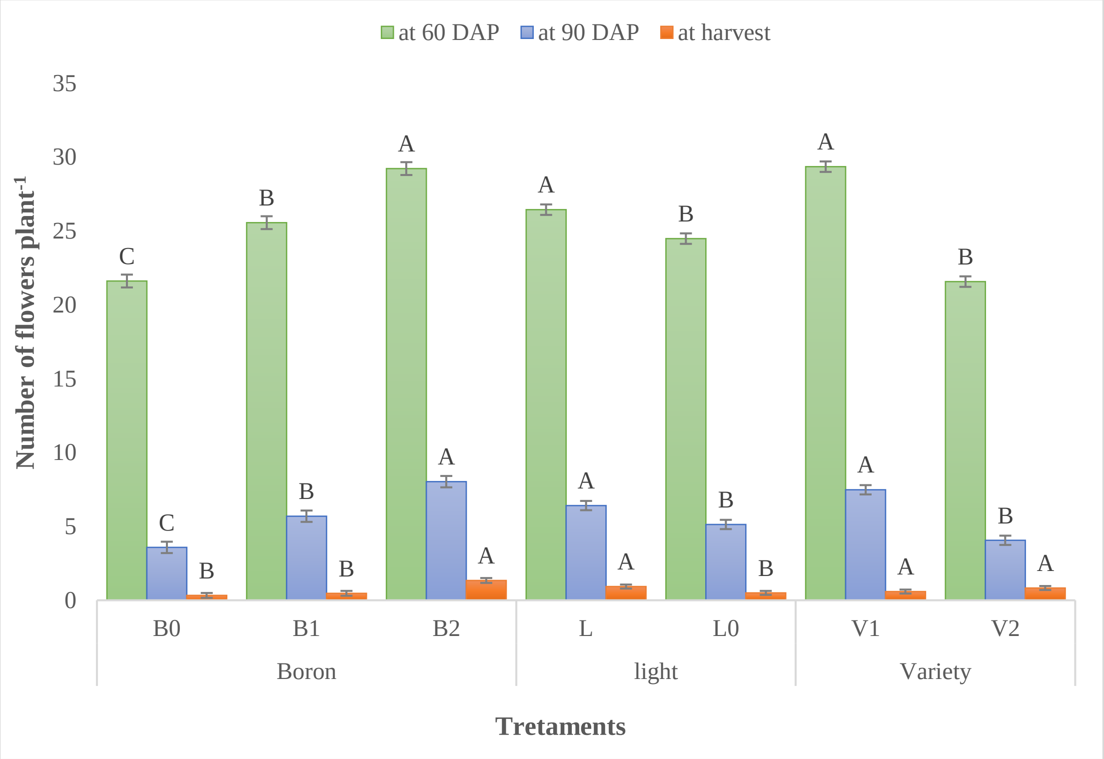
Number of flowers decreased gradually with the increase in plant age due to either pod formation or shedding. Light had the significant result on number of flowers plant^{-1} at all sampling dates (Figure 7 and appendix VIII). Light produced highest flowers at 60 DAP, 90 DAP and during harvest. It might be due to light helped to increase flowering. Cox (1987) stated that the number of flowers was markedly reduced as less light was received by the plants, and the present finding consisted with their findings.

4.2.3.2 Effect of boron

Number of flowers plant^{-1} varied significantly due to influence of different levels of boron application (Figure 7 and appendix VIII). It was noticed that the highest number of flowers plant^{-1} obtained from 2 kg B ha^{-1} and lowest was observed with 0 kg B ha^{-1}. During harvest 2 kg B ha^{-1} and control had a statistically similar result. This might be due to boron had a special importance in retaining flowering and fruit setting of legumes crops (Zhang, 2001). It was reported that total number of flowers increased by B fertilization (Gupta, 1993) and application of B had pronounced influence on flowering in peanut (Singh *et al*., 2009).

4.2.3.3 Effect of variety

Number of flowers plant^{-1} significantly varied from variety to variety. In the present study, data showed that Dhaka-1 produced the maximum number of flowers plant^{-1} over BARI Chinabadam-8 (Figure 7 and appendix VIII). This might be due to genetic variations among the varieties. Singh *et al*. (2007) reported that, in recent years, improved genotypes showed increased productivity of groundnut that is not supported by the present finding.



DAP= Days After Planting, B= Boron; L=Light; V= Variety; B_0= 0 kg B ha^{-1}, B_1= 1 kg B ha^{-1}, B_2= 2 kg B ha^{-1}, L= normal day light + 6-h extended red light at night (≈18-h light), L_0= normal day light (≈12-h light), V_1=Dhaka-1, V_2= BARI Chinabadam-8. Means were separated by Tukey's test at $P \leq 0.05$. Vertical bars represent the standard error of the means.

Figure 7. Effect of boron and light on the number of flowers plant^{-1} of two groundnut varieties

4.2.3.4 Effect of boron-variety interaction

Number of flowers plant^{-1} was significantly influenced by the interaction application of variety and boron at different days after planting (DAP) (Table 11 and appendix VIII). Result showed that the maximum number of flowers plant^{-1} was produced from B_2V_1 at 60 and 90 DAP, respectively. Thought B_2V_2 treatment showed the best result during harvest compared to other interactions but there had no significant variation among the treatment interactions during harvest.

Table 11. Effect of boron-variety interaction on the number of flowers plant^{-1} of groundnut

Treatment	Number of flowers plant^{-1} at		
	60 DAP	90 DAP	Harvest
Boron (B) × Variety (V)			
B_0V_1	25.33 c^z	4.22 cd	0.28
B_1V_1	28.39 b	7.67 b	0.44
B_2V_1	34.33 a	10.56 a	1.06
B_0V_2	17.89 d	2.95 d	0.39
B_1V_2	22.72 c	3.72 cd	0.50
B_2V_2	24.11 c	5.50 bc	1.61
SE (±)	0.615	0.544	-
CV	5.04 %	23.55 %	100.53 %
Significance (*P*)			
B×V	**	**	NS

DAP= Days After Planting, B= Boron; V= Variety; ^{z}means column having same letter (s) are insignificant and different later (s) statistically significant, P= Probability. Means were separated by Tukey's test at $P \leq 0.05$, ** means significant at $p \leq 0.01$, NS=Non Significant, B_0= 0 kg B ha^{-1}, B_1= 1 kg B ha^{-1}, B_2= 2 kg B ha^{-1}, V_1= Dhaka-1, V_2= BARI Chinabadam-8

4.2.3.5 Interaction effect of light, boron and variety

Interaction of boron, varieties and light on number of flowers plant^{-1} of groundnut showed an insignificant result (Table 12 and appendix VIII). Though, the result revealed that LB_2V_1 treatment produced the highest number of flowers palnt^{-1} at 60 and 90 DAP, respectively and at harvest LB_2V_2 produced the maximum number of flowers plant^{-1}over other interactions but there had no significant variations among treatment interactions.

Table 12. Interaction effect of light-boron-variety on the number of flowers plant^{-1} of groundnut

Treatment	Number of flowers plant^{-1} at		
	60 DAP	90 DAP	Harvest
Light (L) × Boron(B) × Variety (V)			
LB_0V_1	26.22	4.56	0.33
$L_0B_0V_1$	24.44	3.89	0.22
LB_1V_1	29.22	8.78	0.56
$L_0B_1V_1$	27.56	6.56	0.33
LB_2V_1	35.33	12.44	1.45
$L_0B_2V_1$	33.33	8.67	0.67
LB_0V_2	19.55	3.11	0.44
$L_0B_0V_2$	16.22	2.78	0.33
LB_1V_2	23.22	4.00	0.56
$L_0B_1V_2$	22.22	3.44	0.43
LB_2V_2	25.11	5.55	2.22
$L_0B_2V_2$	23.11	5.44	1.00
SE (±)	-	-	-
CV	5.04 %	23.55 %	100.53 %
Significance (*P*)			
L×B×V	NS	NS	NS

DAP= Days After Planting, B= Boron; L= light; V= Variety; P= Probability. Means were separated by Tukey's test at $P \leq 0.05$, NS=Non Significant, B_0= 0 Kg B ha^{-1}, B_1= 1 Kg B ha^{-1}, B_2= 2 Kg B ha^{-1}, L= normal day light + 6-h extended red light at night (≈18-h light), L_0= normal day light (≈12-h light), V_1= Dhaka-1, V_2= BARI Chinabadam-8

4.2.4 Number of pegs plant^{-1}

4.2.4.1 Effect of light

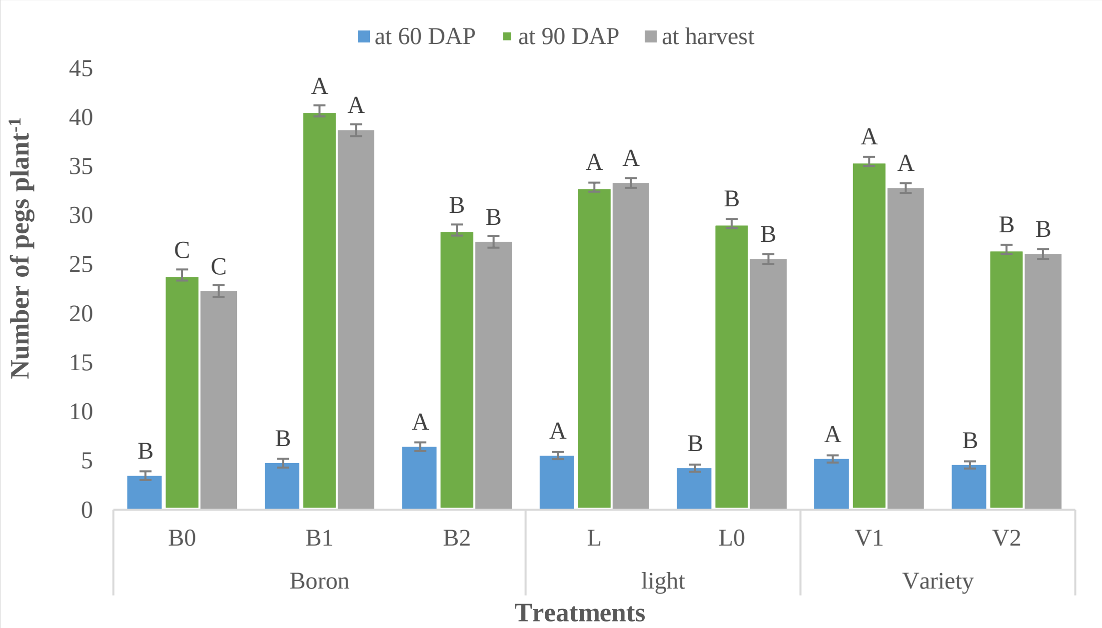
Light had a significant influenced on number of pegs plant^{-1} of groundnut (Figure 8 and appendix IX). Light treatment always produced the highest number of pegs plant^{-1} over control treatment. Light didn't help profuse pegging (Stalker and Wynne, 1983) that was not consisted with the present finding. This might be due to change of different locations and climatic condition.

4.2.4.2 Effect of boron

Number of pegs plant^{-1} showed significant variation with the application of different doses of boron (Figure 8 and appendix IX). Boron at 2-kg ha^{-1} produced the highest number of pegs plant^{-1} at 60 DAP but B at 1-kg ha^{-1} produced the highest number of pegs plant^{-1} at 90 DAP and during harvest compared to control. Probably boron deficiency inhibited peg development (Smith, 1954). Naiknaware *et al*. (2015) also reported that number of pegs increased with the application of boron.

4.2.4.3 Effect of variety

Number of pegs plant^{-1} of groundnut varied significantly from variety to variety (Figure 8 and appendix IX). Dhaka-1 produced the highest number of pegs plant^{-1} compared to BARI Chinabadam-8 at 60, 90 DAP and at during harvest. This might be due to genetic variations among the varieties. Singh *et al*. (2007) reported that, in recent years, improved genotypes increased the productivity of groundnut that is not supported by the present finding.



DAP= Days After Planting, B= Boron; L=Light; V= Variety; B_0= 0 kg B ha^{-1}, B_1= 1 kg B ha^{-1}, B_2= 2 kg B ha^{-1}, L= normal day light + 6-h extended red light at night (≈18-h light), L_0= normal day light (≈12-h light), V_1=Dhaka-1, V_2= BARI Chinabadam-8. Means were separated by Tukey's test at $P \leq 0.05$. Vertical bars represent the standard error of the means.

Figure 8. Effect of boron and light on the number of pegs plant^{-1} of two groundnut varieties

4.2.4.4 Effect of boron-variety interaction

Interaction effect of boron-variety varied significantly in terms of number of pegs plant^{-1} at all sampling dates except 30 DAP (Table 13 and appendix IX). It was observed that the B_2V_1 produced maximum number of pegs plant^{-1} at 60 DAP but B_1V_1 produced the maximum number of pegs plant^{-1} at rest of the sampling dates compared to others interactions.

Table 13. Effect of boron-variety interaction on the number of pegs plant^{-1} of groundnut

Treatment	Number of pegs plant^{-1} at		
	60 DAP	90 DAP	Harvest
Boron (B) × Variety (V)			
B_0V_1	3.22	25.39 c^z	25.33 d
B_1V_1	5.00	48.22 a	43.50 a
B_2V_1	7.33	32.89 b	29.50 c
B_0V_2	3.72	22.45 c	19.22 e
B_1V_2	4.50	33.06 b	33.83 b
B_2V_2	5.50	24.11 c	25.11 d
SE (±)	-	0.800	0.853
CV	23.59 %	7.51 %	7.66 %
Significance (*P*)			
B×V	NS	**	*

DAP= Days After Planting, B= Boron; V= Variety; ^{z}means column having same letter (s) are insignificant and different later (s) statistically significant, P= Probability. Means were separated by Tukey's test at $P \leq 0.05$, ** means significant at $p \leq 0.01$, *means significant at $p \leq 0.05$, NS=Non Significant, B_0= 0 kg B ha^{-1}, B_1= 1 kg B ha^{-1}, B_2= 2 kg B ha^{-1}, V_1= Dhaka-1, V_2= BARI Chinabadam-8

4.2.4.5 Interaction effect of light, boron and variety

Interaction effect of light, boron and variety had an insignificant influenced on number of pegs plant^{-1} of groundnut at all sampling dates except 90 DAP (Table 14 and appendix IX). LB_2V_1 treatment produced the highest number of pegs plant^{-1} at 60 DAP but at 90 DAP and during harvest LB_1V_1 produced the maximum number of pegs plant^{-1} of groundnut over other interactions.

Table 14. Interaction effect of light-boron-variety on the number of pegs plant^{-1} of groundnut

Treatment	Number of pegs plant^{-1} at		
	60 DAP	90 DAP	Harvest
Light (L) × Boron(B) × Variety (V)			
LB_0V_1	3.56	24.33 cd^z	31.22
$L_0B_0V_1$	2.89	24.45 cd	19.44
LB_1V_1	5.33	58.22 a	46.78
$L_0B_1V_1$	4.67	38.22 b	40.22
LB_2V_1	8.22	28.00 c	34.22
$L_0B_2V_1$	6.44	37.78 b	24.78
LB_0V_2	4.11	23.78 cd	21.22
$L_0B_0V_2$	3.33	21.11 d	17.22
LB_1V_2	5.56	38.67 b	37.33
$L_0B_1V_2$	3.44	27.44 c	30.33
LB_2V_2	6.34	24.22 cd	29.00
$L_0B_2V_2$	4.67	24.00 cd	21.22
SE (±)	-	1.131	-
CV	23.59 %	7.51 %	7.66 %
Significance (*P*)			
L×B×V	NS	**	NS

DAP= Days After Planting, B= Boron; L= light; V= Variety; ^{z}means column having same letter (s) are insignificant and different later (s) statistically significant, P= Probability. Means were separated by Tukey's test at P ≤ 0.05, ** means significant at p ≤ 0.01, NS=Non Significant, B_0= 0 kg B ha^{-1}, B_1= 1 kg B ha^{-1}, B_2= 2 kg B ha^{-1}, L= normal day light + 6-h extended red light at night (≈18-h light), L_0= normal day light (≈12-h light), V_1= Dhaka-1, V_2= BARI Chinabadam-8

4.2.5 Number of pods plant^{-1}

4.2.5.1 Effect of light

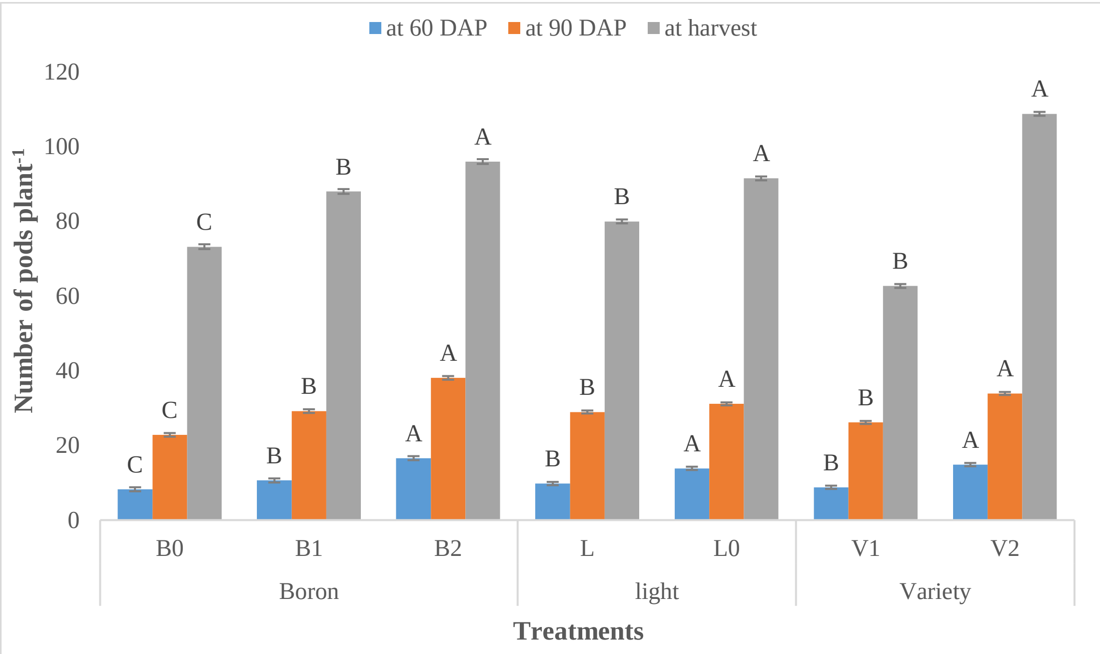
Significant variation was observed for pods plant^{-1} of groundnut from different light treatments at 60, 90 DAP and at harvest. Light treatment produced minimum number of pods plant^{-1} at 60, 90 DAP and at harvest (Figure 9 and appendix X). In light treatment, plants produced the lowest number of pods compared to control. The present finding consisted with the finding of Bagnall and King (1991).

4.2.5.2 Effect of boron

The number of pods plant^{-1} of groundnut was significantly influenced by the application of different levels of boron. B at 2 kg ha^{-1} produced maximum number of pods plant^{-1} and lowest pods was recorded from control treatment (Figure 9 and appendix X). This might be due to that B had a pronounced effect on stigma receptivity, sticky and making pollen grain fertile and enhanced the pollination (Kaisher, 2010). Even boron helped in formation of chlorophyll, photosynthetic process & activation of enzymes as well as grain formation (Naiknaware *et al*., 2015). The present finding consisted with the findings of Luo *et al*. (1990).

4.2.5.3 Effect of variety

Variety had a significant effect on number of pods plant^{-1} of groundnut and BARI Chinabadam-8 produced the highest number of pods plant^{-1} at 60, 90 DAP and during harvest. On the other hand, Dhaka-1 produced lowest number of pods plant^{-1} at all sampling dates (Figure 9 and appendix X). This might be due to that genetic variation among the varieties. Singh *et al*. (2007) reported that, in recent years, improved genotypes increased the productivity of groundnut.



DAP= Days After Planting, B= Boron; L=Light; V= Variety; B_0= 0 kg B ha^{-1}, B_1= 1 kg B ha^{-1}, B_2= 2 kg B ha^{-1}, L= normal day light + 6-h extended red light at night (≈18-h light), L_0= normal day light (≈12-h light), V_1=Dhaka-1, V_2= BARI Chinabadam-8. Means were separated by Tukey's test at $P \leq 0.05$. Vertical bars represent the standard error of the means.

Figure 9. Effect of boron and light on the number of pods plant^{-1} of two groundnut varieties

4.2.5.4 Effect of boron-variety interaction

Interaction of doses and varieties on the number of pods plant^{-1} showed a wide range of variations. BARI Chinabadam-8 with B-2 kg ha^{-1} produced highest number of pods plant^{-1} and Dhaka-1 with no boron produced the lowest number of pods plant^{-1} (Table 15 and appendix X).

Table 15. Effect of boron-variety interaction on number of pods plant^{-1} of groundnut

Treatment	Number of pods plant^{-1} at		
	60 DAP	90 DAP	Harvest
Boron (B) × Variety (V)			
B_0V_1	6.22 d^z	20.06 d	50.33 f
B_1V_1	8.45 cd	26.50 c	63.38 e
B_2V_1	11.67 bc	31.83 b	74.22 d
B_0V_2	10.28 bc	25.56 c	96.00 c
B_1V_2	12.78 b	31.83 b	112.50 b
B_2V_2	21.50 a	44.28 a	117.67 a
SE (±)	0.769	0.696	0.908
CV	15.80 %	5.42 %	2.67 %
Significance (*P*)			
B×V	**	**	*

DAP= Days After Planting, B= Boron; V= Variety; ^{z}means column having same letter (s) are insignificant and different later (s) statistically significant, P= Probability. Means were separated by Tukey's test at $P \leq 0.05$, ** means significant at $p \leq 0.01$, *means significant at $p \leq 0.05$, B_0= 0 kg B ha^{-1}, B_1= 1 kg B ha^{-1}, B_2= 2 kg B ha^{-1}, V_1= Dhaka-1, V_2= BARI Chinabadam-8

4.2.5.5 Interaction effect of light, boron and variety

Interaction effect of light, boron and variety had a significant influenced on number of pods plant^{-1} of groundnut at all sampling dates except 60 DAP. Data revealed that the $L_0B_2V_2$ treatment produced highest number of pods plant^{-1} but LB_0V_1 produced the lowest number of pods plant^{-1} (Table 16 and appendix X). But at 60 DAP $L_0B_2V_2$ and LB_2V_2 gave the similar result.

Table 16. Interaction effect of light-boron-variety on number of pods plant^{-1} of groundnut

Treatment	Number of pods plant^{-1} at		
	60 DAP	90 DAP	Harvest
Light(L)×Boron(B)×Variety(V)			
LB_0V_1	5.22	18.00 g^z	45.67 h
$L_0B_0V_1$	7.22	22.11 fg	55 g
LB_1V_1	7.33	27.45 de	49.44 gh
$L_0B_1V_1$	9.56	25.56 def	77.33 e
LB_2V_1	10.44	33.56 c	63.78 f
$L_0B_2V_1$	12.89	30.11 cd	84.67 d
LB_0V_2	7.00	23.56 ef	94.67 c
$L_0B_0V_2$	13.56	27.56 de	97.33 c
LB_1V_2	8.33	29.78 cd	111.33 b
$L_0B_1V_2$	17.22	33.89 c	113.67 b
LB_2V_2	20.33	41.22 b	114.67 ab
$L_0B_2V_2$	22.67	47.33 a	120.67 a
SE (±)	-	0.984	1.283
CV	15.80 %	5.42 %	2.67 %
Significance (*P*)			
L×B×V	NS	**	**

DAP= Days After Planting, B= Boron; L= light; V= Variety; ^{z}means column having same letter (s) are insignificant and different later (s) statistically significant, P= Probability. Means were separated by Tukey's test at $P \le 0.05$, ** means significant at $p \le 0.01$, NS=Non Significant, B_0= 0 kg B ha^{-1}, B_1= 1 kg B ha^{-1}, B_2= 2 kg B ha^{-1}, L= normal day light + 6-h extended red light at night (≈18-h light), L_0= normal day light (≈12-h light), V_1= Dhaka-1, V_2= BARI Chinabadam-8

4.2.6 Pods dry weight plant^{-1} (g)

4.2.6.1 Effect of light

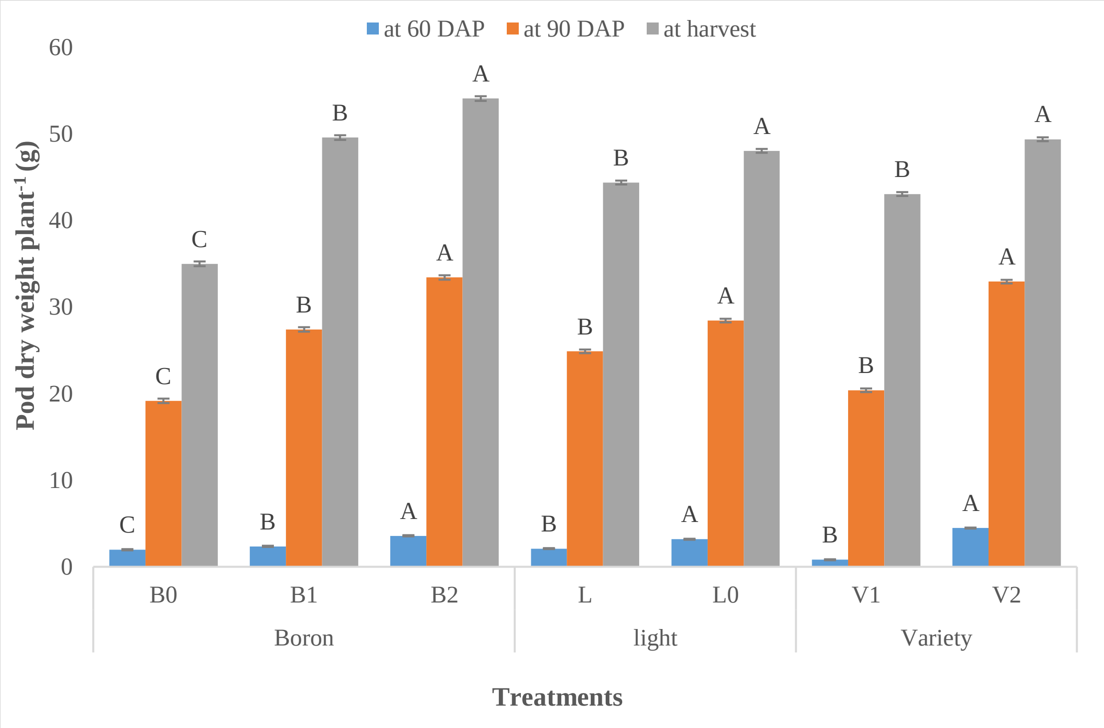
Pods dry weight plant^{-1} of groundnut increased gradually with throughout the harvesting. Always, control treatment produced the highest pods dry weight plant^{-1} over the light treatment (Figure 10 and appendix XI). The reason behind the finding might be due to extend photoperiod had limited reproductive growth (Ketring, 1979). Bagnall and King (1991) stated the same findings.

4.2.6.2 Effect of boron

Pods dry weight plant^{-1} showed significant variations with the application of different levels of boron on groundnut. Data revealed that the application of B at 2-kg ha^{-1} produced maximum pods dry weight plant^{-1} and control treatment produced lowest pod dry weight plant^{-1} (Figure 10 and appendix XI). This might be due to that pods dry weight significantly increased with the application of B (Ansari *et al*., 2013). The present finding is agreed with the findings of Chitdeshwari & Poongothai (2003).

4.2.6.3 Effect of variety

Variety had a significant effect on pods dry weight plant^{-1} of groundnut. BARI Chinabadam-8 produced the highest pods dry weight plant^{-1} than to Dhaka-1 (Figure 10 and appendix XI). This might be due to genetic variations among the varieties. Singh *et al*. (2007) reported that, in recent years, improved genotypes increased the productivity of groundnut.



DAP= Days After Planting, B= Boron; L=Light; V= Variety; B_0= 0 kg B ha^{-1}, B_1= 1 kg B ha^{-1}, B_2= 2 kg B ha^{-1}, L= normal day light + 6-h extended red light at night (≈18-h light), L_0= normal day light (≈12-h light), V_1=Dhaka-1, V_2= BARI Chinabadam-8. Means were separated by Tukey's test at $P \leq 0.05$. Vertical bars represent the standard error of the means.

Figure 10. **Effect of boron and light on pod dry weight plant^{-1} of two groundnut varieties**

4.2.6.4 Effect of boron-variety interaction

Interaction effect of variety and boron interaction also had a significant influenced on pods dry weight plant^{-1} of groundnut. BARI Chinabadam-8 with B at 2 kg B ha^{-1} produced the highest pods dry weight plant^{-1} (Table 17 and appendix XI). V_1B_0

treatment produced the lowest pods dry weight plant^{-1}. But during harvest there had no significant variation among the treatment interactions.

Table 17. Effect of boron-variety interaction on pod dry weight plant^{-1} of groundnut

Treatment	Pod dry weight plant^{-1} (g) at		
	60DAP	90DAP	Harvest
Boron (B) × Variety (V)			
B_0V_1	0.50 e^z	16.00 e	31.50
B_1V_1	0.76 de	21.50 d	46.33
B_2V_1	1.15 d	23.67 c	51.01
B_0V_2	3.45 c	22.33 cd	38.50
B_1V_2	3.97 b	33.33 b	52.50
B_2V_2	6.01 a	43.17 a	57.17
SE (±)	0.100	0.365	-
CV	8.48 %	2.76 %	2.18 %
Significance (*P*)			
B×V	**	**	NS

DAP= Days After Planting, B= Boron; V= Variety; ^{z}means column having same letter (s) are insignificant and different later (s) statistically significant, P= Probability. Means were separated by Tukey's test at $P \leq 0.05$, ** means significant at $p \leq 0.01$, NS=Non Significant, B_0= 0 kg B ha^{-1}, B_1= 1 kg B ha^{-1}, B_2= 2 kg B ha^{-1}, V_1= Dhaka-1, V_2= BARI Chinabadam-8

4.2.6.5 Interaction effect of light, boron and variety

Interaction of light, boron and varieties on pods dry weight plant^{-1} showed a wide range of variations at all growth stages except at 60 DAP (Table 18 and appendix XI). Result revealed that the $L_0B_2V_2$ produced highest pods dry palnt^{-1} at 60, 90 DAP and at harvest compared to others interactions.

Table 18. Interaction effect of light-boron-variety on pod dry weight plant^{-1} of groundnut

Treatment	Pod dry weight plant^{-1} (g) at		
	60 DAP	90 DAP	Harvest
Light(L)×Boron(B)×Variety(V)			
LB_0V_1	0.48	15.67 g^z	31.33 f
$L_0B_0V_1$	0.52	16.33 g	31.67 f
LB_1V_1	0.55	20.00 f	44.00 e
$L_0B_1V_1$	0.97	23.00 de	49.33 d
LB_2V_1	1.08	23.00 de	50.02 d
$L_0B_2V_1$	1.23	24.33 d	52.00 cd
LB_0V_2	2.71	20.67 ef	34.00 f
$L_0B_0V_2$	4.18	24.00 d	43.00 e
LB_1V_2	2.86	33.00 c	51.67 cd
$L_0B_1V_2$	5.07	33.67 c	53.33 bc
LB_2V_2	4.88	37.00 b	55.33 b
$L_0B_2V_2$	7.13	49.33 a	59.00 a
SE (±)	-	0.516	0.549
CV	8.48 %	2.76 %	2.18 %
Significance (*P*)			
L×B×V	NS	**	**

DAP= Days After Planting, B= Boron; L= light; V= Variety; ^{z}means column having same letter (s) are insignificant and different later (s) statistically significant, P= Probability. Means were separated by Tukey's test at $P \leq 0.05$, **means significant at $p \leq 0.01$, NS=Non Significant, B_0= 0 kg B ha^{-1}, B_1= 1 kg B ha^{-1}, B_2= 2 kg B ha^{-1}, L= normal day light + 6-h extended red light at night (≈18-h light), L_0= normal day light (≈12-h light), V_1= Dhaka-1, V_2= BARI Chinabadam-8

4.2.7 The hundred seeds weight (g)

4.2.7.1 Effect of light

The 100 seed weight of groundnut had a significant influenced on light treatment. It was noticed that control treatment produced the highest 100 seeds weight over the light treatment (Figure 11 and appendix XII). Probably light treatment decreased the reproductive development of groundnut Bagnall and King, (1991). The similar result was reported by Nigam *et al*. (1998).

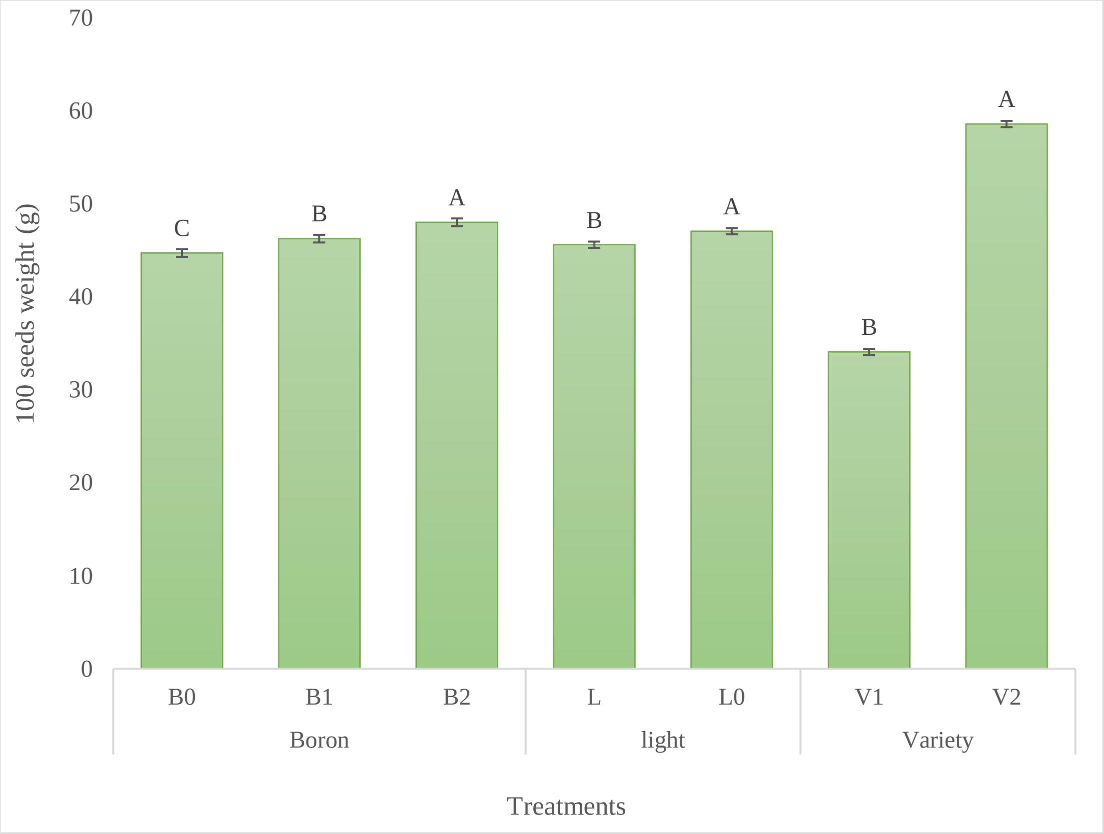
4.2.7.2 Effect of boron

Hundred seed weight of groundnut showed significant variations with the application of different levels of boron. Data revealed that the application of B at 2-kg ha^{-1} produced the highest 100 seeds weight over the control treatment (Figure 11 and appendix XII). This might be due to that application of boron helped to increase the 100 seed weight

Kabir *et al*. (2013). The present investigations were supported by Singaravel *et al*. (2006) and Luo *et al*. (1990).

4.2.7.3 Effect of variety

Variety had a significant effect on hundred seed weight of groundnut. BARI Chinabadam-8 produced the highest 100 seeds weight than to the Dhaka-1 (Figure 11 and appendix XII). This might be due to that genetic variation among the varieties. Singh *et al*. (2007) reported that, in recent years, improved genotypes increased the productivity of groundnut.



B= Boron; L=Light; V= Variety; B_0= 0 kg B ha^{-1}, B_1= 1 kg B ha^{-1}, B_2= 2 kg B ha^{-1}, L= normal day light + 6-h extended red light at night (≈18-h light), L_0= normal day light (≈12-h light), V_1=Dhaka-1, V_2= BARI Chinabadam-8. Means were separated by Tukey's test at $P \leq 0.05$. Vertical bars represent the standard error of the means.

Figure 11. **Effect of boron and light on 100 seed weight of two groundnut varieties**

4.2.7.4 Effect of boron-variety interaction

Interaction effect of variety and boron interaction had no significant influenced on hundred seeds weight of groundnut. BARI Chinabadam-8 with 2-kg B ha^{-1} produced highest hundred seed weight (Table 19 and appendix XII). B_0V_1 treatment produced the lowest 100 seeds weight.

Table 19. Effect of boron-variety interaction on 100 seed weight of groundnut

Treatment	100 seed weight (g)
Boron (B) × Variety (V)	
B_0V_1	32.49
B_1V_1	34.11
B_2V_1	35.62
B_0V_2	56.93
B_1V_2	58.39
B_2V_2	60.41
SE (±)	-
CV	2.28 %
Significance (*P*)	
B×V	NS

B= Boron; V= Variety; P= Probability. Means were separated by Tukey's test at $P \leq 0.05$, NS=Non Significant, B_0= 0 kg B ha^{-1}, B_1= 1 kg B ha^{-1}, B_2= 2 kg B ha^{-1}, V_1= Dhaka-1, V_2= BARI Chinabadam-8

4.2.7.5 Interaction effect of light boron and variety

Interaction of light and doses-varieties on hundred seed weight of groundnut showed an insignificant variation (Table 20 and appendix XII). Result revealed that the $L_0B_2V_2$ treatment produced highest hundred seed weight compared to other interactions.

Table 20. Interaction effect of light-boron-variety interaction on 100 seed weight of groundnut

Treatment	100 seed weight (g)
Light (L) × Boron (B) × Variety (V)	
LB_0V_1	31.76
$L_0B_0V_1$	33.21
LB_1V_1	33.87
$L_0B_1V_1$	34.36
LB_2V_1	34.67
$L_0B_2V_1$	36.56
LB_0V_2	56.39
$L_0B_0V_2$	57.48
LB_1V_2	57.33
$L_0B_1V_2$	59.45
LB_2V_2	59.58
$L_0B_2V_2$	59.58
SE (±)	-
CV	2.28 %
Significance (*P*)	
L×B×V	NS

B= Boron; L= light; V= Variety; P= Probability. Means were separated by Tukey's test at $P \leq 0.05$, NS=Non Significant, B_0= 0 kg B ha^{-1}, B_1= 1 kg B ha^{-1}, B_2= 2 kg B ha^{-1}, L= normal day light + 6-h extended red light at night (≈18-h light), L_0= normal day light (≈12-h light), V_1= Dhaka-1, V_2= BARI Chinabadam-8

4.2.8 Shelling percentage

4.2.8.1 Effect of light

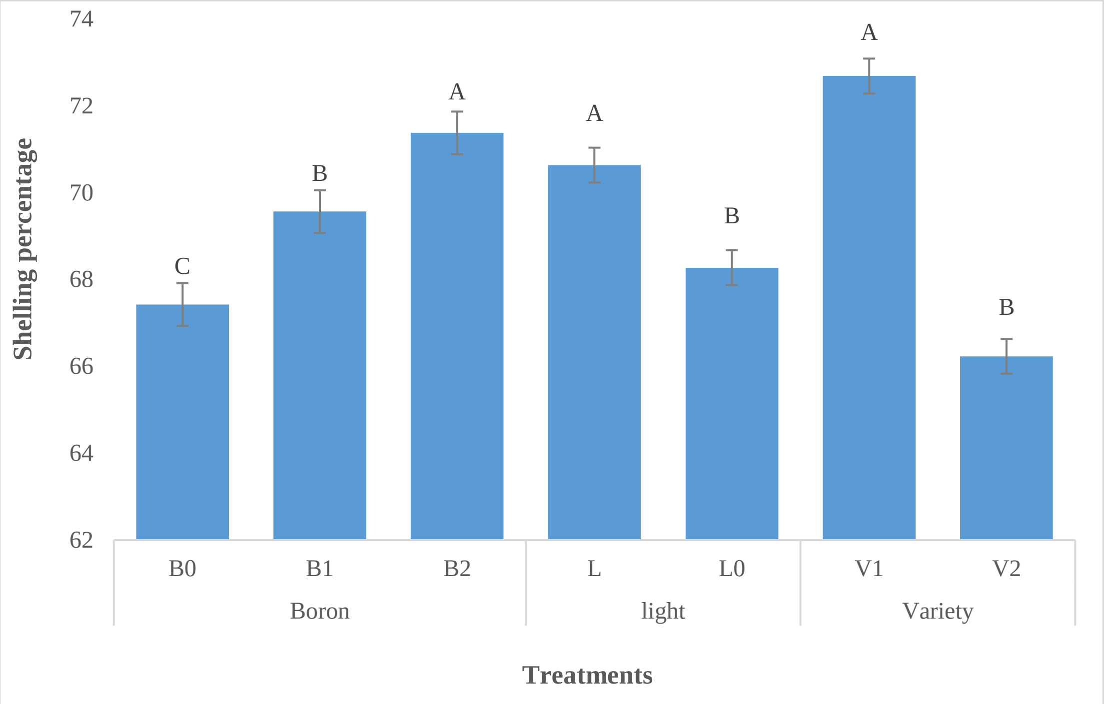
Significant variation for the shelling percentage of groundnut were observed due to light treatments (Figure 12 and appendix XII). Light produced the highest shelling percentage than to control. This might be that light had a significant effect to shell development in groundnut and make the healthier seeds. Probably during stress condition plant made defense mechanism on itself (Sharma *et al*., 2012). Demmig-Adams and Adams, (1992) reported that plants exposed to excessive light can suffer photo-inhibition, serious damage to the photosynthetic apparatus, and degradation of photosynthetic proteins.

4.2.8.2 Effect of boron

The shelling percentage of groundnut was influenced significantly due to that different levels of boron application. The highest shelling percentage recorded from B at 2-kg ha^{-1} and the lowest shelling percentage was observed in control treatment (Figure 12 and appendix XII). The fact that boron was involved in cell development (Naiknaware *et al*., 2015). Golakiya and Patel (1986) also reported that B helped to increase the shelling percentage of groundnut.

4.2.8.3 Effect of variety

In present study, a significant variation of shelling percentage in both varieties of groundnut was observed. From the experiment it was noticed that Dhaka-1 produced the highest shelling percentage whereas, BARI Chinabadam-8 produced lowest (Figure 12 and appendix XII). This might be due to that genetic variations among the varieties. Singh *et al*. (2007) reported that, in recent years, improved genotypes increased the productivity of groundnut.



B= Boron; L=Light; V= Variety; B_0= 0 kg B ha^{-1}, B_1= 1 kg B ha^{-1}, B_2= 2 kg B ha^{-1}, L= normal day light + 6-h extended red light at night (≈18-h light), L_0= normal day light (≈12-h light), V_1=Dhaka-1, V_2= BARI Chinabadam-8. Means were separated by Tukey's test at $P \leq 0.05$. Vertical bars represent the standard error of the means.

Figure 12. Effect of boron and light on shelling percentage of two groundnut varieties

4.2.8.4 Effect of boron-variety interaction

The shelling percentage of groundnut influenced insignificantly by interaction of boron variety interaction. B_2V_1 treatment produced the highest shelling percentage and B_0V_2 produced the lowest shelling percentage (Table 21 and appendix XII).

Table 21. Effect of boron-variety interaction on shelling percentage of groundnut

Treatment	Shelling percentage
Boron (B) × Variety (V)	
B_0V_1	70.95
B_1V_1	72.85
B_2V_1	74.22
B_0V_2	63.89
B_1V_2	66.27
B_2V_2	68.52
SE (±)	-
CV	2.56 %
Significance (*P*)	
B×V	NS

B= Boron; V= Variety; P= Probability. Means were separated by Tukey's test at $P \leq 0.05$, B_0= 0 kg B ha^{-1}, B_1= 1 kg B ha^{-1}, B_2= 2 kg B ha^{-1}, V_1= Dhaka-1, V_2= BARI Chinabadam-8

4.2.8.5 Interaction effect of light, boron and variety

Interaction effect of light, boron and variety did not show the variations in terms of shelling percentage (Table 22 and appendix XII). Though Dhaka-1 produced highest shelling percentage with light and 2-kg B ha^{-1} whereas, BARI Chinabdam-8 produced the lowest shelling percentage with control boron and light treatment, but there had no significant variations among the treatment interactions.

Table 22. Interaction effect of light-boron-variety on shelling percentage of groundnut

Treatment	Shelling percentage
Light (L) × Boron (B) × Variety (V)	
LB_0V_1	71.85
$L_0B_0V_1$	70.05
LB_1V_1	73.51
$L_0B_1V_1$	72.19
LB_2V_1	75.23
$L_0B_2V_1$	73.22
LB_0V_2	64.94
$L_0B_0V_2$	62.84
LB_1V_2	67.45
$L_0B_1V_2$	65.08
LB_2V_2	70.80
$L_0B_2V_2$	66.25
SE (±)	-
CV	2.56 %
Significance (*P*)	
L×B×V	NS

B= Boron; L= light; V= Variety; P= Probability. Means were separated by Tukey's test at $P \leq 0.05$, NS=Non Significant, B_0= 0 kg B ha^{-1}, B_1= 1 kg B ha^{-1}, B_2= 2 kg B ha^{-1}, L= normal day light + 6-h extended red light at night (≈18-h light), L_0= normal day light (≈12-h light), V_1= Dhaka-1, V_2= BARI Chinabadam-8

4.2.9 Pod yield (t/ha)

4.2.9.1 Effect of light

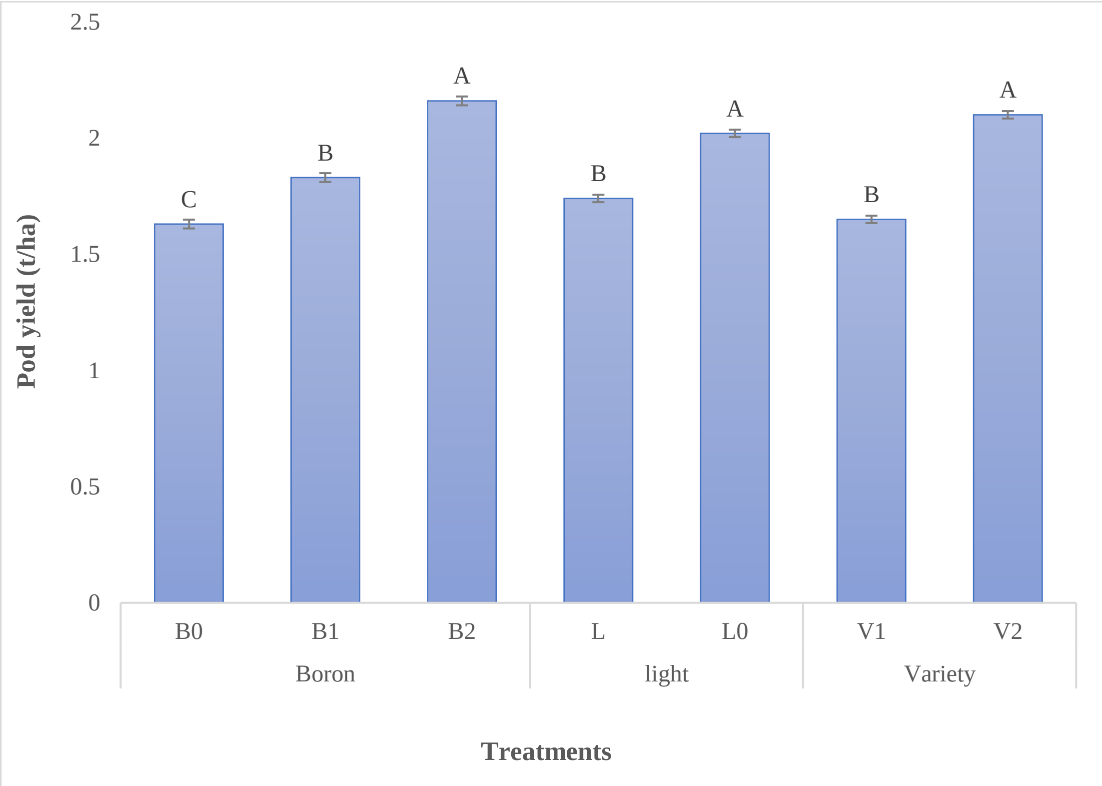
Total pod yields of groundnut showed statistically significant variations with the light treatment. From the experiment it was observed that light produced lowest pod yield (2.02 t/ha) than to control treatment (1.74 t/ha) (Figure 13 and appendix XII). This might be due to that extended photoperiod limited the reproductive development of groundnut (Ketring, 1979). The present finding is consisted with the findings of Wynne & Emery (1974).

4.2.9.2 Effect of boron

Pod yield showed significant variations due to different levels of boron application. The data revealed that B at 2- kg ha^{-1} produced the highest total pods yield (2.16 kg ha^{-1}) and control plant produced the lowest pods yield (1.63 t/ha) (Figure 13 and appendix XII). This might be that B helped to increase the reproductive development of groundnut and finally increased the pods yield (Jena *et al.*, 2009). Naiknaware *et al.* (2015) reported that, with the application of boron increased the pod yield of groundnut.

4.2.9.3 Effect of variety

Pod yield had significant variations in both of the varieties. BARI Chinabadam-8 produced the highest pod yield (2.10 t/ha) whereas, Dhaka-1 produced the lowest pod yield (1.65 t/ha) (Figure 13 and appendix XII). This might be due to that genetic variations between the varieties. Singh *et al*. (2007) reported that, in recent years, improved genotypes increased the productivity of groundnut.



B= Boron; L=Light; V= Variety; B_0= 0 Kg B ha^{-1}, B_1= 1 Kg B ha^{-1}, B_2= 2 Kg B ha^{-1}, L= normal day light + 6-h extended red light at night (≈18-h light), L_0= normal day light (≈12-h light), V_1=Dhaka-1, V_2= BARI Chinabadam-8. Means were separated by Tukey's test at $P \leq 0.05$. Vertical bars represent the standard error of the means.

Figure 13. **Effect of boron and light on total pod yield of two groundnut varieties**

4.2.9.4 Effect of boron-variety interaction

Pod yield was significantly influenced by the interaction of boron doses and varieties. Result showed that, the highest total pod yield was obtained from B_2V_2 (2.48 t/ha) compared to other interactions (Table 23 and appendix XII).

Table 23. Effect of boron-variety interaction on total pod yield of groundnut

Treatment	Yield (t/ha)
Boron (B) x Variety (V)	
B_0V_1	1.50 d^z
B_1V_1	1.61 d
B_2V_1	1.84 c
B_0V_2	1.76 c
B_1V_2	2.07 b
B_2V_2	2.48 a
SE (±)	0.027
CV	4.16 %
Significance (*P*)	
B×V	**

B= Boron; V= Variety; ^{z}means column having same letter (s) are insignificant and different later (s) statistically significant, P= Probability. Means were separated by Tukey's test at $P \leq 0.05$. **means significant at $p \leq 0.01$, B_0= 0 kg B ha^{-1}, B_1= 1 kg B ha^{-1}, B_2= 2 kg B ha^{-1}, V_1= Dhaka-1, V_2= BARI Chinabadam-8

4.2.9.5 Interaction effect of light, boron and variety

Interaction effect of light, boron and variety of groundnut showed significant differences on the pod yield. Total pod yield varied from B doses to doses (Table 24 and appendix XII). The data revealed that the $L_0B_2V_2$ produced the height total pod yield (2.75 t/ha) compared to other treatment interactions.

Table 24. Interaction effect of light-boron-variety on total pod yield of groundnut

Treatment	Yield (t/ha)
Light (L) × Boron(B) × Variety (V)	
LB_0V_1	1.43 g^z
$L_0B_0V_1$	1.57 fg
LB_1V_1	1.51 fg
$L_0B_1V_1$	1.70 def
LB_2V_1	1.86 cd
$L_0B_2V_1$	1.82 cd
LB_0V_2	1.61 efg
$L_0B_0V_2$	1.92 c
LB_1V_2	1.80 cde
$L_0B_1V_2$	2.34 b
LB_2V_2	2.20 b
$L_0B_2V_2$	2.75 a
SE (±)	0.038
CV	4.16 %
Significance (*P*)	
L×B×V	**

B= Boron; L= light; V= Variety; ^{z}means column having same letter (s) are insignificant and different later (s) statistically significant, P= Probability. Means were separated by Tukey's test at $P \leq 0.05$, **means significant at $p \leq 0.01$, B_0= 0 kg B ha^{-1}, B_1= 1 kg B ha^{-1}, B_2= 2 kg B ha^{-1}, L= normal day light + 6-h extended red light at night (≈18-h light), L_0= normal day light (≈12-h light), V_1= Dhaka-1, V_2= BARI Chinabadam-8

4.2.10 Seed yield (t ha^{-1})

4.2.10.1 Effect of light

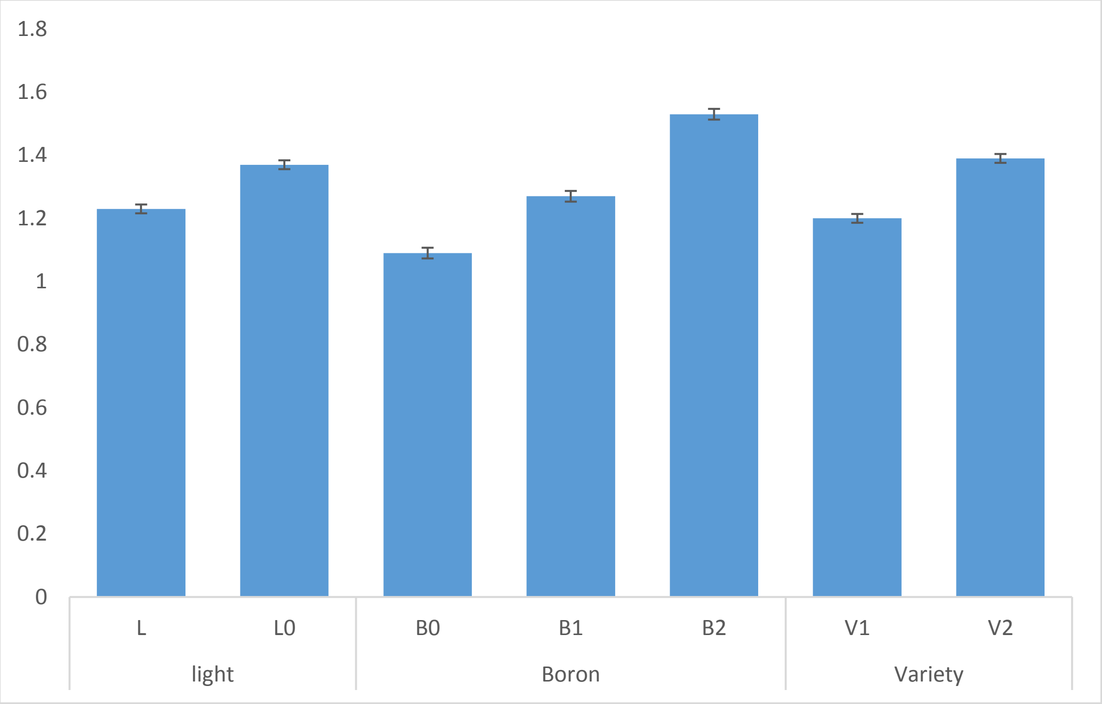
Seed yield showed significant variations due to imposition of light. The highest seed yield was obtained from the control treatment (L_0) (1.37 t/ha) over the light treatment (L) (1.23 t/ha) (Figure 14 and appendix XII). The fact that imposition of light decreased the reproductive development of groundnut (Bagnall and King, 1991). The similar result was reported by Nigam *et al*. (1998).

4.2.10.2 Effect of boron

Boron applied at 2 kg ha^{-1} facilitated the highest seed yield (1.53 t/ha) than the control (1.09 t/ha) (Figure 14 and appendix XII). This might be due to that boron helped to increased seed yield of groundnut (Kabir *et al*., 2013). The present investigated result was supported by Singaravel *et al*. (2006) and Luo *et al*. (1990).

4.2.10.3 Effect of variety

BARI Chinabadam-8 produced the highest amount of seed yield (1.39 t ha^{-1}) while Dhaka-1 showed the lowest (1.20 t ha^{-1}) (Figure 14 and appendix XII). This might be due to genetic variation among the varieties. Singh *et al*. (2007) reported that, in recent years, improved genotypes increased the productivity of groundnut.



DAP= Days after planting, B= Boron; L=Light; V= Variety; B_0= 0 kg B ha^{-1}, B_1= 1 kg B ha^{-1}, B_2= 2 kg B ha^{-1}, L= normal day light + 6-h extended red light at night (≈18-h light), L_0= normal day light (≈12-h light), V_1=Dhaka-1, V_2= BARI Chinabadam-8. Means were separated by Tukey's test at $P \leq 0.05$. Vertical bars represent the standard error of the means.

Figure 14. Effect of boron and light on seed weight (t ha^{-1}) of two groundnut varieties

4.2.10.4 Effect of boron-variety interaction

Seed yield showed significant variations with the application of different doses of boron in both of verities. Data revealed that 2 B kg ha^{-1} with BARI Chinabadam-8 produced the highest seed yield over other interactions (Table 25 and appendix XII).

Table 25. Effect of boron-variety interaction on seed yield of groundnut

Treatment	Seed weight (t/ha)
Boron (B) × Variety (V)	
B_0V_1	1.07 c
B_1V_1	1.12 c
B_2V_1	1.17 c
B_0V_2	1.37 b
B_1V_2	1.37 b
B_2V_2	1.69 a
SE (±)	0.024
CV	4.71
Significance (*P*)	
B×V	**

B= Boron; V= Variety; ^{z}means column having same letter (s) are insignificant and different later (s) statistically significant, P= Probability. Means were separated by Tukey's test at $P \leq 0.05$, ** means significant at $p \leq 0.01$, B_0= 0 kg B ha^{-1}, B_1= 1 kg B ha^{-1}, B_2= 2 kg B ha^{-1}, V_1= Dhaka-1, V_2= BARI Chinabadam-8

4.2.10.5 Interaction effect of light, boron and variety

Interaction between light boron and variety had a significant effect on seed yield and data showed that $L_0B_2V_2$ gave the best result compared to other combinations (Table 26 and Appendix XII).

Table 26. Interaction effect of light, boron and variety on seed yield of groundnut

Treatment	Seed yield (t/ha)
Light (L) × Boron (B) × Variety (V)	
LB_0V_1	1.03 e[z]
$L_0B_0V_1$	1.04 e
LB_1V_1	1.11 e
$L_0B_1V_1$	1.21 de
LB_2V_1	1.40 bcd
$L_0B_2V_1$	1.56 b
LB_0V_2	1.10 e
$L_0B_0V_2$	1.20 de
LB_1V_2	1.23 de
$L_0B_1V_2$	1.52 bc
LB_2V_2	1.33 cd
$L_0B_2V_2$	1.82 a
SE (±)	0.033
CV	4.71
Significance (*P*)	
L×B×V	*

B= Boron; L= light; V= Variety; [z]means column having same letter (s) are insignificant and different later (s) statistically significant, P= Probability. Means were separated by Tukey's test at $P \leq 0.05$, *means significant at $p \leq 0.05$, B_0= 0 kg B ha^{-1}, B_1= 1 kg B ha^{-1}, B_2= 2 kg B ha^{-}1, L= normal day light + 6-h extended red light at night (≈18-h light), L_0= normal day light (≈12-h light), V_1= Dhaka-1, V_2= BARI Chinabadam-8

4.2.11 Stover yield (t/ha)

4.2.11.1 Effect of light

There had no significant variations in the stover yield of groundnut due to the light treatment (Figure 15 and appendix XII). Light treatment and control produced statistically similar result (5.47 t/ha and 5.22 t/ha, respectively). The fact is that light helped to increase the vegetative growth in groundnut (Nigam *et al*., 1998). Wynne *et al*. (1973) also reported that vegetative growth increased light treatment.

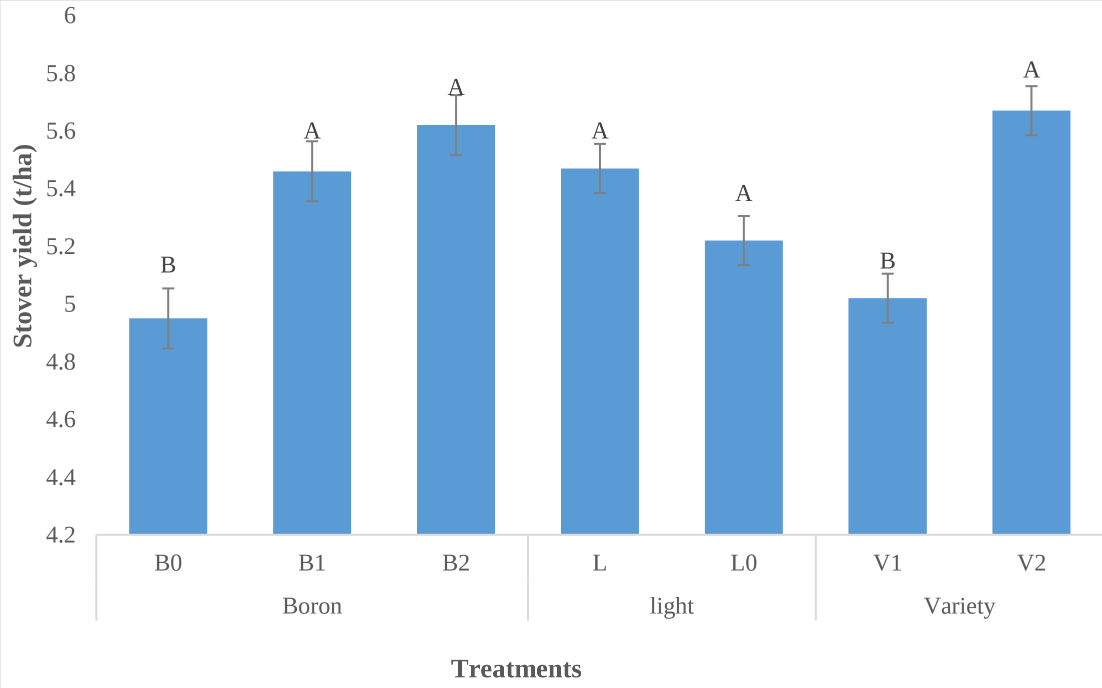
4.2.11.2 Effect of boron

The stover yield of groundnut was influenced significantly due to different levels of boron application (Figure 15 and appendix XII). The highest stover yield (5.62 t/ha) produced from 2-kg B ha^{-1} which was statistically similar with 1-kg B ha^{-1} (5.46 t/ha) and the lowest stover yield was recorded from control treatment (4.95 t/ha). This might be due to that boron helped to increase the vegetative development of groundnut

(Singaravel *et al*., 2006). The present finding is consisted with the findings of Kabir *et al*. (2013)

4.2.11.3 Effect of variety

From this study significant variations were observed in stover yield of groundnut (Figure 15 and appendix XII). BARI chinabadam-8 produced the highest stover yield (5.67 t/ha) whereas, Dhaka-1 produced the lowest stover yield (5.02 t/ha). This might be due to genetic variation among the varieties. Singh *et al*. (2007) reported that, in recent years, improved genotypes increased the productivity of groundnut.



B= Boron; L=Light; V= Variety; B_0= 0 kg B ha^{-1}, B_1= 1 kg B ha^{-1}, B_2= 2 kg B ha^{-1}, L= normal day light + 6-h extended red light at night (≈18-h light), L_0= normal day light (≈12-h light), V_1=Dhaka-1, V_2= BARI Chinabadam-8. Means were separated by Tukey's test at $P \leq 0.05$. Vertical bars represent the standard error of the means.

Figure 15. **Effect of boron and light on stover yield of two groundnut varieties**

4.2.11.4 Effect of boron-variety interaction

The stover yield of groundnut had no significant influenced by the boron-variety interaction (Table 27 and appendix XII). B_2V_2 produced the highest stover yield (5.99 t/ha) and V_1B_0 produced the lowest stover yield (4.60 t/ha).

Table 27. Effect of boron-variety interaction on the stover yield of groundnut

Treatment	Stover yield (t/ha)
Boron(B) × Variety (V)	
B_0V_1	4.60
B_1V_1	5.20
B_2V_1	5.26
B_0V_2	5.29
B_1V_2	5.72
B_2V_2	5.99
SE (±)	-
CV	6.73 %
Significance (*P*)	
B×V	NS

B= Boron; V= Variety; P= Probability. Means were separated by Tukey's test at $P \leq 0.05$, NS= Non significant, B_0= 0 kg B ha^{-1}, B_1= 1 kg B ha^{-1}, B_2= 2 kg B ha^{-1}, V_1= Dhaka-1, V_2= BARI Chinabadam-8

4.2.11.5 Interaction effect of light, boron and variety

Interaction effect of light, boron and variety had no significant effect on treatment stover yield of groundnut (Table 28 and appendix XII).

Table 28. Interaction effect of light-boron-variety on the stover yield of groundnut

Treatment	Stover yield (t/ha)
Light (L) × Boron(B) × Variety (V)	
LB_0V_1	5.09
$L_0B_0V_1$	4.13
LB_1V_1	5.27
$L_0B_1V_1$	5.13
LB_2V_1	5.33
$L_0B_2V_1$	5.18
LB_0V_2	5.29
$L_0B_0V_2$	5.29
LB_1V_2	5.80
$L_0B_1V_2$	5.64
LB_2V_2	6.02
$L_0B_2V_2$	5.95
SE (±)	-
CV	6.73 %
Significance (*P*)	
L×B×V	NS

B= Boron; L= light; V= Variety; [z]means column having same letter (s) are insignificant and different later (s) statistically significant, P= Probability. Means were separated by Tukey's test at $P \leq 0.05$, NS= Non significant, B_0= 0 kg B ha^{-1}, B_1= 1 kg B ha^{-1}, B_2= 2 kg B ha^{-1}, L= normal day light + 6-h extended red light at night (≈18-h light), L_0= normal day light (≈12-h light), V_1= Dhaka-1, V_2= BARI Chinabadam-8

4.3 Coefficient of determination

Some significant correlation among days to 1st emergence, days to 1st and 50% flowering, number of branches plant^{-1} at 30 DAP, 60 DAP, 90 DAP and during harvest was found out (Figure, 16, 17, 18, 19). Coefficient of determination showed that with decrease of days to 1st emergence, 1st flowering and 50% flowering the pod yield of groundnut was increased. On the contrary, with the increase in number of branches plant^{-1} at all the sampling dates, increased the pods yield of groundnut.

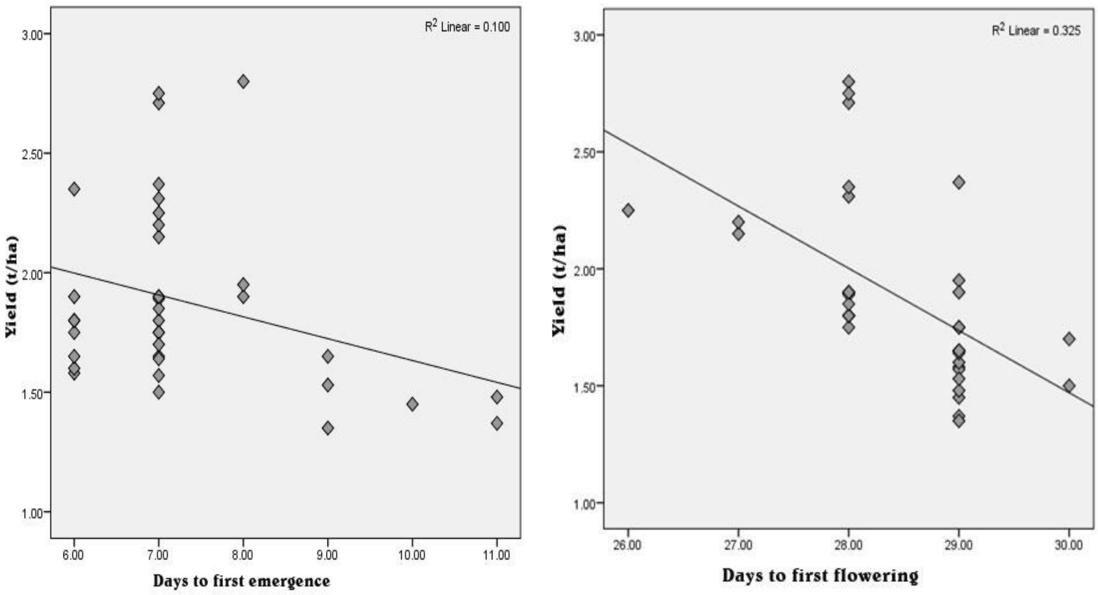


Figure 16. **Relationship between days to 1st emergence and 1st flowering on yield of groundnut**

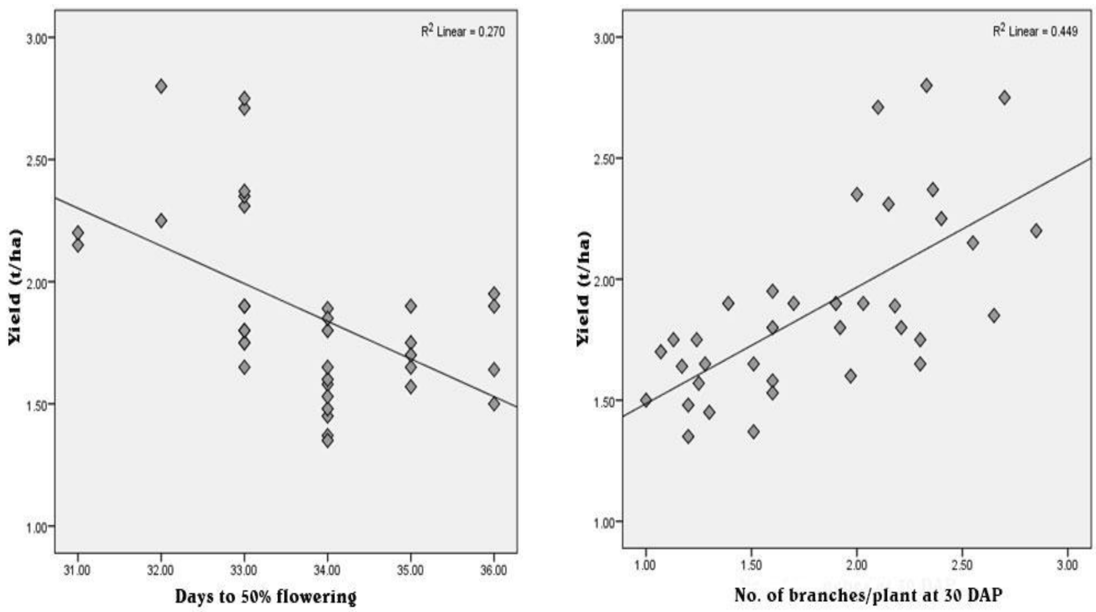


Figure 17. **Relationship between days to 50% flowering & number of branches plant^{-1} at 30 DAP on yield of groundnut**

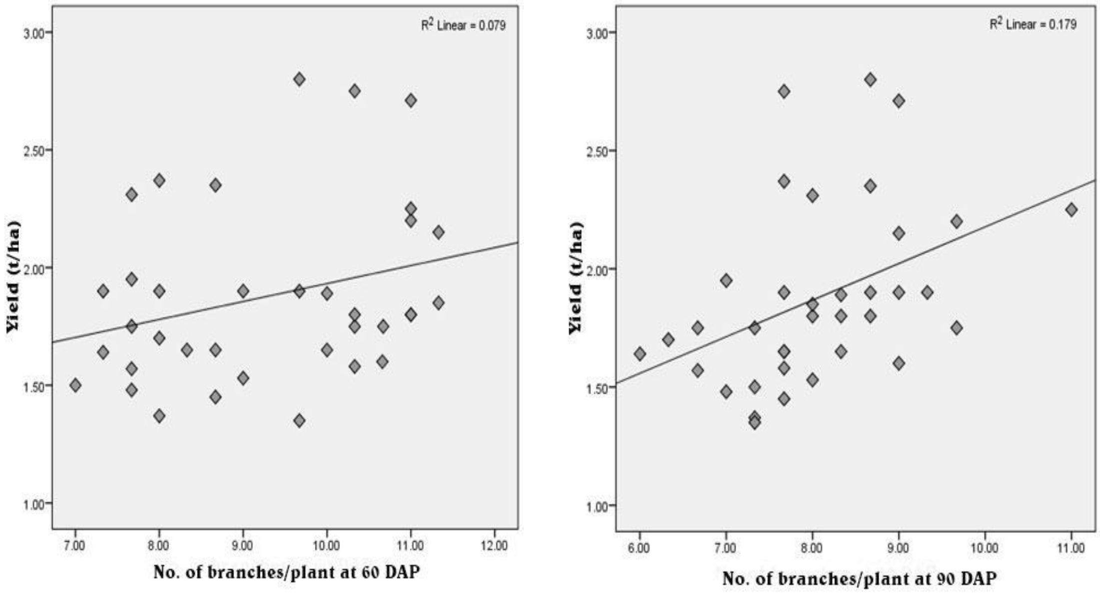


Figure 18. **Relationship between number of branches plant^{-1} at 60 DAP & number of branches plant^{-1} at 90 DAP on yield of groundnut**

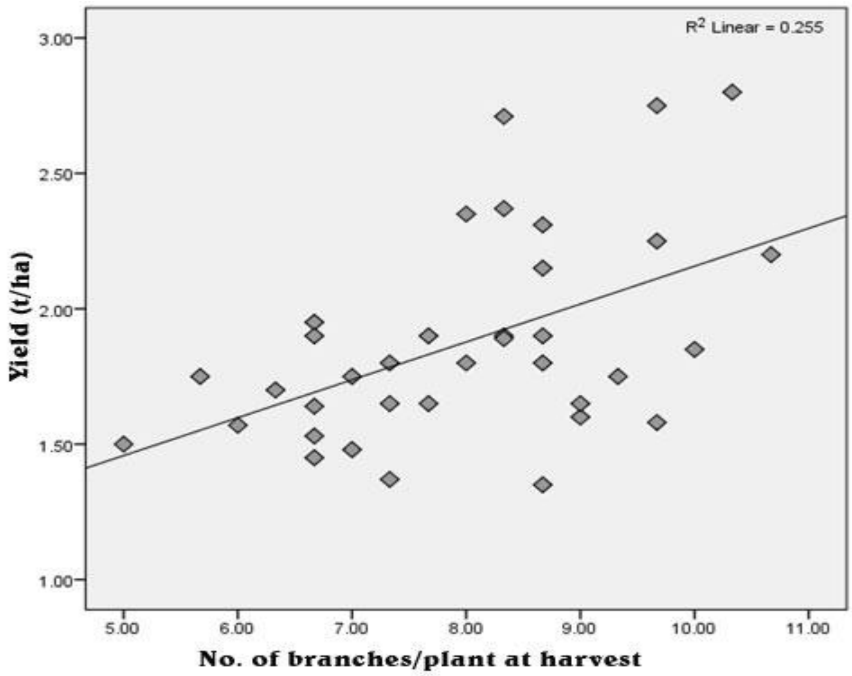


Figure 19. **Relationship between number of branches plant^{-1} during harvest on yield of groundnut**

4.4 Effect of light and boron on the quality attributes of groundnut

4.4.1 Seed protein Content (%)

4.4.1.1 Effect of light

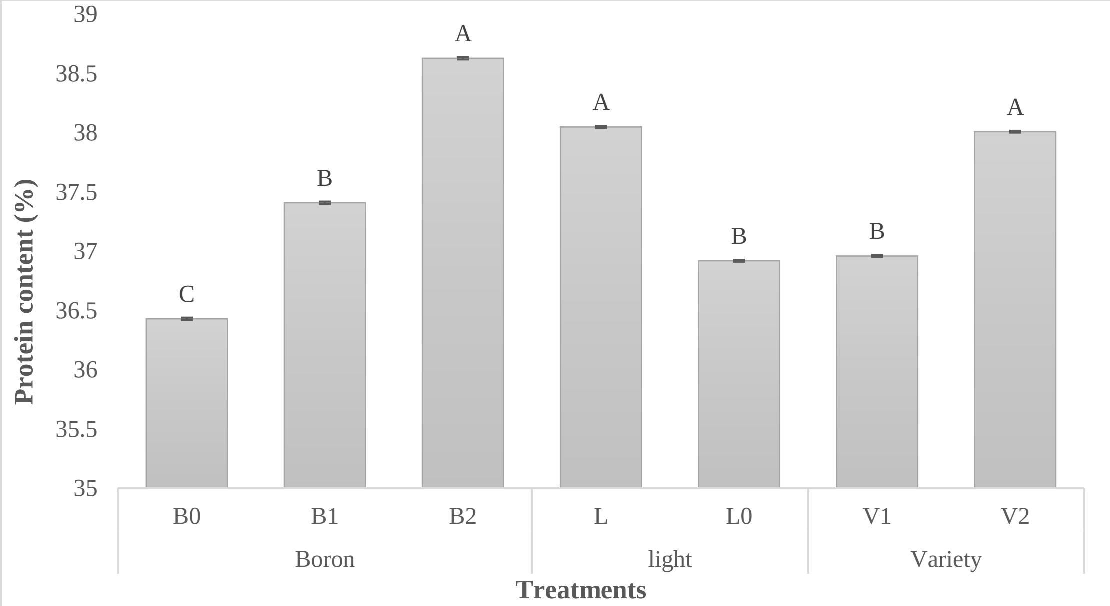
Light treatment had a significant effect on protein content of groundnut seed, while 38.05% protein was recorded from light treatment but lowest amount of protein (36.92%) was found from control treatment (Figure 20 and appendix XIII). Less or no information is available regarding the effect of light on protein content of groundnut. Present study is not supported by Han *et al*. (1996). This might be due to that change of different locations and climatic conditions.

4.4.1.2 Effect of boron

Protein content showed significant variation due to different levels of boron application (Figure 20 and appendix XIII). The data revealed that B at 2- kg ha^{-1} produced the highest protein content (38.63%) and control plant produced the lowest amount of protein content (36.43%). This might be due to that boron helped in formation of chlorophyll, photosynthetic process & activation of enzymes as well as grain formation (Naiknaware *et al*., 2015). Jena *et al*. (2009) reported that protein content in groundnut increased over the control due to B application.

4.4.1.3 Effect of variety

Seed protein content of groundnut had significant variations between the both varieties. BARI Chinabadam-8 produced the highest amount of protein content (38.01%) and Dhaka-1 produced the lowest amount of protein content (36.96%) (Figure 20 and appendix XIII). This might be due to genetic variation among the varieties. Singh *et al*. (2007) reported that, in recent years, improved genotypes increased the productivity of groundnut.



B= Boron; L=Light; V= Variety; B_0= 0 kg B ha^{-1}, B_1= 1 kg B ha^{-1}, B_2= 2 kg B ha^{-1}, L= normal day light + 6-h extended red light at night (≈18-h light), L_0= normal day light (≈12-h light), V_1=Dhaka-1, V_2= BARI Chinabadam-8. Means were separated by Tukey's test at $P \leq 0.05$. Vertical bars represent the standard error of the means.

Figure 20. **Effect of boron and light on seed protein content of two groundnut varieties**

4.4.1.4 Effect of boron-variety interaction

Protein content was significantly influenced by the interaction of boron doses and varieties (Table 29 and appendix XIII). Result showed that, the highest amount of protein content was recorded from B_2V_2 treatment (39.25%) and lowest amount recorded from B_0V_1 (36.08%).

Table 29. Effect of boron-variety interaction on seed protein content of groundnut

Treatment	Protein (%)
Boron (B) × Variety (V)	
B_0V_1	36.08 d^z
B_1V_1	36.81 c
B_2V_1	38.00 b
B_0V_2	36.78 c
B_1V_2	38.01 b
B_2V_2	39.25 a
SE (±)	0.014
CV	0.10 %
Significance (*P*)	
B×V	**

B= Boron; V= Variety; ^{z}means column having same letter (s) are insignificant and different later (s) statistically significant, P= Probability. Means were separated by Tukey's test at $P \leq 0.05$, **means significant at $p \leq 0.01$, B_0= 0 kg B ha^{-1}, B_1= 1 kg B ha^{-1}, B_2= 2 kg B ha^{-1}, V_1= Dhaka-1, V_2= BARI Chinabadam-8

4.4.1.5 Interaction effect of light, boron and variety

Interaction effect of light, boron and variety of groundnut showed significant differences on protein content (Table 30 and appendix XIII). Protein content varied from B doses to doses. Data revealed that LB_2V_2 produced the highest protein content (39.98%) compared to other interactions.

Table 30. Interaction effect of light, boron and variety on seed protein content of groundnut

Treatment	Protein (%)
Light (L) × Boron(B) × Variety (V)	
LB_0V_1	36.36 f[z]
$L_0B_0V_1$	35.80 h
LB_1V_1	37.16 e
$L_0B_1V_1$	36.46 f
LB_2V_1	38.85 b
$L_0B_2V_1$	37.15 e
LB_0V_2	37.40 d
$L_0B_0V_2$	36.16 g
LB_1V_2	38.57 c
$L_0B_1V_2$	37.44 d
LB_2V_2	39.98 a
$L_0B_2V_2$	38.53 c
SE (±)	0.020
CV	0.10 %
Significance (*P*)	
L×B×V	**

DAP= Days After Planting, B= Boron; L= light; V= Variety; [z]means column having same letter (s) are insignificant and different later (s) statistically significant, P= Probability. Means were separated by Tukey's test at $P \leq 0.05$, **means significant at $p \leq 0.01$, B_0= 0 kg B ha^{-1}, B_1= 1 kg B ha^{-1}, B_2= 2 kg B ha^{-1}, L= normal day light + 6-h extended red light at night (≈18-h light), L_0= normal day light (≈12-h light), V_1= Dhaka-1, V_2= BARI Chinabadam-8

4.4.2 Oil content (%)

4.4.2.1 Effect of light

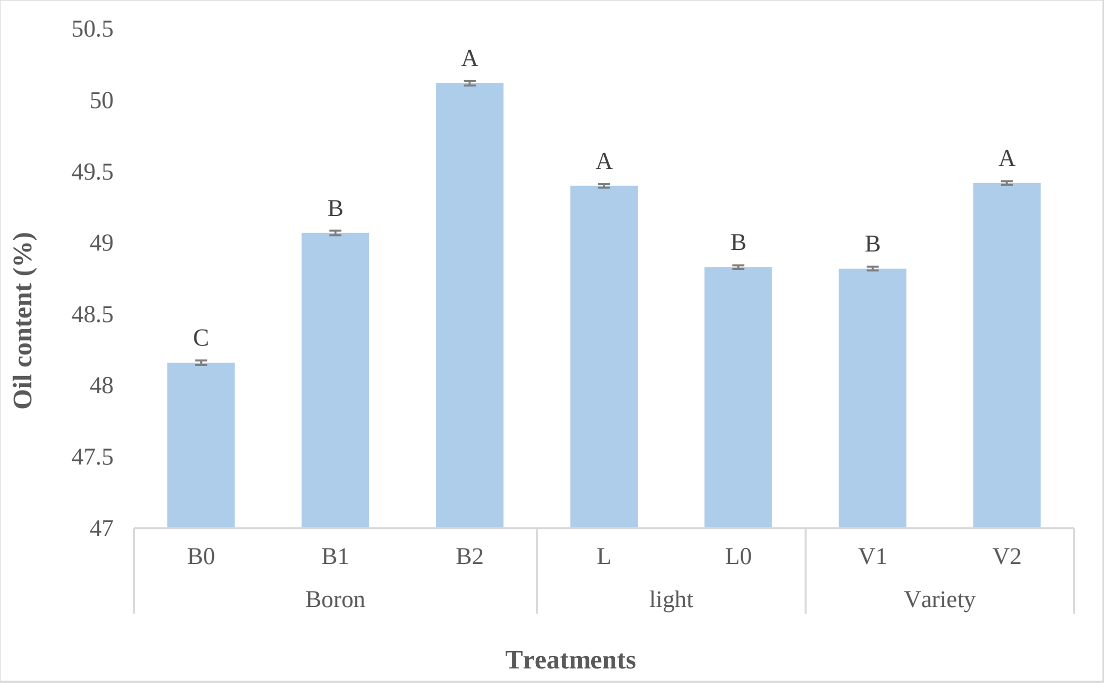
Light treatment had a significant effect on oil content of groundnut seed, while 49.40% oil was recorded from light treatment but lowest amount of oil content (48.83%) was found in control treatment (Figure 21 and appendix XIII). Less or no information is available regarding the effect of light on oil content of groundnut. The present finding of oil content is supported by reported result of Han *et al*. (1996).

4.4.2.2 Effect of boron

Oil content showed significant variations with the application of different levels of boron on groundnut. Data revealed that the application of B at 2-kg ha^{-1} produced the highest oil content and control treatment produced the lowest oil content (Figure 21 and appendix XIII). This might be due to that the application of B fertilizer promoted the uptake of N, P, K (Luo *et al*., 1990) and interaction effect of Nitrogen and Sulphur significantly enhanced the quality component of groundnut as well as oil content (Jamal *et al*., 2006). Naiknaware *et al*. (2015) also found that, application of varying boron levels helped to increase the oil content of groundnut seed.

4.4.2.3 Effect of variety

Variety had a significant effect on oil content of groundnut. BARI Chinabadam-8 produced the highest oil content (49.42%) than Dhaka-1 (48.82%) (Figure 21 and appendix XIII). This might be due to that genetic variations among the varieties. Singh *et al*. (2007) reported that, in recent years, improved genotypes increased the productivity of groundnut.



B= Boron; L=Light; V= Variety; B_0= 0 kg B ha^{-1}, B_1= 1 kg B ha^{-1}, B_2= 2 kg B ha^{-1}, L= normal day light + 6-h extended red light at night (≈18-h light), L_0= normal day light (≈12-h light), V_1=Dhaka-1, V_2= BARI Chinabadam-8. Means were separated by Tukey's test at $P \leq 0.05$. Vertical bars represent the standard error of the means.

Figure 21. **Effect of boron and light on seed oil content of two groundnut varieties**

4.4.2.4 Effect of boron-variety interaction

Interaction effect of boron-variety had a significant influenced on oil content of groundnut. BARI Chinabadam-8 with 2-kg B ha^{-1} produced the highest amount of oil content (50.55%) & V_1B_0 produced the lowest oil content of groundnut (47.95%) (Table 31 and appendix XIII).

Table 31. Effect of boron-variety interaction on seed oil content of groundnut

Treatment	%Oil
Boron (B) × Variety (V)	
B_0V_1	47.95 f^z
B_1V_1	48.81 d
B_2V_1	49.69 b
B_0V_2	48.36 e
B_1V_2	49.33 c
B_2V_2	50.55 a
SE (±)	0.022
CV	0.10 %
Significance (*P*)	
B×V	**

B= Boron; V= Variety; ^{z}means column having same letter (s) are insignificant and different later (s) statistically significant, P= Probability. Means were separated by Tukey's test at $P \leq 0.05$, **means significant at $p \leq 0.01$, B_0= 0 kg B ha^{-1}, B_1= 1 kg B ha^{-1}, B_2= 2 kg B ha^{-1}, V_1= Dhaka-1, V_2= BARI Chinabadam-8

4.4.2.5 Interaction effect of light, boron and variety

Interaction effect of light, boron doses and varieties on oil content of groundnut showed a wide range of variations (Table 32 and appendix XIII). Result revealed that LB_2V_2 produced the highest oil content (50.94%) and $L_0B_0V_1$ produced the lowest oil content (47.84%).

Table 32. Interaction effect of light-boron-variety on seed oil content of groundnut

Treatment	%Oil
Light (L)× Boron (B) × Variety (V)	
LB_0V_1	48.05 g^z
$L_0B_0V_1$	47.84 h
LB_1V_1	49.02 e
$L_0B_1V_1$	48.59 f
LB_2V_1	50.12 b
$L_0B_2V_1$	49.26 d
LB_0V_2	48.64 f
$L_0B_0V_2$	48.09 g
LB_1V_2	49.62 c
$L_0B_1V_2$	49.04 e
LB_2V_2	50.94 a
$L_0B_2V_2$	50.16 b
SE (±)	0.031
CV	0.10 %
Significance (*P*)	
L×B×V	*

B= Boron; L= light; V= Variety; ^{z}means column having same letter (s) are insignificant and different later (s) statistically significant, P= Probability. Means were separated by Tukey's test at $P \leq 0.05$, **means significant at $p \leq 0.01$, B_0= 0 kg B ha^{-1}, B_1= 1 kg B ha^{-1}, B_2= 2 kg B ha^{-1}, L= normal day light + 6-h extended red light at night (≈18-h light), L_0= normal day light (≈12-h light), V_1= Dhaka-1, V_2= BARI Chinabadam-8

4.4.3 Vitamin E content (mg/100 g seed)

4.4.3.1 Effect of light

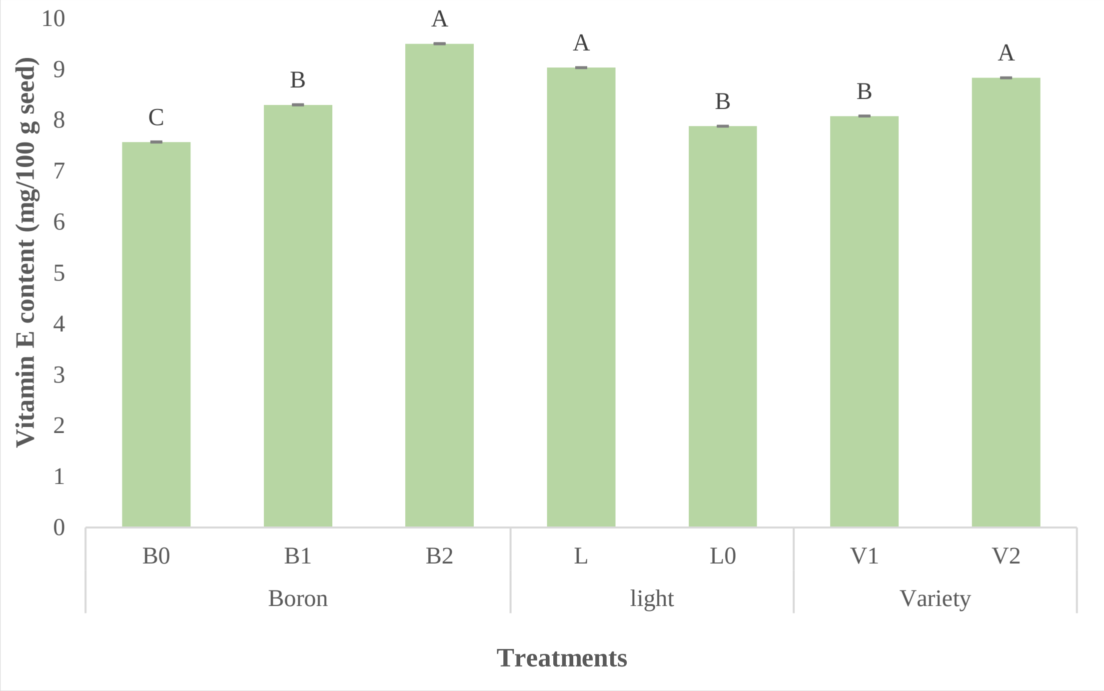
An additional supplementation of light had the significant result of vitamin E content (Figure 22 and appendix XIII). Light treatment had the highest result (9.03 mg/100 g seed) over the control treatment (7.88 mg/100 g seed). Vitamin E (α-tocopherol) content of groundnut varied with the supplementation of light. With the supplementation of artificial lightening at night it increased the vitamin E content of groundnut. Artificial lightening might be caused stress condition and the present finding happened due to suffering of plants from light stress. Literature revealed that plants exposed to excessive light can suffer photo-inhibition, serious damage to the photosynthetic apparatus, and degradation of photosynthetic proteins (Demmig-Adams and Adams, 1992). Mittler (2002) reported that light stress can lead to ROS accumulation and antioxidant enzymes activation. Vitamin E is one kind of antioxidant, so in our present study artificial lightening might be increased the activities of antioxidant enzyme and as a result vitamin E content of groundnut also increased. So, the additional light correlated with each other to impart a better vitamin E content for groundnut.

4.4.3.2 Effect of boron

Vitamin E content varied from boron doses to doses. Result revealed that B at 2-kg ha^{-1} produced the highest amount of vitamin E and control treatment produced the lowest amount of vitamin E (Figure 22 and appendix XIII). By the application of B 2-kg ha^{-1} vitamin E content of groundnut was obtained 9.50 mg/100g seed and from the control treatment 7.57 mg/100g seed. The possible reason behind the finding might be that boron helped to uptake the highest value of N, P, K, Fe and Mn (Nasef *et al*., 2006) and Almeida *et al*. (2015) stated that potassium fertilization improved the nutritional status of kernel of peanuts. Caretto *et al*. (2008) reported that K helped to increase vitamin E (α-tocopherol) content in Tomato. Literature revealed that potassium helped to improve the nutritional status in peanut and B helped to uptake the highest percentage of K in groundnut, so in our present study vitamin E content of groundnut might be increased for the application of boron. Because vitamin E is a nutritive value of groundnut (Source: USDA) and in our study we also applied the recommended dose of potassium fertilizer.

4.4.3.3 Effect of variety

Vitamin E content varied from variety to variety (Figure 22 and appendix XIII). BARI Chinabadam-8 produced the highest vitamin E content (8.83 mg/100 g seed) over Dhaka-1 (8.08 mg/100 g seed). This might be due to genetic variations among the varieties. Singh *et al*. (2007) reported that, in recent years, improved genotypes increased the productivity of groundnut.



B= Boron; L=Light; V= Variety; B_0= 0 kg B ha^{-1}, B_1= 1 kg B ha^{-1}, B_2= 2 kg B ha^{-1}, L= normal day light + 6-h extended red light at night (≈18-h light), L_0= normal day light (≈12-h light), V_1=Dhaka-1, V_2= BARI Chinabadam-8. Means were separated by Tukey's test at $P \leq 0.05$. Vertical bars represent the standard error of the means.

Figure 22. Effect of boron and light on vitamin E content of two groundnut varieties

4.4.3.4 Effect of boron-variety interaction

Interaction of boron doses and varieties showed a wide range of significant variations of vitamin E content (Table 33 and appendix XIII). BARI Chinabadam-8 produced the highest value of vitamin E content with B at 2-kg ha^{-1} and the lowest value recorded from Dhaka-1 with control.

Table 33. Effect of boron-variety interaction on vitamin E content of groundnut

Treatment	Vitamin E (mg/100g seed)
Boron (B) × Variety (V)	
B_0V_1	7.26 e[z]
B_1V_1	7.86 d
B_2V_1	9.11 b
B_0V_2	7.88 d
B_1V_2	8.74 c
B_2V_2	9.88 a
SE (±)	0.016
CV	0.37 %
Significance (*P*)	
B×V	**

B= Boron; V= Variety; [z]means column having same letter (s) are insignificant and different later (s) statistically significant, P= Probability. Means were separated by Tukey's test at $P \leq 0.05$, **means significant at $p \leq 0.01$, B_0= 0 kg B ha^{-1}, B_1= 1 kg B ha^{-1}, B_2= 2 kg B ha^{-1}, V_1= Dhaka-1, V_2= BARI Chinabadam-8

4.4.3.5 Interaction effect of light, boron and variety

Different treatment interactions of light and boron-variety had a significant influenced on the vitamin E content of groundnut (Table 34 and appendix XIII). It was noticed that LB_2V_2 treatment interaction produced the highest vitamin E content (10.61 mg/100 g seed) whereas $L_0B_0V_1$ produced the lowest amount of vitamin E (6.71 mg/100 g seed).

Table 34. Interaction effect of light, boron and variety on vitamin E content of groundnut

Treatment	Vitamin E (mg/100g seed)
Light (L) × Boron(B) × Variety (V)	
LB_0V_1	7.81 h^z
$L_0B_0V_1$	6.71 k
LB_1V_1	8.42 ef
$L_0B_1V_1$	7.30 j
LB_2V_1	9.70 b
$L_0B_2V_1$	8.52 e
LB_0V_2	8.34 f
$L_0B_0V_2$	7.42 i
LB_1V_2	9.30 c
$L_0B_1V_2$	8.17 g
LB_2V_2	10.61 a
$L_0B_2V_2$	9.15 d
SE (±)	0.022
CV	0.37 %
Significance (*P*)	
L×B×V	**

B= Boron; L= light; V= Variety; ^{z}means column having same letter (s) are insignificant and different later (s) statistically significant, P= Probability. Means were separated by Tukey's test at $P \leq 0.05$, **means significant at $p \leq 0.01$, B_0= 0 kg B ha^{-1}, B_1= 1 kg B ha^{-1}, B_2= 2 kg B ha^{-1}, L= normal day light + 6-h extended red light at night (≈18-h light), L_0= normal day light (≈12-h light), V_1= Dhaka-1, V_2= BARI Chinabadam-8

4.4.4 Germination percentage

4.4.4.1 Effect of light

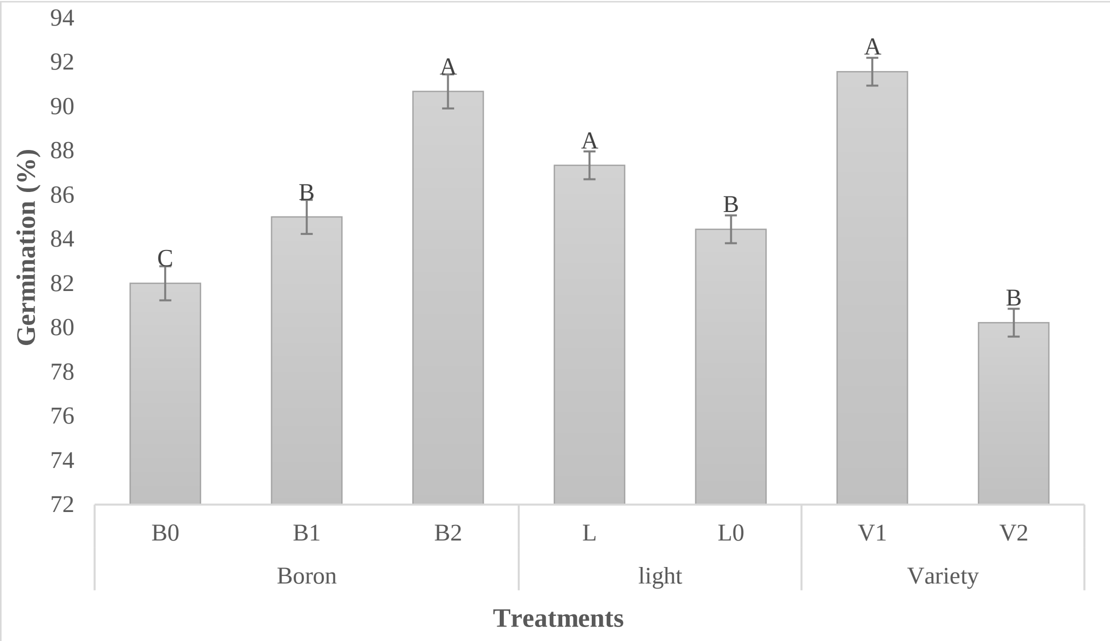
Germination percentage of groundnut showed statistically significant variation with the imposition of light. It was observed that light treatment showed highest germination percentage (87.33%) than to control treatment (84.44%) (Figure 11 and appendix XIII). Little or no information available regarding this finding. This might be due to crop cultivated under artificial light helped to get viable seed.

4.4.4.2 Effect of boron

Germination percentage showed significant variation due to different levels of boron application (Figure 11 and appendix XIII). Data revealed that 2-kg B ha^{-1} showed the highest germination percentage (90.67%) and control showed the lowest germination percentage (82.00%). This might be due to that boron helped to get viable seed (Roekkasem, 1994). The present finding is consisted with the findings of Gupta and Solanki (2012).

4.4.4.3 Effect of variety

Germination percentage had a variation among both of varieties. Dhaka-1 showed the highest germination percentage (91.56%) and BARI Chinabadam-8 showed the lowest germination percentage (80.22%) (Figure 23 and appendix XIII). Present finding is not consisted with the findings of Singh *et al*. (2007). Probably, due to that genetic variations among the varieties.



B= Boron; L=Light; V= Variety; B_0= 0 kg B ha^{-1}, B_1= 1 kg B ha^{-1}, B_2= 2 kg B ha^{-1}, L= normal day light + 6-h extended red light at night (≈18-h light), L_0= normal day light (≈12-h light), V_1=Dhaka-1, V_2= BARI Chinabadam-8. Means were separated by Tukey's test at $P \leq 0.05$. Vertical bars represent the standard error of the means.

Figure 23. Effect of boron and light on germination percentage of two groundnut varieties

4.4.4.4 Effect of boron-variety interaction

Germination percentage was significantly influenced by the interaction of B doses and varieties (Table 35 and appendix XIII). Result showed that the highest germination percentage was obtained from B_2V_1 treatment (95.33%) compared to other interactions.

Table 35. Effect of boron-variety interaction on seed germination of groundnut

Treatment	Germination (%)
Boron (B) × Variety (V)	
B_0V_1	88.00 bc^z
B_1V_1	91.33 ab
B_2V_1	95.33 a
B_0V_2	76.00 d
B_1V_2	78.67 d
B_2V_2	86.00 c
SE (±)	1.089
CV	3.56 %
Significance (*P*)	
B×V	*

B= Boron; V= Variety; ^{z}means column having same letter (s) are insignificant and different later (s) statistically significant, P= Probability. Means were separated by Tukey's test at $P \leq 0.05$, *means significant at $p \leq 0.05$, B_0= 0 kg B ha^{-1}, B_1= 1 kg B ha^{-1}, B_2= 2 kg B ha^{-1}, V_1= Dhaka-1, V_2= BARI Chinabadam-8

4.4.4.5 Interaction effect of light, boron and variety

Interaction effect of light, boron and variety of groundnut showed the significant differences on germination percentage (Table 36 and appendix XIII). Data revealed that the LB_2V_1 produced the highest germination percentage (98.67%) compared to other interactions.

Table 36. Interaction effect of light, boron and variety on seed germination of groundnut

Treatment	Germination (%)
Light (L)× Boron (B) × Variety (V)	
LB_0V_1	89.33 bc^z
$L_0B_0V_1$	86.67 c
LB_1V_1	94.67 ab
$L_0B_1V_1$	88.00 bc
LB_2V_1	98.67 a
$L_0B_2V_1$	92.00 abc
LB_0V_2	77.33 e
$L_0B_0V_2$	74.67 e
LB_1V_2	78.67 de
$L_0B_1V_2$	78.67 de
LB_2V_2	85.33 cd
$L_0B_2V_2$	86.67 c
SE (±)	1.540
CV	3.56 %
Significance (*P*)	
L×B×V	*

B= Boron; L= light; V= Variety; ^{z}means column having same letter (s) are insignificant and different later (s) statistically significant, P= Probability. Means were separated by Tukey's test at $P \leq 0.05$, *means significant at $p \leq 0.05$, B_0= 0 kg B ha^{-1}, B_1= 1 kg B ha^{-1}, B_2= 2 kg B ha^{-1}, L= normal day light + 6-h extended red light at night (≈18-h light), L_0= normal day light (≈12-h light), V_1= Dhaka-1, V_2= BARI Chinabadam-8

Chapter 5

Summary and Conclusion

CHAPTER 5

SUMMARY AND CONCLUSION

The present investigation indicated that the application of boron on soil and supplementation of artificial light have a positive effect on vegetative and reproductive development as well yield and quality of groundnut.

Application of boron helps to reduce days to seedling emergence. B at 2 kg ha^{-1} took lower times than control. In case of first emergence B_2V_2 and in case of last emergence V_1B_2, B_0V_1 interactions take shorter time compared to other interactions. For days to flowering B 2-kg ha^{-1} and V_2 took lower times. B_2V_2 gave the best result compared than that of other interactions for days to flowering in groundnut.

B at 2 kg ha^{-1}, light and V_1 gave the highest plant height. B_2V_1 and LB_2V_1 interaction showed the highest plant height over other interactions.

B at 1 kg ha^{-1}, light and V_2 produced the highest result in term of leaf area and interaction B_1V_2 and $L_0B_1V_2$ gave the best result compared to other interactions.

B at 2-kg ha^{-1}, light and V_2 showed the best result for number of branches plant^{-1}. B_2V_2 and LB_2V_2 interactions gave the highest number of branches plant^{-1} over other interactions.

2-kg B ha^{-1}, light and BARI Chinabadam-8 produced highest shoot dry weight plant^{-1}. B_2V_2 & LB_2V_2 interaction produced the highest shoot dry weight plant^{-1} compared than that of others interactions.

Number of flowers plant^{-1} was the highest for B at 2-kg ha^{-1}, light and Dhaka-1 variety. B_2V_1 produced the highest number of flowers plant^{-1} at 60 DAP, 90 DAP and during harvest B_2V_2 produced the highest. LB_2V_1 produced maximum flowers plant^{-1} compared than others.

Number of pegs plant^{-1} were maximum at 60 DAP for B at 2-kg ha^{-1} but at 90 DAP and during harvest B-1 kg ha^{-1} showed best result. At 60 DAP B_2V_1 showed best result for number of pegs plant^{-1} but V_1B_1 showed statistically similar result as like others interactions. At 90 DAP and during harvest B_1V_1 showed the best result. At 60 DAP LB_2V_1 produced maximum pegs plant^{-1} but LB_1V_1, $L_0B_1V_1$, $L_0B_2V_1$, LB_1V_2 showed statistically similar result as like others interactions. During 90 DAP and at harvest V_1B_1L produced the maximum number pegs plant^{-1} compared than others interactions.

B at 2-kg ha^{-1}, control light and V_2 showed the best result for number of pods $plant^{-1}$. B_2V_2 and $L_0B_2V_2$ interactions gave the highest number of pods $plant^{-1}$ over other interactions.

B at 2-kg ha^{-1}, control light and V_2 showed the best result for pod dry weight $plant^{-1}$. B_2V_2 and $L_0B_2V_2$ interactions gave the highest pod dry weight $plant^{-1}$ compared than that of other interactions.

Boron at 2-kg ha^{-1}, control light and V_2 showed the best result for 100 seed weight. B_2V_2 and $L_0B_2V_2$ interactions gave the best result for 100 seed weight compared than that of other interactions.

Shelling percentage were highest for boron at 2-kg ha^{-1}, light and Dhaka-1 variety. B_2V_1 and LB_2V_1 interactions showed the best result for shelling percentage over other interactions.

2-kg B ha^{-1}, control light and BARI Chinabadam-8 produced the highest pod and seed yield. B_2V_2 and $L_0B_2V_2$ interactions produced the highest yield compared than that of other interactions.

B 1-kg and 2-kg ha^{-1} produced the highest and similar result for stover yield over control. Light and control light showed similar result where BARI Chinabadam-8 produced the highest stover yield. B_2V_2 interaction produced the highest result and $V_1B_0L_0$ interactions produced the lowest result for stover yield compared than that of other interactions.

Protein content was the highest for B at 2-kg ha^{-1}, light and BARI Chinabadam-8 variety. V_2B_2 and V_2B_2L interactions showed the best result for protein content over other interactions.

B at 2-kg ha^{-1}, light and BARI Chinabadam-8 variety produced highest percentage of oil content. B_2V_2 and LB_2V_2 interactions produced the highest oil content compared to other interactions.

Boron at 2-kg ha^{-1}, light and BARI Chinabadam-8 variety gave the highest result for Vitamin E content. B_2V_2 and LB_2V_2 interactions showed the best result for vitamin E content over other interactions.

B at 2-kg ha^{-1}, light and Dhaka-1 variety produced the highest germination percentage. B_2V_1 and LB_2V_1 interactions produced the highest germination percentage compared to that of other interactions.

Above results revealed that imposition of light did not increase the number of pods, pod dry weight, 100 seed weight, pod yield and seed yield, but stover yield. This explained that dry matter increased due to the imposition of light did not transform into the reproductive organs. Furthermore, we imposed light for 6 hours, probably the dry matter produced by the 6 hours imposed light contributed to the vegetative growth and was not enough to be partitioned into yield components. Again, quality components increased and it might be due to that imposition of light created stress condition that helped to create defense mechanism on plants and finally improved quality of seeds. To have a clear idea, we should continue the study furthermore imposing light for more than 6 hours. The present investigation also indicated that the application of boron on soil have a positive effect on growth, yield and quality of groundnut and B at 2-kg ha^{-1} maximum times gave the best result. So further study should be carried out to verify the increasing trend of B by increasing the boron levels. Furthermore, BARI Chinabadam-8 showed the best result than Dhaka-1. Therefore, it can be concluded that the application of boron has a positive impact on improved groundnut varieties but supplementation of artificial light has both positive and negative impact on it.

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APPENDICES

Appendix I. Soil test result of the experimental filed reported by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

Element	Levels in the soil plot
pH	5.9
N	0.071%
K	0.31 meq/100g soil
Ca	6.36 meq/100g soil
P	14.04 µg/g soil
S	15.16 µg/g soil
B	0.30 µg/g soil

Appendix II. Monthly record of air temperature, relative humidity and rainfall of the experimental site during the period of March, 2014 to July 2014

Month	Air temperature (^{0}C)		Relative humidity (%)		Rainfall (mm) (total)
	Maximum	Minimum	Maximum	Minimum	
March, 2014	37.4	20.2	80.2	32.4	3.80
April, 2014	39.4	19.4	80.2	39.2	65.60
May, 2014	38.2	19.3	89.2	40	202
June, 2014	37.2	17.4	88.4	46.3	282.7
July, 2014	35.6	18.2	88.2	55.4	107.8

Source: SAU mini weather station, Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh

Appendix III. Effect of boron on days to emergence and days to flowering of two groundnut varieties

Sources of variation	Degrees of freedom	Mean square			
		Days to emergence		Days to flowering	
		1st emergence	Last emergence	1st flowering	50% flowering
Replication	2	0.0833	0.25000	0.11111	1.00000
Light (A)	1	5.4444	6.25000	0.69444	6.25000
Error A	2	0.1944	0.08333	0.77778	5.273E-31
Boron (B)	2	3.5833	5.58333	4.77778	15.2500
Light*Boron	2	0.8611	3.25000	0.77778	1.58333
Error A*B	8	0.1389	0.20833	0.11111	0.16667
Variety (C)	1	5.4444	4.69444	4.69444	4.69444
Light*Variety	1	16.0000	3.36111	0.02778	0.02778
Boron*Variety	2	6.3611	3.52778	0.11111	1.19444
Boron*Variety*light	2	4.0833	2.19444	0.77778	2.52778
Error A*B*C	12	0.1389	0.25000	0.16667	0.11111

Appendix IV. Effect of light and boron on plant height of two groundnut varieties

Sources of variation	Degrees of freedom	Mean square			
		Plant height (cm) at			
		30 DAP	60 DAP	90 DAP	Harvest
Replication	2	0.24959	0.219	1.73	4.45
Light (A)	1	0.11447	575.520	1418.15	3297.25
Error A	2	0.06092	0.128	0.51	0.11
Boron (B)	2	2.29114	15.916	139.18	208.55
Light*Boron	2	0.02884	0.170	2.79	0.34
Error A*B	8	0.20977	0.262	1.13	0.67
Variety (C)	1	22.8962	160.107	198.39	412.97
Light*Variety	1	2.500E-05	0.250	79.06	75.43
Boron*Variety	2	0.33812	0.407	10.02	4.03
Boron*Variety*light	2	0.08433	0.005	4.11	2.71
Error A*B*C	12	0.45614	0.291	0.95	1.09

Appendix V. Effect of light and boron on leaf area of two groundnut varieties

Sources of variation	Degrees of freedom	Mean square			
		Leaf area (cm^2) at			
		30 DAP	60 DAP	90 DAP	Harvest
Replication	2	0.188	0.24194	0.02	1.829
Light (A)	1	3.162	558.062	425.12	41.281
Error A	2	0.287	4.978E-03	0.48	1.676
Boron (B)	2	273.879	1118.79	649.40	163.887
Light*Boron	2	5.760	35.9021	51.29	8.823
Error A*B	8	1.760	0.47038	1.55	0.758
Variety (C)	1	39.417	7743.41	3633.08	507.826
Light*Variety	1	12.145	15.5762	56.23	22.801
Boron*Variety	2	70.551	225.657	94.43	8.794
Boron*Variety*light	2	8.086	18.7447	32.65	7.514
Error A*B*C	12	0.208	1.74817	0.31	1.001

Appendix VI. Effect of light and boron on number of branches plant^{-1} of two groundnut varieties

Sources of variation	Degrees of freedom	Mean square			
		Number of branches plant^{-1} at			
		30 DAP	60 DAP	90 DAP	Harvest
Replication	2	0.04323	0.1882	0.02614	0.6041
Light (A)	1	0.60063	14.6817	4.00000	10.7693
Error A	2	0.05423	0.2324	0.12130	0.8216
Boron (B)	2	0.78811	12.7366	4.61547	4.2975
Light*Boron	2	0.03606	3.1235	0.02806	0.2784
Error A*B	8	0.04390	0.2186	0.67630	0.4376
Variety (C)	1	6.04340	8.6534	9.71361	31.4908
Light*Variety	1	0.04914	6.2250	0.30618	0.1508
Boron*Variety	2	0.07602	0.2784	0.09442	0.0221
Boron*Variety*light	2	0.01314	0.0635	0.64775	0.5193
Error A*B*C	12	0.05276	0.2393	0.56198	0.5000

Appendix VII. Effect of light and boron on shoot dry weight plant^{-1} (g) of two groundnut varieties

Sources of variation	Degrees of freedom	Mean square			
		Shoot dry weight plant^{-1} (g) at			
		30 DAP	60 DAP	90 DAP	Harvest
Replication	2	0.04323	0.22609	0.08	5.2
Light (A)	1	0.60063	413.106	2652.25	1024.0
Error A	2	0.05423	0.27756	0.76	1.6
Boron (B)	2	0.78811	369.856	5767.00	4429.4
Light*Boron	2	0.03606	65.3729	703.00	114.3
Error A*B	8	0.04390	0.86497	1.38	0.4
Variety (C)	1	6.04340	911.335	3344.69	37895.1
Light*Variety	1	0.04914	1.361E-04	1534.03	1.0
Boron*Variety	2	0.07602	28.2926	492.44	92.5
Boron*Variety*light	2	0.01314	81.1251	430.11	187.7
Error A*B*C	12	0.05276	0.70729	1.55	0.5

Appendix VIII. Effect of light and boron on number of flowers plant^{-1} of two groundnut varieties

Sources of variation	Degrees of freedom	Mean square		
		Number of flowers plant^{-1} at		
		60 DAP	90 DAP	Harvest
Replication	2	4.006	3.937	0.00331
Light (A)	1	34.672	14.669	1.63840
Error A	2	1.830	2.007	0.33498
Boron (B)	2	173.929	59.257	3.54566
Light*Boron	2	1.125	1.594	0.73786
Error A*B	8	2.880	1.065	0.12873
Variety (C)	1	544.522	105.678	0.52321
Light*Variety	1	0.195	8.028	0.02668
Boron*Variety	2	15.809	11.311	0.22395
Boron*Variety*light	2	0.974	2.108	0.06519
Error A*B*C	12	1.648	1.845	0.51424

Appendix IX. Effect of light and boron on number of pegs plant^{-1} of two groundnut varieties

Sources of variation	Degrees of freedom	Mean square		
		Number of pegs plant^{-1} at		
		60 DAP	90 DAP	Harvest
Replication	2	3.5215	0.022	1.146
Light (A)	1	14.7200	123.432	541.803
Error A	2	0.1191	0.760	3.412
Boron (B)	2	26.1571	895.753	846.079
Light*Boron	2	0.7745	338.259	2.550
Error A*B	8	4.3330	3.175	4.349
Variety (C)	1	3.3489	723.072	406.694
Light*Variety	1	0.5329	9.020	20.220
Boron*Variety	2	4.0939	112.072	21.752
Boron*Variety*light	2	0.5314	70.456	13.660
Error A*B*C	12	1.3255	5.427	5.082

Appendix X. Effect of light and boron on number of pods plant^{-1} of two groundnut varieties

Sources of variation	Degrees of freedom	Mean square		
		Number of pods plant^{-1} at		
		60 DAP	90 DAP	Harvest
Replication	2	2.090	1.527	0.5
Light (A)	1	149.410	42.228	1194.0
Error A	2	1.541	1.365	5.4
Boron (B)	2	221.413	704.072	1602.6
Light*Boron	2	7.606	8.064	70.6
Error A*B	8	4.525	4.026	5.5
Variety (C)	1	332.090	541.881	19106.2
Light*Variety	1	30.840	59.676	554.7
Boron*Variety	2	31.847	49.419	24.5
Boron*Variety*light	2	9.021	17.930	67.3
Error A*B*C	12	3.484	2.646	5.3

Appendix XI. Effect of light and boron on pods dry weight plant^{-1} (g) of two groundnut varieties

Sources of variation	Degrees of freedom	Mean square		
		Pods dry weight plant^{-1} (g)at		
		60 DAP	90 DAP	Harvest
Replication	2	0.041	0.11	0.46
Light (A)	1	10.617	113.78	120.67
Error A	2	0.167	1.54	0.18
Boron (B)	2	8.430	614.25	1194.63
Light*Boron	2	0.264	24.19	2.61
Error A*B	8	0.053	1.17	1.02
Variety (C)	1	121.037	1418.78	360.81
Light*Variety	1	7.084	32.11	11.19
Boron*Variety	2	3.217	131.19	1.08
Boron*Variety*light	2	0.085	34.03	28.67
Error A*B*C	12	0.050	0.54	1.02

Appendix XII. Effect of light and boron on 100 seed weight (g), shelling percentage, yield (t/ha), Seed yield (t/ha) and stover yield (t/ha) of two groundnut varieties

Sources of variation	Degrees of freedom	Mean square				
		100 seed weight (g)	Shelling percentage	Yield (t/ha)	Seed yield (t/ha)	Stover yield (t/ha)
Replication	2	15.06	3.479	0.00220	0.00439	0.03450
Light (A)	1	18.95	50.150	0.70840	0.18347	0.54760
Error A	2	0.30	1.528	0.00257	0.00142	0.06761
Boron (B)	2	32.80	46.935	0.84254	0.57084	1.46134
Light*Boron	2	0.25	1.911	0.01744	0.01194	0.12703
Error A*B	8	0.59	2.723	0.00277	0.00290	0.16851
Variety (C)	1	5404.70	374.229	1.86323	0.34223	3.75068
Light*Variety	1	0.27	3.783	0.31547	0.09507	0.27040
Boron*Variety	2	0.21	1.427	0.10578	0.05343	0.03524
Boron*Variety*light	2	0.93	0.977	0.03492	0.01154	0.21863
Error A*B*C	12	1.12	3.149	0.00609	0.00372	0.12946

Appendix XIII. Effect of light and boron on protein content (%), oil content (%), vitamin E content (mg/100 g seed) and germination (%) of two groundnut varieties

Sources of variation	Degrees of freedom	Mean square			
		Protein content (%)	Oil content (%)	Vitamin E content (mg/100 g seed)	Germination (%)
Replication	2	0.0007	0.0068	0.0004	5.78
Light (A)	1	11.4357	2.8900	11.8795	75.11
Error A	2	0.0004	0.0007	0.0047	11.11
Boron (B)	2	14.5564	11.6340	11.3602	232.44
Light*Boron	2	0.4447	0.1558	0.0724	0.44
Error A*B	8	0.0014	0.0030	0.0018	3.11
Variety (C)	1	9.9120	3.2280	5.1680	1156.00
Light*Variety	1	0.1835	0.0413	0.0036	53.78
Boron*Variety	2	0.2795	0.1619	0.0487	9.33
Boron*Variety*light	2	0.1740	0.0327	0.0403	13.78
Error A*B*C	12	0.0013	0.0027	0.0010	9.33

Plate 1. Field view of experimental field

Plate 2. Comparison of plant height among the treatment interactions

Plate 3. Harvested groundnut

Plate 4.1. Comparison of pods plant^{-1} among the treatment interactions

Plate 4.2. Comparison of pods plant^{-1} among the treatment interactions

LB_2V_1

LB_2V_2

LB_1V_1

LB_1V_2

LB_0V_1

LB_0V_2

Plate 5.1. Comparison of germination percentage among the treatment interactions

$L_0B_2V_1$

$L_0B_2V_2$

$L_0B_1V_1$

$L_0B_1V_2$

$V_1L_0B_0$

$L_0B_0V_2$

Plate 5.2. Comparison of germination percentage among the treatment interactions