EFFECT OF SULFUR AND BORON ON THE GROWTH AND YIELD OF MUNGBEAN (*Vigana radiata* L.)

BY

MOHAMMAD ANISUZZAMAN

REG. No. : 00857

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

MASTER OF SCIENCE (MS)

IN

SOIL SCIENCE

SEMESTER: JULY-DECEMBER, 2008

APPROVED BY:

A. T. M. Shamsuddoha
Associate Professor
Supervisor
Department of Soil Science
SAU, Dhaka

Prof. Dr. Gopinath Chandra Sutradhar
Co-Supervisor
Department of Soil Science
SAU, Dhaka

A. T. M. Shamsuddoha
Chairman
Examination Committee

DEDICATED

TO

MY BELOVED PARENTS

DEPARTMENT OF SOIL SCIENCE

Sher-e-Bangla Agricultural University

Sher-e-Bangla Nagar, Dhaka-1207

Memo No: SAU/Soil Science/(09)/ Date :

CERTIFICATE

This is to certify that the thesis entitled "**Effect of Sulfur and Boron on the Growth and Yield of Mungbean** (*Vigana radiata* L.)" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE in Soil Science**, embodies the result of a piece of bonafide research work carried out by **Mohammad Anisuzzaman**, Registration number: **00857** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated:
Dhaka, Bangladesh

A. T. M. Shamsuddoha
Associate Professor
Department of Soil Science
Sher-e-Bangla Agricultural University
Dhaka-1207

ACKNOWLEDGEMENT

The author first wants to articulate his enormous wisdom of kindness to the Almighty Allah for His never ending blessing, protection, regulation, perception and assent to successfully complete the Master of Science (MS).

The author likes to express his deepest sense of gratitude to his respected supervisor A. T. M. Shamsuddoha, Associate Professor, Department of Soil Science, Sher-e-Bangla Agricultural University (SAU), Dhaka, Bangladesh, for his scholastic guidance, support, encouragement and invaluable suggestions and constructive criticism throughout the study period in conducting and successfully completing the research work and in the preparation of the manuscript.

The author also expresses his gratefulness to respected Co-Supervisor, Dr. Gopinath Chandra Sutradhar, Professor, Department of Soil Science, Sher-e-Bangla Agricultural University, Dhaka for his scholastic guidance, helpful comments and constant inspiration, inestimatable help, valuable suggestions throughout the research work and in preparation of the thesis.

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

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

The Author

ABSTRACT

The experiment was conducted in the Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from February to May 2008 to study the effect of sulfur and boron on the growth and yield of mungbean. The variety BARI mung-6 was used as the test crop. The experiment consists of two factors: Factor A: Sulfur (4 levels); S_0: 0 kg (Control), S_4: 4 kg, S_8: 8 kg and S_{12}: 12 kg S ha^{-1}; Factor B: Boron (3 levels): B_0: No boron (Control), B_1: 1 kg and B_2: 2 kg B ha^{-1}. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. At 25, 35, 45 and 55 DAS the maximum plant height, maximum number of leaves $plant^{-1}$, highest number of pods $plant^{-1}$ and highest seed yield was recorded from S_{12} (12 kg S ha^{-1}), while the shortest plant, lowest number of pod and lowest seed yield was recorded from S_0 (no sulfur). At 25, 35, 45 and 55 DAS the longest plant, highest number of pods $plant^{-1}$ and highest seed yield was recorded from B_2 (2 kg B ha^{-1}). On the other hand the shortest plant, lowest number of pod and lowest seed yield was recorded from B_0 (no boron). At 25, 35, 45 and 55 DAS, the longest plant, highest number of pods $plant^{-1}$ and highest seed yield was recorded from S_8B_2 (8 kg S ha^{-1} and 2 kg B ha^{-1}), while the shortest plant, lowest number of pod and lowest seed yield was recorded from S_0B_0 (no sulfur and boron). The highest pH, organic matter, total N, available P, exchangeable K, available S and available B was recorded from S_8 and the lowest pH, organic matter, total N, available P, exchangeable K, available S and available B was observed from S_0 (no sulfur). The highest pH, organic matter, total N, available P, exchangeable K, available S and available B was recorded from B_2 (2 kg B ha^{-1}) and the lowest pH, organic matter, total N, available P, exchangeable K, available S and available B was observed from B_0 (no boron). The highest pH, organic matter, total N, available P, exchangeable K, available S and available B was recorded from S_8B_2 (8 kg S ha^{-1} and 2 kg B ha^{-1}) and the lowest pH, organic matter, total N, available P, exchangeable K, available S and available B was observed from S_0B_0 (no sulfur and boron).

Sher-e-Bangla Agricultural University Library

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

Chapter I

শেরেবাংলা কৃষি বিশ্ববিদ্যালয় গ্রন্থাগার
সংযোজন নং.........................
স্বাক্ষর..................তাং..........

INTRODUCTION

Bangladesh is a developing country. The land of our country is limited but the population is very high. More people need more food. Due to our huge population we have to produce more food in our limited land. To meet the increased demand of food, farmers are growing more cereal crops. Moreover due to the high population pressure the total cultivable land is decreasing day by day for housing. So at present the cultivation of pulse has gone to marginal land because no one interested to use his fertile land for pulse cultivation. Pulse cultivation is also decreasing because of its low yield & low production. Besides this long term cereal crop cultivation also effects soil fertility and productivity which could be overcome by growing pulses.

Usually Bangladesh grows various types of pulse crops. Among them grasspea, lentil, mungbean, blackgram, chickpea, field pea and cowpea are important. Pulse crop is an important food crops because it provides a cheap source of easily digestible dietary protein which complements the stable rice diet in the country. According to FAO (1999) a minimum intake of pulse by a human should be 80 g per head per day, whereas it is only 14.19 g in Bangladesh (BBS, 2007). This is because of the fact that national production of the pulses is not adequate to meet the national demand. Mungbean can also fix atmospheric nitrogen through the symbiotic relationship between the host mungbean roots and soil bacteria and thus improves soil fertility.

Mungbean play an important role to supplement protein in the cereal-based low-protein diet of the people of Bangladesh, but the acreage and production of mungbean is steadily declining (BBS, 2007). However, it is one of the least cared crops. Mungbean is cultivated with minimum land preparation and without fertilizer application and insect, diseases or weed control. All these factors are responsible for low yield of mungbean. Kharif-I especially in dry season is not favorable for mungbean germination. Kharif-II period is occupied by T. aman. Cultivation of high yielding varieties of wheat and winter rice has occupied considerable land suitable for mungbean cultivation.

Beside these, low yield potentiality of this crop is responsible for declining area and production. At its present the area under pulse crops is 0.406 million hectares with a production of 0.322 million tones where mungbean is cultivated in the area of 0.108 million hectares (BBS, 2007). The average yield of mungbean is 0.69 t ha^{-1} which is very poor in comparision to mungbean growing countries in the world. There are many reasons of low yield of mungbean. The management of fertilizer is the important one that greatly affects the growth, development and yield of this crop. There are 18 essential nutrient elements than can effect the growth and yield of mungbean. Among them a very few works has done on sulfur and boron on the yield of mungbean.

Sulfur plays a remarkable role in protein metabolism. It is required for the synthesis of proteins, vitamins and chlorophyll and also S containing amino acid such as cystine, cysteine and methionine which are essential components of proteins (Tisdale *et al.*, 1999). Lack of S causes retardation of terminal growth and root development. S deficiency induced chlorosis in young leaves and decreased seed yield by 45% (BARI, 2004). On the other hand boron is an essential mineral element for all vascular plant like mungbean. It plays a vital role in the physiological processes of plants such as cell maturation, cell elongation and cell division, sugar transport, hormone development, carbohydrate, protein and nucleic acid metabolisms, cytokinins synthesis and phenol metabolisms (Lewis, 1980). Some functions of B are interrelated with those of N, P, K and Ca in plants.

Hence, the present study was undertaken to maximize the seed yield of mungbean with optimum sulfur and boron level. Considering the above circumstances, the present investigation has been undertaken with the following objectives:

i. To find out optimum level of sulfur for the maximum production of yield of mungbean.

ii. To determine the optimum level of boron for the maximum production of yield of mungbean.

iii. To find out the interaction effect between sulfur and boron on the yield of mungbean.

Sher-e-Bangla Agricultural University Library Sher-e-Bangla Nagar, Dhaka

Chapter 2

REVIEW OF LITERATURE

In Bangladesh and in many countries of the world mungbean is an important pulse crop. The crop has conventional less attention by the researchers on various aspects because normally it grows without less care or management practices. Based on this a very few research work related to growth, yield and development of mungbean have been carried out in our country. However researches are going on in many countries to maximize the yield of mungbean. An optimum sulfur and boron fertilizer plays an important role in improving mungbean yield. But research works related to sulfur and boron fertilizer and weeding are limited in Bangladesh. However, some of the important and informative works and research findings related to the sulfur and boron so far been done at home and abroad on this crop and other pulse crop have been reviewed in this chapter under the following headings-

2.1 Effects of sulfur fertilizer on growth and yield

A study was conducted by Dey and Basu (2004) in West Bengal, India, to determine the effects of potassium fertilizer and sulfur fertilizer on the growth, nodulation, yield and quality of green gram cv. B-1. Treatments comprised: 0, 20 and 40 kg K/ha, and 0, 20 and 40 kg S/ha. Growth characters such as plant height and dry matter accumulation in aerial plant parts were highest at 20, 40 and 65 days after sowing upon treatment with 40 kg K/ha along with 40 kg S/ha. The number of nodules and dry weight of nodules increased with increasing rates of sulfur and potassium. Yield components (i.e. number of pods per plant, number of seeds per pod and 1000-seed weight) increased with increasing rates of sulfur and potassium. The increment in yield components further contributed to increased seed yield. Protein content also increased with increasing rates of sulfur and potassium.

Yadav (2004) conducted an experiment to find out the effects of phosphorus (0, 20 and 40 kg/ha) and sulfur (0, 20, 40 and 60 kg/ha) on the growth and yield of green gram cv. RMG-62 were determined in a field experiment conducted in Rajasthan, India during the kharif seasons of 1998-99. Plant height, number of branches, number of pods per plant, number of seeds per pod, seed yield, stover yield and biological yield increased with increasing rates of phosphorus and sulfur up to 40 kg/ha and decreased thereafter.

Srinivasarao *et al.* (2004) conducted an experiment with Available sulfur (S) extracted in five extractants, crop response to S application and use efficiency of S by mungbean and urdbean were studied on different soil types of pulse growing regions of India. Among extractants tested, 1 N NH_4OAc extracted higher S followed by Morgan's reagent, 0.001 N HCl, 0.15% $CaCl_2$, and 1% NaCl. Response of urdbean was in higher magnitude as compared to mungbean to 20 mg S kg^{-1}. In both the crops, larger response was obtained in Inceptisols followed by Vertisols and lower response was found in Alfisols. Larger utilization of native soil S in case of Alfisols by both the crops resulted in lower levels of response to added fertilizer S. Owing to high degree of correlation with plant response, 0.15% $CaCl_2$ and Morgan's reagent can be used as soil test methods for assessing the available S supply and predicting the crop response to applied S on these soils.

A trial was conducted by Siag and Yadav (2003) during kharif seasons of 1998, 1999 and 2000 under irrigated conditions to study the response of mungbean cv. MUM 2 to sulfur (applied as gypsum) with different application methods in sandy loam soil of Sriganganagar, Rajasthan, India. Treatments comprised: two sulfur rates (20 and 40 kg/ha) and three application methods as basal, side dressing at 25 days after sowing (DAS) and half as basal + half as side dressing at 25 DAS, along with a control (no sulfur). The number of pods per plant increased with increasing sulfur rates. Basal dose of 40 kg S/ha recorded the highest number of pods per plant (34.2). Plant heights, number of seeds per pod and 1000-seed weight were not influenced by different treatments in any year. Grain yield obtained at basal dose of 20 kg S/ha (973 kg/ha) was 42.9% higher than that of the control treatment (681 kg/ha). Grain yield was highest with a basal dose of 40 kg S/ha (1095 kg/ha), but did not differ significantly from 20 kg S/ha. A side dressing of 20 kg S/ha at 25 DAS did not increase grain yield over the control.

Nita *et al*. (2002) conducted an experiment to find out the effects of K and S at 0, 20 and 40 kg/ha, applied singly or in combination, on the growth and productive attributes of mungbean as well as on the fertility of the soil were determined in a field experiment conducted in West Bengal, India during the summer of 1998-99. Leaf area index, seed yield, protein yield, harvest index and net production value increased with increasing rates of K and S. Similarly, the status of N and P in soil decreased with increasing rates of K and S.

The effects of phosphorus (30, 60 and 90 kg/ha), sulfur (0, 10, 20 and 30 kg/ha) and *Rhizobium* inoculation on the protein and S-containing amino acids of green gram (*V. radiata*) were determined in a field experiment conducted by Shahi *et al.* (2002) in Allahabad, Uttar Pradesh, India during 1996-97. Application of P and S, and inoculation with *Rhizobium* enhanced the protein content in the grains of green gram, with 60 kg P/ha and 30 kg S/ha application resulting in the highest increase in the protein content. *Rhizobium* inoculation also significantly increased the protein content in the grains of the crop. The S-containing amino acids were highest at 30 kg S/ha. The methionine, cystine and cysteine content of the grains were highest with the application of 30 kg S/ha, which was at par with the application of 20 kg S/ha.

Pandey and Singh (2001) conducted an experiment with P_2O_5/ha at 0, 25 or 50 kg/ha and S at 0, 20 and 40 kg/ha were applied as a basal dressing at the time of sowing of mung in a field experiment conducted in Pura, Jammu and Kashmir, India, during 1995-96. Mung responded significantly to the addition of P_2O_5 and S. The highest seed grain and stover yields were obtained at 50 kg P_2O_5/ha and 40 kg S/ha. The protein and sulfur-containing amino acid contents of the grains linearly increased with increasing rates of phosphorus and sulfur, with the highest protein and sulfur-containing amino acid contents observed at 50 kg P_2O_5/ha and 40 kg S/ha and the lowest contents observed in the control, during both the years.

Summer mungbean were grown in the field in India for two years with the application of elemental sulfur (0, 15, 30 and 45 kg/ha) by Singh *et al.* (1997). Sulfur application significantly improved plant biomass, nodule number and weight, seed grain and stover yield, nitrogen and sulfur uptake, the optimum application rate being 30 kg/ha. Application of sulfur up to 15 kg/ha increased the population of total bacteria and *Azotobacter*. However, addition of sulfur decreased the population of fungi and actinomycetes.

Trivedi *et al.* (1997) carried a field experiment to study the effect of nitrogen, phosphorus and sulfur on yield and nutrient uptake of blackgram (*Vigna mungo*) at Gwalior, Madhya Pradesh during the 1990-91 kharif (monsoon) seasons. Application of 30 kg N, 60 kg P_2O_5 and 60 kg S ha^{-1} increased yield, net profit and nutrient uptake.

Trivedi (1996) conducted a field trials in the rainy seasons of 1990-91 at Gwalior, Madhya Pradesh, India with *P. mungo* (*Vigna mungo*) cv. Jawahar Urd-2 and was given 0-30 kg N, 0-60 kg P_2O_5 and 0 or 60 kg S ha^{-1}. Seed yield, net returns and N, P and S contents in seed increased with rate of N, P and S applications.

In a field experiment conducted by Tiwari and Chaplot (1995) during the summer seasons of 1990 and 1991 at Udaipur, Rajasthan the effects were studied of irrigation regimes (irrigation water : cumulative pan evaporation ratios, IW:CPE of 0.5, 0.7, 0.9 or 1.1) and application of 0-150 kg elemental S/ha on mungbean. Irrigation at 0.9 IW:CPE ratio, at par with 1.1, gave 59.8 and 29.5% higher yield than at 0.5 and 0.7 IW:CPE ratio, respectively. Seed yield of mungbean increased significantly with an increase in sulfur rate up to 100 kg/ha.

Sharma *et al.* (1995) carried out a field trial in the monsoon season of 1991 at Gwalior, Madhya Pradesh with blackgram (*Vigna mungo*) cv. JU-2 treated with 0, 15 or 30 kg N, 0, 30 or 60 kg P_2O_5 and 0 or 60 kg S ha^{-1}. Application of N and P, either alone or with S, increased Mn, Zn, Cu and Fe contents in seeds and straw and the available Mn and Zn content in soil. Application of 30 kg N + 60 kg P_2O_5 + 60 kg S ha^{-1} gave the highest trace element content in blackgram. Soil available Cu content decreased with increasing N and P applications but increased with S application. Soil available Fe increased with increasing N and P applications and decreased with increasing S applications.

Patel *et al.* (1992) conducted a field trial to evaluate the response of mungbean to sulphur fertilization under different levels of nitrogen and phosphorus. Greengram cv. Gujrarat 2 and K 851 were given 10 kg N + 20 kg P ha^{-1} , 20kg N + 40 kg P $ha^{l}$and 0, 10, 20 or 30 kg S ha^{-1} as gypsum and found that plant growth with highest doses. Seed yield was 1.2 and 1.24 t ha^{-1} in Gujrarat 2 K 851, respectively 20 kg N + 40 kg P ha^{-1}.

2.2 Effects of boron fertilizer on growth and yield

Rizk and Abdo (2001) conducted two field experiments were carried out at Giza Experimental Station, ARC, Egypt during 1998 and 1999 seasons to investigate the response of mungbean (*Vigna radiata*) to treatments with some micronutrients. Two cultivars of mungbean (V-2010 and VC-1000) were used in this investigation. Zn (0.2 or 0.4 g/l), Mn (1.5 or 2.0 g/l), B (3.0 or 5.0 g/l) and a mixture of Zn, Mn, and B (0.2, 1.5 and 3.0 g/l, respectively), in addition to distilled water as control were sprayed once at 35 days after sowing (DAS). The obtained results could be summarized in the following: Generally, cultivar VC-1000 surpassed cultivar V-2010 in yield and its components as well as in the chemical composition of seeds with exception in 100-seed weight and phosphorus percentage in seeds. All treatments increased significantly yield and its components especially Zn (0.2 g/l) which showed a highly significant increase in all characters under investigation compared to the control. All adopted treatments increased significantly protein percentage in seeds of the two mungbean cultivars in both seasons. Among all treatments of micronutrients, B gave the highest percentage of crude protein.

Verma and Mishra (1999) conducted a pot experiment with mungbean cv. PDM 54, boron was applied by seed treatment, soil application (basally or at flowering) or foliar spraying. Boron increased yield and growth parameters, with the best results in terms of seed yield/plant given when the equivalent of 5 kg borax/ha was applied at flowering.

Saha *et al*. (1996) carried out a field trials in pre-kharif seasons of 1993-94 at Pundibari, India, yellow sarson was given 0, 2.5 or 5.0 kg borax and 0, 1 or 2 kg sodium molybdate/ha applied as soil, 66% soil + 33% foliar or foliar applications and the residual effects were studied on summer green gram [*Vigna radiata*]. In both years green gram seed yield was highest with a combination of 5 kg borax + 2 kg sodium molybdate. Soil application gave higher yields than foliar or soil + foliar application.

Chapter III

MATERIALS AND METHODS

The experiment was conducted in the Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from February to May 2008 to study the effect of sulfur and boron on the growth and yield of mungbean. This chapter includes materials and methods that were used in conducting the experiment. The details regarding materials and methods of this experiment are presented below under the following headings –

3.1 Experimental site

The experiment was conducted at the Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh. The experimental site is situated between $23^{0}74'$N latitude and $90^{0}35'$E longitude (Anon., 1989).

3.2 Soil

The soil of the experimental field belongs to the Tejgaon series under the Agroecological Zone, Madhupur Tract (AEZ- 28) and the General Soil Type is Deep Red Brown Terrace Soils. A composite sample was made by collecting soil from several spots of the field at a depth of 0-15 cm before the initiation of the experiment. The collected soil was air-dried, ground and passed through 2 mm sieve and analyzed for some important physical and chemical parameters. The initial physical and chemical characteristics of the experimental soil are presented in Table 1.

Table 1. Initial characteristics of the soil in experimental field

1. pH		6.0
2. Particle-size analysis of soil	Sand	29.04
	Silt	41.80
	Clay	29.16
3. Textural Class		Silty Clay Loam
4. Organic matter (%)		0.840
5. Total N (%)		0.0670
6. Phosphorous (ppm)		8.333
7. Potassium (ppm)		25.00

3.3 Climate

The climate of experimental site was subtropical, characterized by three distinct seasons, the monsoon or the rainy season from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October (Edris *et al.*, 1979). Meteorological data related to the temperature, relative humidity and rainfalls during the period of the experiment was collected from the Bangladesh Meteorological Department (Climate Division), Sher-e-Bangla Nagar and presented in Appendix I.

3.4 Planting material

The variety BARI Mung-6 was used as the test crop. The seeds were collected from the Pulse Seed Division of Bangladesh Agricultural Research Institute, Joydevpur, Gajipur. BARI Mung-6 is a recommended variety of mungbean, which was developed by the national seed board. It grows both in kharif and rabi season. Life cycle of this variety ranges from 55-60 days. Maximum seed yield is 1.1-1.4 ton/ha.

3.5 Land preparation

The land was irrigated before ploughing. After having zoe condition the land was first opened with the tractor drawn disc plough. Ploughed soil was then brought into desirable fine tilth by 4 operations of ploughing, harrowing and laddering. The stubble and weeds were removed. The first ploughing and the final land preparation were done on 20 February and 28 February 2008, respectively. Experimental land was divided into unit plots following the design of experiment. The plots were spaded one day before planting and the basal dose of fertilizers was incorporated thoroughly.

3.6 Fertilizer application

Urea, Triple Super Phosphate (TSP) and Muriate of Potash (MoP) were used as a source of nitrogen, phosphorous, and potassium respectively. Total N and K_2O were applied at the rate of 40 and 50 kg per hectare respectively following the BARI recommendation and sulfur and boron was applied as per treatment.

3.7 Treatments of the experiment

The experiment consists of two factors:

Factor A: Sulfur (4 levels)

i. S_0: 0 kg S ha^{-1} (Control)

ii. S_4: 4 kg S ha^{-1}

iii. S_8: 8 kg S ha^{-1}

iv. S_{12}: 12 kg S ha^{-1}

Factor B: Boron (3 levels)

i. B_0: 0 kg B ha^{-1} (Control)

ii. B_1: 1 kg B ha^{-1}

iii. B_2: 2 kg B ha^{-1}

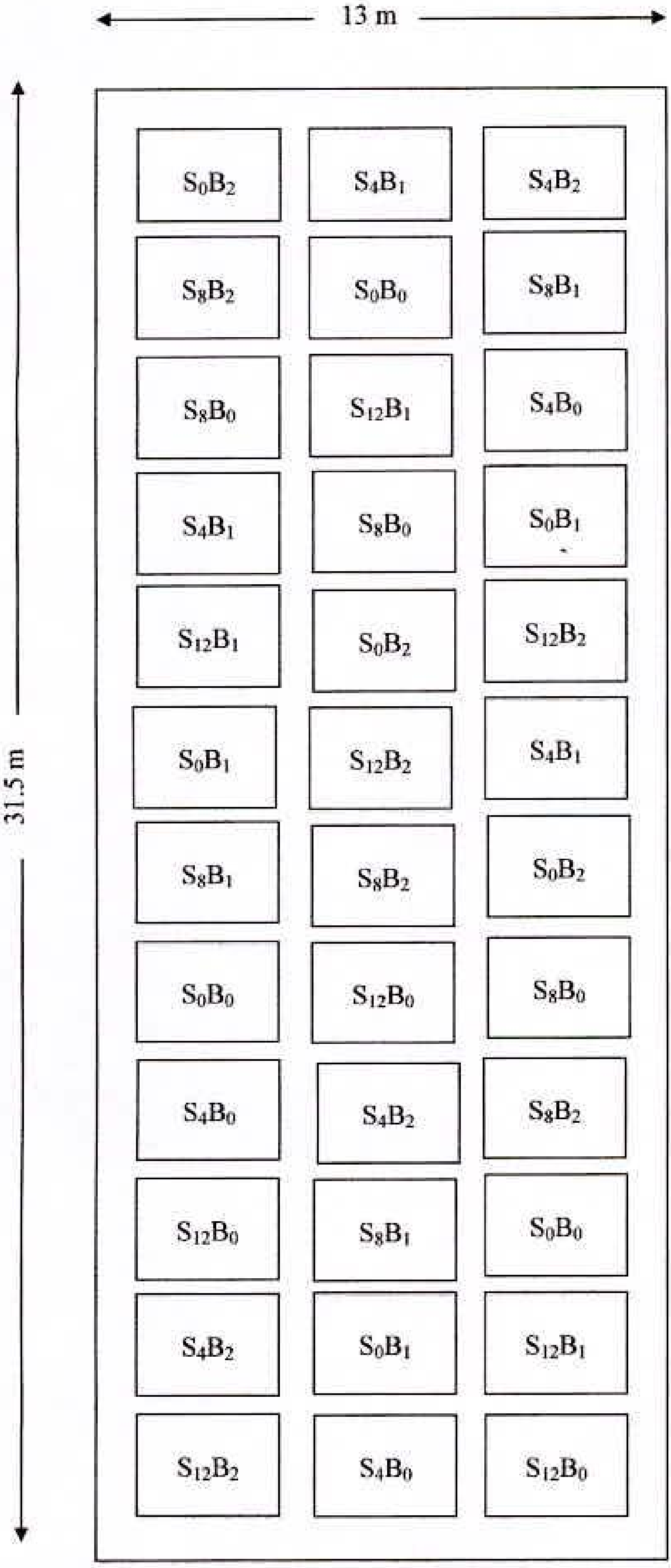
There were on the whole 12 treatment combinations such as S_0B_0, S_0B_1, S_0B_2, S_4B_0, S_4B_1, S_4B_2, S_8B_0, S_8B_1, S_8B_2, $S_{12}B_0$, $S_{12}B_1$ and $S_{12}B_2$.

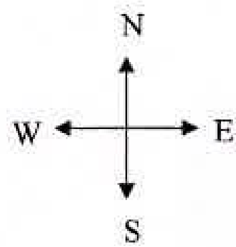
3.8 Experimental design and layout

The two factors experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. An area of 31.5 m × 13.0 m was divided into three equal blocks. Each block was divided into 12 plots where 12 treatment combinations were allotted at random. There were 36 unit plots altogether in the experiment. The size of the each unit plot was 3.0 m × 2.0 m. The distance maintained between two blocks and two plots were 1.0 m and 0.5 m, respectively. The layout of the experiment is shown in Figure 1.

3.9 Sowing of seeds in the field

The seeds of mungbean were sown on March 9, 2008. Seeds were treated with Bavistin before sowing the seeds to control the seed borne disease. The seeds were sown in solid rows in the furrows having a depth of 2-3 cm. Row to row distance was 30 cm.





Plot size = 3 m × 2 m
Plot spacing = 50 cm
Between replication = 0.75 m

Factors A:

S_0: 0 kg S ha^{-1} (Control)
S_4: 4 kg S ha^{-1}
S_8: 8 kg S ha^{-1}
S_{12}: 12 kg S ha^{-1}

Factors B:

B_0: 0 kg B ha^{-1}
B_1: 1 kg B ha^{-1}
B_2: 2 kg B ha^{-1}

Figure 1. Layout of the experimental plot

3.10 Intercultural operations

3.10.1 Thinning

Seeds germinated four days after sowing (DAS). Thinning was done two times; first thinning was done at 8 days after sowing and second was done at 15 days after sowing to maintain proper plant population in each plot.

3.10.2 Irrigation and weeding

Irrigation was done as per requirements. The crop field was weeded twice; first weeding was done at 15 DAS and second weeding was done 30 DAS.

3.10.3 Protection against insect and pest

At early stage of growth few worms (*Agrotis ipsilon*) and virus vectors (jassid) attacked the young plants and at latter stage of growth pod borer (*Maruca testulalis*) attacked the plant. Dimacron 50EC was sprayed at the rate of 1 litre/ha to control the pest.

3.11 Crop sampling and data collection

Ten plants from each treatment were randomly sampled and marked with sample card. The data of plant height, number of leaves and flowers, pod per plant, pod length were recorded from sampled plants at an interval of 10 days which was started from 25 DAS.

3.12 Harvest and post harvest operations

Harvesting was done when 90% of the pods became brown to black in color. The matured pods were collected by hand picking from a pre demarcated area of three linear at the center of each plot.

3.13 Data collection

The following data were recorded

i. Plant height (cm)
ii. Number of leaves per plant
iii. Leaf area (cm^2) per plant
iv. Total dry matter (g)
v. Number of nodule per plant
vi. Number of flowers per plant
vii. Number of pods per plant
viii. Pod length (cm)
ix. Number of seeds per pod
x. 1000- seed weight (g)
xi. Seed yield (t ha^{-1})
xii. Stover yield (t ha^{-1})
xiii. Biological yield
xiv. Harvest index

Sher-e-Bangla Agricultural University Library

3.14 Procedure of data collection

3.14.1 Plant height (cm)

The heights of plants were measured with a meter scale from the ground level to the top of the plants and the mean height was expressed in cm. Data were recorded as the average of 10 plants selected at random from the inner rows of each plot starting from 25 to 55 DAS at 10 days interval.

3.14.2 Number of leaves per plant

The leaves (trifoliate) were counted from selected plants. The average number of leaves per plant was determined. Data were recorded as the average of 10 plants selected at random from the inner rows of each plot starting from 25 to 55 DAS at 10 days interval.

3.14.3 Leaf area (cm^2) per plant

Leaf area were measured with multiply leaf length and breadth was expressed in cm^2. Data were recorded as the average of 10 plants selected at random from the inner rows of each plot starting from 25 to 55 DAS at 10 days interval.

3.14.4 Total dry matter

Ten plants were collected randomly, from each plot at 10 day interval started from 25 days after sowing (DAS). Plants including roots, stem (with pods) and leaves was oven dried at 70^0C for 72 hours than transferred into desiator and allowed to cool down to the room temperature and final weight was taken and converted into dry weight of per plant.

3.14.5 Number of flowers per plant

Number of flowers of selected plants from each plot was counted and the mean number of flower and was expressed as per plant basis. Data were recorded at the time of final harvest.

3.14.6 Number of pods per plant

Number of total pods of selected plants from each plot was counted and the mean number was expressed as per plant basis. Data were recorded as the average of 10 plants selected at random from the inner rows of each plot.

3.14.7 Pod length

Pod length of selected plants were taken from each plot was counted and the mean length was expressed on per pod basis. Data were recorded as the average of 10 pods selected at random from the inner rows plant of each plot.

3.14.8 Number of seeds per pods

The number of seeds in each pod was also recorded from randomly selected pods at the harvest. Data were recorded as the average of 10 plants selected at random from the inner rows of each plot.

3.14.9 Weight of 1000-seed

One thousand cleaned dried seeds were counted randomly from each harvest sample and weighed by using a digital electric balance and weight was expressed in gram (g).

3.14.10 Seed yield per hectare

The seeds collected from 1 m^2 of each plot were sun dried properly. The weight of seeds was taken and converted the yield in t ha^{-1}.

3.14.11 Stover yield per hectare

The Stover collected from 1 m^2 of each plot was sun dried properly. The weight of stover was taken and converted the yield in t ha^{-1}.

3.14.12 Biological yield

Biological yield was measured by adding seed yield and stover yield.

Biological yield = Seed yield + Stover yield

3.14.13 Harvest index

The harvest index was calculated by using the following formula

$$\text{Harvest Index (\%)} = \frac{\text{Seed Yield}}{\text{Biological Yield}} \times 100$$

3.14.14 Number of nodules per plant

The number of nodules in each plant was recorded from randomly selected plant at the time of flower initiation. Data were recorded as the average of 10 plants selected at random from the inner rows of each plot.

3.15 Chemical analysis of plant samples

3.15.1 Collection of plant samples

Grain seed stover samples were collected after threshing. The samples were finely ground by using a Wiley-Mill with stainless contact points to pass through a 60-mesh sieve. The samples were stored in plastic vial for analyses of N, P, K and S.

3.15.2 Preparation of plant samples

The plant samples were dried in an oven at 70^0C for 72 hours and then ground by a grinding machine to pass through a 20-mesh sieve. The grain seed and stover samples were analyzed for determination of N, P, K and S concentrations. The methods were as follows:

3.15.3 Digestion of plant samples with sulphuric acid for N

For the determination of nitrogen an amount of 0.2 g oven dry, ground sample were taken in a micro kjeldahl flask. 1.1 g catalyst mixture (K_2SO_4: $CuSO_4$. $5H_2O$:

Se in the ratio of 100: 10: 1), and 5 ml conc. H_2SO_4 were added. The flasks were heating at 120^{0}C and added 2.5 ml 30% H_2O_2 then heated was continued at 180 ^{0}C until the digests became clear and colorless. After cooling, the content was taken into a 100 ml volumetric flask and the volume was made up to the mark with de-ionized water. A reagent blank was prepared in a similar manner. Nitrogen in the digest was estimated by distilling the digest with 10 N NaOH followed by titration of the distillate trapped in H_3BO_3 indicator solution with 0.01N H_2SO_4.

3.15.4 Digestion of plant samples with nitric-perchloric acid for P, K and S

A sub sample weighing 0.5 g was transferred into a dry, clean 100 ml digestion vessel. Ten ml of di-acid (HNO_3: $HClO_4$ in the ratio 2:1) mixture was added to the flask. After leaving for a while, the flasks were heated at a temperature slowly raised to 200^{0}C. Heating were stopped when the dense white fumes of $HClO_4$ occurred. The content of the flask were boiled until they were became clean and colorless. After cooling, the content was taken into a 100 ml volumetric flask and the volume was made up to the mark with de-ionized water. P, K and S were determined from this digest.

3.15.5 Determination of P, K and S from plant samples

3.15.5.1 Phosphorus

Phosphorus was digested from the plant sample (seed grain and stover) with 0.5 M $NaHCO_3$ solutions, pH 8.5 (Olsen *et al.*, 1954). Phosphorus in the digest was determined by using 1 ml for grain sample and 2 ml for stover sample from 100 ml extract was then determined by developing blue color with reduction of phosphomolybdate complex and the color intensity were measured colorimetrically at 660 nm wavelength and readings were calibrated with the standard P curve (Page *et al.*, 1982).

3.15.5.2 Potassium

Five milli-liter of digest sample for the grain and 10 ml for the stover were taken and diluted 50 ml volume to make desired concentration so that the absorbance of sample were measured within the range of standard solutions. The absorbances were measured by atomic absorption flame photometer.

3.15.5.3 Sulphur

Sulphur content was determined from the digest of the plant samples (seed grain and stover) with $CaCl_2$ (0.15%) solution as described by (Page *et al.*, 1982). The digested S was determined by developing turbidity by adding acid seed solution (20 ppm S as K_2SO_4 in 6N HCl) and $BaCl_2$ crystals. The intensity of turbidity was measured by spectrophotometer at 420 nm wavelengths (Hunter, 1984).

3.16 Nutrient Uptake

After chemical analysis of stover and seed grain samples the nutrient contents were calculated and from the value of nutrient contents, nutrient uptakes were also calculated by following formula:

Nutrient uptake = Nutrient content (%) × Yield (kg/ha)/100

3.17 Post harvest soil sampling

After harvest of crop soil samples were collected from each plot at a depth of 0 to 15 cm. Soil sample of each plot were air-dried, crushed and passed through a two mm (10 meshes) sieve. The soil samples were kept in plastic container to determine the physical and chemical properties of soil.

3.18 Soil analysis

Soil samples were analyzed for both physical and chemical characteristics viz. organic matter, pH, total N and available P, K, and S contents. These results have been shown in the Table 4.6. The soil samples were analyzed by the following standard methods as follows:

3.18.1 Textural class

Mechanical analysis of soil were done by hydrometer method (Bouyoucos, 1926) and the textural class was determined by plotting the values of % sand, % silt and % clay to the Marshall's triangular co-ordinate following the USDA system.

3.18.2 Soil pH

Soil pH was measured with the help of a glass electrode pH meter, the soil water ratio being maintained at 1: 2.5 (Jackson, 1962).

3.18.3 Organic matter

Organic carbon in soil sample was determined by wet oxidation method of Walkley and Black (1935). The underlying principle was used to oxidize the organic matter with an excess of 1N $K_2Cr_20_7$ in presence of conc. H_2SO_4 and conc. H_3PO_4 and to titrate the excess $K_2Cr_20_7$ solution with 1N $FeSO_4$. To obtain the content of organic matter was calculated by multiplying the percent organic carbon by 1.73 (Van Bemmelen factor) and the results were expressed in percentage (Page *et al.*, 1982).

3.18.4 Total nitrogen

Total N content of soil were determined followed by the Micro Kjeldahl method. One gram of oven dry ground soil sample was taken into micro kjeldahl flask to which 1.1 gm catalyst mixture (K_2SO_4: $CuSO_4$. $5H_2O$: Se in the ratio of 100: 10: 1), and 6 ml H_2SO_4 were added. The flasks were swirled and heated 200 ^{0}C and added 3 ml H_2O_2 and then heating at 360 ^{0}C was continued until the digest was clear and colorless. After cooling, the content was taken into 100 ml volumetric flask and the volume was made up to the mark with distilled water. A reagent blank was prepared in a similar manner. These digests were used for nitrogen determination (Page *et al.*, 1982).

Then 20 ml digest solution was transferred into the distillation flask, Then 10 ml of H_3BO_3 indicator solution was taken into a 250 ml conical flask which is marked to indicate a volume of 50 ml and placed the flask under the condenser outlet of the distillation apparatus so that the delivery end dipped in the acid. Add sufficient amount of 10 N-NaOH solutions in the container connecting with distillation apparatus. Water runs through the condenser of distillation apparatus was checked. Operating switch of the distillation apparatus collected the distillate. The conical flask was removed by washing the delivery outlet of the distillation apparatus with distilled water. Finally the distillates were titrated with standard 0.01 N H_2SO_4 until the color changes from green to pink. The amount of N was calculated using the following formula:

$$\% N = (T-B) \times N \times 0.014 \times 100 / S$$

Where,

T = Sample titration (ml) value of standard H_2SO_4

B = Blank titration (ml) value of standard H_2SO_4

N = Strength of H_2SO_4

S = Sample weight in gram

3.18.5 Available phosphorus

Available P was extracted from the soil with 0.5 M $NaHCO_3$ solutions, pH 8.5 (Olsen *et al.*, 1954). Phosphorus in the extract was then determined by developing blue color with reduction of phosphomolybdate complex and the color intensity were measured colorimetrically at 660 nm wavelength and readings were calibrated the standard P curve (Page *et al.*, 1982).

3.18.6 Exchangeable potassium

Exchangeable K was determined by 1 N NH_4OAc (pH 7) extraction methods and by using flame photometer and calibrated with a standard curve (Page *et al.* 1982).

3.18.7 Available sulfur

Available S content was determined by extracting the soil with $CaCl_2$ (0.15%) solution as described by (Page *et al.*, 1982). The extractable S was determined by developing turbidity by adding acid seed solution (20 ppm S as K_2SO_4 in 6N HCl) and $BaCl_2$ crystals. The intensity of turbidity was measured by spectrophotometer at 420 nm wavelengths.

38721 29.02.15

3.18.8 Available boron

Available boron (B) content in the soil samples was determined by the method described by Hunter (1984). The extracting agent used was monocalcium phosphate [$CaH_4(PO_4)_2 . H_2O$] solution and colour was developed by curcumin solution. The absorbance was read on spectrophotometer at 555 nm wavelengths.

3.19 Statistical analysis

The data obtained for different parameters were statistically analyzed to find out the significant difference of different level of sulfur and boron on yield and yield contributing characters of mungbean. The mean values of all the characters were calculated and analysis of variance was performed by the 'F' (variance ratio) test. The significance of the difference among the treatment means was estimated by the Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

Sher-e-Bangla Agricultural University Library Sher-e-Bangla Nagar, Dhaka

Chapter IV

RESULTS AND DISCUSSION

The present study was conducted to determine the effect of different levels of sulfur and boron on the growth and yield of mungbean. Data on different yield contributing characters and yield were recorded to find out the optimum levels of sulfur and boron for mungbean cultivation. The analysis of variance (ANOVA) of the data on different yield components and yield are given in Appendix II-X. The results have been presented and discussed, and possible interpretations given under the following headings:

4.1 Plant height

A statistically significant variation was recorded for plant height of mungbean due to the application of different levels of sulfur at 25, 35, 45 and 55 DAS (Appendix II). The longest plant (28.53 cm, 41.11 cm, 55.30 cm and 62.83 cm) was recorded from S_{12} which was statistically similar (27.68 cm, 40.23 cm, 54.08 cm and 62.69 cm) with S_8 and closely followed (22.72 cm, 34.59 cm, 49.00 cm and 56.33 cm) by S_4, while the shortest plant (18.38 cm, 30.20 cm, 41.54 cm and 50.17 cm) was recorded from S_0 i.e. control condition at 25, 35, 45 and 55 DAS (Figure 2). Sulfur increased plant height of mungbean upto maximum doses following an increasing trend. Probably, sulfur ensured the availability of other essential nutrients as a result of which maximum growth was occurred and the ultimate results is the maximum plant height. Siag and Yadav (2003) reported that plant height was not influenced by the application of sulfur.

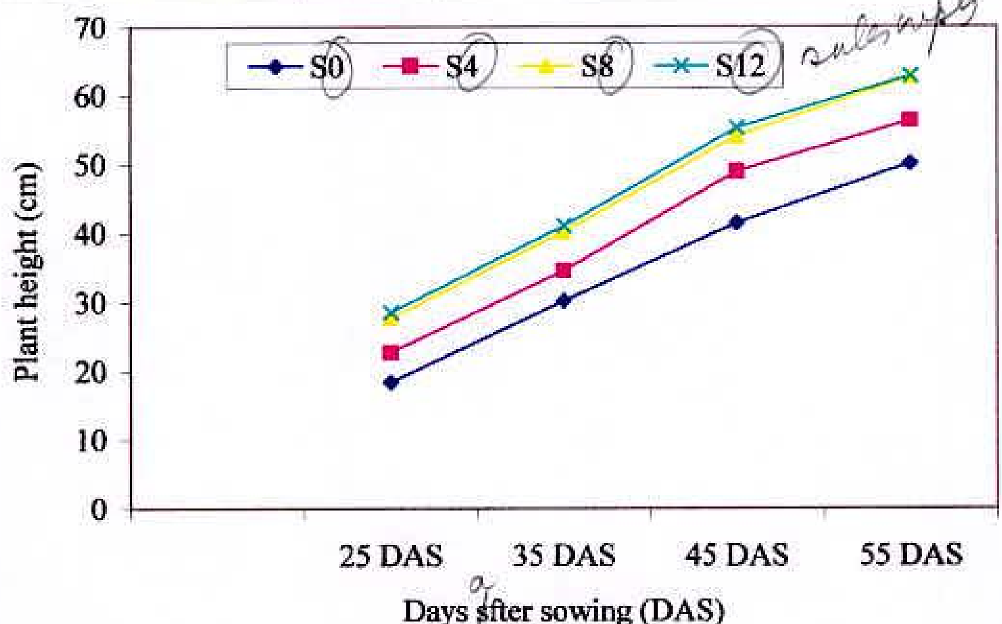


Figure 2. Effect of sulfur on plant height of mungbean

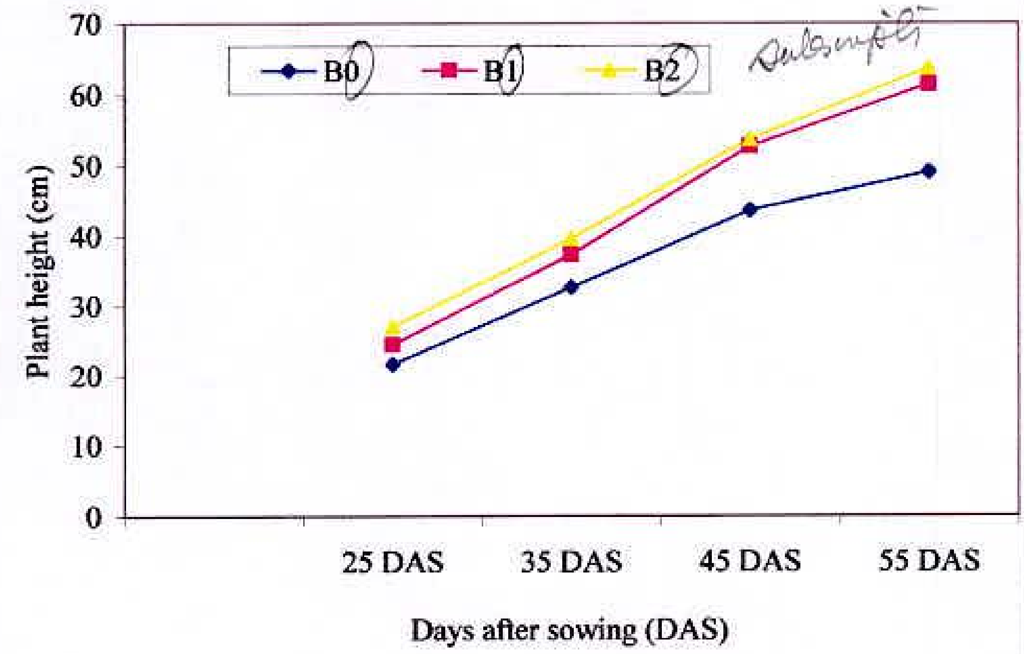


Figure 3. Effect of boron on plant height of mungbean

Plant height of mungbean varied significantly due to different level of boron at 25, 35, 45, 55 DAS (Appendix II). At 25, 35, 45 and 55 DAS the longest plant (26.92 cm, 37.36 cm, 52.65 cm and 61.35 cm) was found from B_2 which was statistically identical (24.44 cm, 37.36 cm, 52.65 cm and 61.35 cm) with B_1 and the shortest plant (21.62 cm, 32.63 cm, 43.60 cm and 49.04 cm) was recorded from B_0 as no boron (Figure 3). Results indicated that boron favored the mungbean plants to have better growth and produced the tallest plants. Verma and Mishra (1999) also reported highest growth parameter when the equivalent of 5 kg borax/ha was applied at flowering.

Interaction effect of sulfur and boron showed statistically significant differences for plant height at 25, 35, 45 and 55 DAS (Appendix II). The longest plant (33.89 cm, 47.15 cm, 63.52 cm and 75.31 cm) was observed from S_8B_2 and the shortest plant (16.90 cm, 28.20 cm and 39.58 cm) was recorded from S_0B_0 at 25, 35 and 45 DAS but 46.88 cm was found from S_0B_1 treatment at 55 DAS (Table 2).

4.2 Number of leaves plant^{-1}

Due to the application of different levels of sulfur a statistically significant variation was recorded for number of leaves plant^{-1} of mungbean at 25, 35, 45 and 55 DAS (Appendix III). The maximum number of leaves plant^{-1} (5.41, 11.64, 19.23 and 21.95) was obtained from S_{12} which was statistically similar (5.12, 11.24, 18.74 and 21.63) with S_8 and closely followed (4.55, 10.87, 18.04 and 20.02) by S_4, while the minimum number of leaves plant^{-1} (3.79, 9.72, 14.62 and 17.21) was found from S_0 i.e. control condition at 25, 35, 45 and 55 DAS (Figure 4).

Table 2. Interaction effect of sulfur and boron on plant height of mungbean

Treatment	Plant height (cm) at			
	25 DAS	35 DAS	45 DAS	55 DAS
S_0B_0	16.90 f	28.20 d	39.58 de	49.05 de
S_0B_1	17.62 f	30.35 d	39.71 de	46.88 e
S_0B_2	20.62 ef	32.04 d	45.32 cde	54.60 cde
S_4B_0	20.29 ef	28.94 d	44.38 cde	46.97 e
S_4B_1	22.62 de	36.99 c	49.76 bcd	60.50 bcd
S_4B_2	25.24 cd	37.83 c	52.86 abc	61.53 bc
S_8B_0	18.43 f	30.68 d	37.58 e	43.45 e
S_8B_1	30.72 ab	42.85 ab	61.15 a	69.33 ab
S_8B_2	33.89 a	47.15 a	63.52 a	75.31 a
$S_{12}B_0$	27.14 bc	38.84 bc	47.13 cde	51.15 cde
$S_{12}B_1$	27.52 bc	41.41 bc	60.00 ab	66.50 ab
$S_{12}B_2$	30.93 ab	43.09 ab	58.77 ab	70.84 ab
$LSD_{(0.05)}$	3.631	4.498	9.899	10.61
Level of significance	0.01	0.01	0.01	0.01
CV(%)	8.82	7.27	11.70	10.80

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

S_0: 0 kg S ha^{-1}
S_4: 4 kg S ha^{-1}
S_8: 8 kg S ha^{-1}
S_{12}: 12 kg S ha^{-1}

B_0: No boron (control)
B_1: 1 kg B ha^{-1}
B_2: 2 kg B ha^{-1}

Sulfur increased number of leaves plant^{-1} of mungbean upto maximum doses following an increasing trend. Probably, sulfur ensured the availability of other essential nutrients as a result of which maximum growth was occurred and the ultimate results is the maximum number of leaves plant^{-1}.

A statistically significant variation was recorded for number of leaves plant^{-1} of mungbean due to different level of boron at 25, 35, 45, 55 DAS (Fig. 5 and Appendix III). At 25, 35, 45 and 55 DAS the maximum number of leaves plant^{-1} (5.23, 11.81, 20.23 and 22.95 respectively) was observed from B_2 which was statistically similar (4.72, 11.22, 18.08 and 20.96) with B_1 and the minimum number of leaves plant^{-1} (4.20, 9.59, 14.66 and 16.69) was found from B_0 ~~as no boron~~ (Figure 5). Results indicated that boron favored the mungbean plants to have better growth and produced the maximum number of leaves plant^{-1}. Verma and Mishra (1999) also reported highest growth parameter when the equivalent of 5 kg borax/ha was applied at flowering.

Sulfur and boron showed statistically significant interaction effect for number of leaves plant^{-1} at 25, 35, 45 and 55 DAS (Table 3 and Appendix III). The maximum number of leaves plant^{-1} (6.11, 12.97, 23.50 and 26.69) was observed from S_8B_2 and the minimum number of leaves plant^{-1} (3.46, 9.37, 13.74 and 16.14) was found from S_0B_1 at 25, 35, 45 and 55 DAS (Table 3).

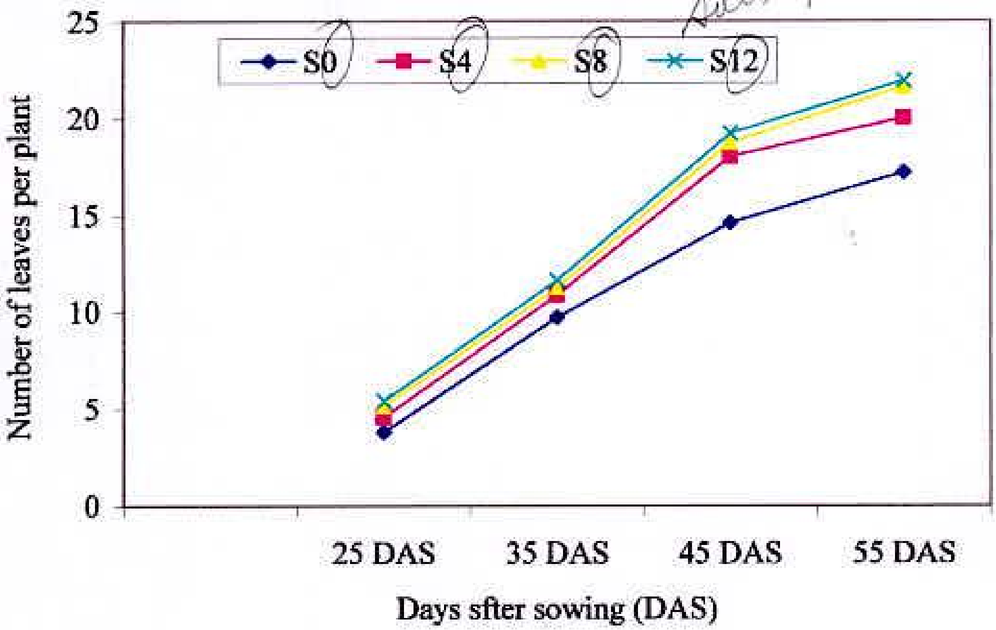


Figure 4. Effect of sulfur on number of leaves per plant of mungbean

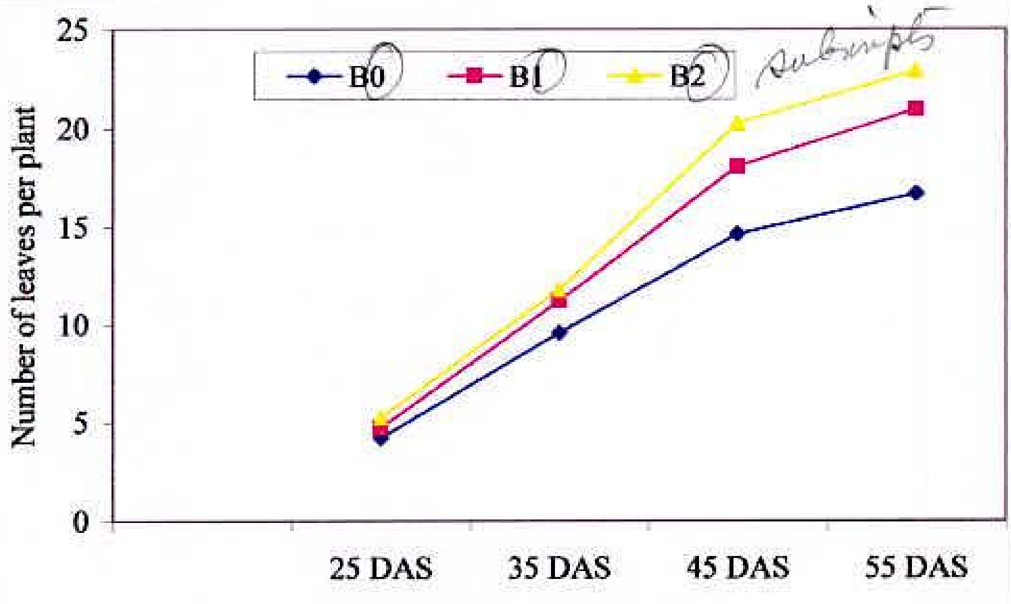


Figure 5. Effect of boron on number of leaves per plant of mungbean

Table 3. Interaction effect of sulfur and boron on number of leaves plant^{-1} of mungbean

Treatment	Number of leaves plant^{-1} at			
	25 DAS	35 DAS	45 DAS	55 DAS
S_0B_0	3.84 ef	9.60 def	15.60 cde	17.99 cde
S_0B_1	3.46 f	9.37 ef	13.74 e	16.14 e
S_0B_2	4.09 def	10.19 cde	14.52 de	17.50 de
S_4B_0	4.12 def	9.63 def	14.75 de	16.91 de
S_4B_1	4.59 cde	11.13 bcd	18.41 bcd	20.91 bcd
S_4B_2	4.94 bcd	11.85 abc	20.95 ab	22.24 abc
S_8B_0	3.79 ef	8.35 f	12.19 e	14.73 e
S_8B_1	5.45 abc	12.42 ab	20.53 ab	23.46 ab
S_8B_2	6.11 a	12.97 a	23.50 a	26.69 a
$S_{12}B_0$	5.07 bc	10.78 bcde	16.09 cde	17.12 de
$S_{12}B_1$	5.38 abc	11.94 ab	19.65 abc	23.32 ab
$S_{12}B_2$	5.78 ab	12.22 ab	21.95 ab	25.42 ab
$LSD_{(0.05)}$	0.789	1.546	3.965	4.179
Level of significance	0.01	0.01	0.01	0.01
CV(%)	9.88	8.40	13.26	12.21

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

S_0: 0 kg S ha^{-1}
S_4: 4 kg S ha^{-1}
S_8: 8 kg S ha^{-1}
S_{12}: 12 kg S ha^{-1}

B_0: No boron (control)
B_1: 1 kg B ha^{-1}
B_2: 2 kg B ha^{-1}

4.3 Leaf area

Significant variation was recorded for leaf area of mungbean due to the application of different level of sulfur at 25, 35, 45 and 55 DAS (Appendix IV). The highest leaf area (976.01 cm^2, 1338.12 cm^2, 1485.33 cm^2 and 1663.05 cm^2) was recorded from S_{12} which was statistically similar (929.33 cm^2, 1301.95 cm^2, 1453.72 cm^2 and 1635.54 cm^2) with S_8 and followed (842.58 cm^2, 1243.72 cm^2, 1424.52 cm^2 and 1505.96 cm^2) by S_4, while the lowest leaf area (676.56 cm^2, 994.79 cm^2, 1133.12 cm^2 and 1206.40 cm^2) was recorded from S_0 i.e. control condition at 25, 35, 45 and 55 DAS (Figure 6). Sulfur increased leaf area of mungbean upto maximum doses following an increasing trend. Probably, sulfur ensured the availability of other essential nutrients as a result of which maximum growth was occurred and the ultimate results is the maximum leaf area. Nita *et al.* (2002) reported that application of sulfur at 40 kg ha^{-1} resulted in the significant increase in Leaf area index.

Leaf area of mungbean differed significantly due to different level of boron at 25, 35, 45, 55 DAS (Appendix IV). At 25, 35, 45 and 55 DAS the highest leaf area (952.98 cm^2, 1333.76 cm^2, 1576.58 cm^2 and 1758.68 cm^2) was recorded from B_2 which was statistically identical (856.29 cm^2, 1274.59 cm^2, 1451.15 cm^2 and 1532.83 cm^2) with B_1 and the lowest leaf area (759.09 cm^2, 1050.58 cm^2, 1094.79 cm^2 and 1216.71 cm^2) was obtained from B_0 ~~as no boron~~ (Figure 7). Results indicated that boron favored the mungbean plants to have better growth and produced the maximum leaf area. Verma and Mishra (1999) also reported highest growth parameter when the equivalent of 5 kg borax/ha was applied at flowering.

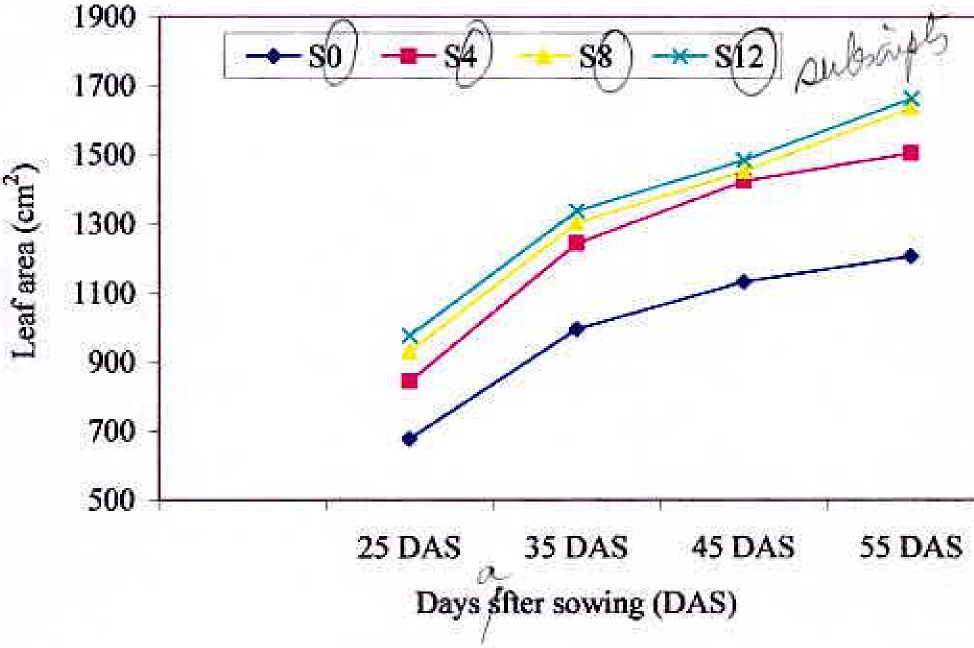


Figure 6. Effect of sulfur on leaf area of mungbean

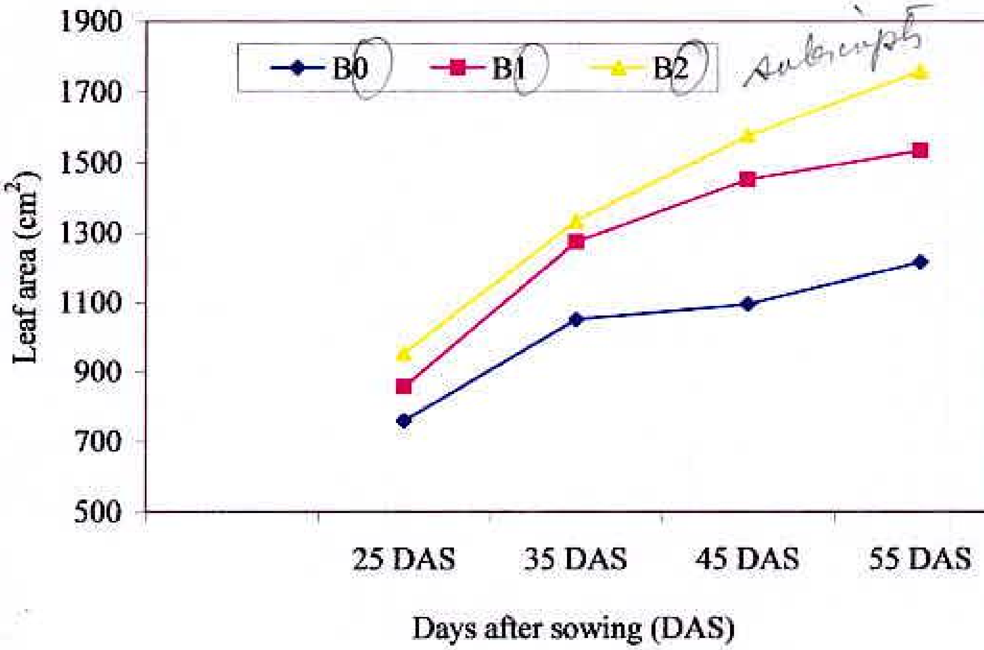


Figure 7. Effect of boron on leaf area of mungbean

Interaction effect of sulfur and boron showed statistically significant variation for leaf area at 25, 35, 45 and 55 DAS (Appendix IV). The highest leaf area (1172.13 cm^2, 1603.43 cm^2, 1877.39 cm^2 and 2116.60 cm^2) was recorded from S_8B_2 and the lowest leaf area (641.26 cm^2, 891.64 cm^2, 1033.24 cm^2 and 1206.61 cm^2) was found from S_0B_1 at 25, 35, 45 and 55 DAS (Table 4).

4.4 Dry matter content plant^{-1}

Dry matter content plant^{-1} of mungbean differed significantly due to the application of different level of sulfur at 25, 35, 45 and 55 DAS (Appendix V). The maximum dry matter content plant^{-1} (256.43 g, 336.56 g, 376.48 g and 450.59 g) was observed from S_{12} which was statistically similar (251.83 g, 324.58 g, 372.18 g and 439.27) with S_8 and closely followed (211.12 g, 280.44 g, 351.42 g and 384.67 g) by S_4, while the minimum dry matter content plant^{-1} (188.87 g, 225.94 g, 304.64 g and 346.61 g) was found from S_0 i.e. control condition at 25, 35, 45 and 55 DAS (Figure 8). Sulfur increased dry matter content plant^{-1} of mungbean upto maximum doses following an increasing trend. Probably, sulfur ensured the availability of other essential nutrients as a result of which maximum growth was occurred and the ultimate results is the maximum dry matter content plant^{-1}. Dey and Basu (2004) reported that dry matter accumulation in aerial plant parts of green gram were highest at 20, 40 and 65 days after sowing upon treatment with 40 kg S/ha.

Table 4. Interaction effect of sulfur and boron on leaf area of mungbean

Treatment	Leaf area (cm^2) at			
	25 DAS	35 DAS	45 DAS	55 DAS
S_0B_0	730.84 ef	1066.83 d	1201.82 d	1306.01 de
S_0B_1	657.59 fg	1025.90 d	1164.29 d	1106.59 e
S_0B_2	641.26 fg	891.64 de	1033.24 de	1206.61 de
S_4B_0	785.55 e	1047.25 d	1179.11 d	1300.68 de
S_4B_1	825.94 de	1291.76 bc	1458.56 c	1508.25 cd
S_4B_2	916.25 cd	1392.13 bc	1635.90 abc	1708.95 bc
S_8B_0	612.42 g	847.83 e	837.96 e	1036.54 e
S_8B_1	1003.44 bc	1454.6 ab	1645.80 abc	1753.47 bc
S_8B_2	1172.13 a	1603.43 a	1877.39 a	2116.60 a
$S_{12}B_0$	907.54 cd	1240.43 c	1160.26 d	1223.60 de
$S_{12}B_1$	938.19 c	1326.12 bc	1535.96 bc	1762.99 bc
$S_{12}B_2$	1082.29 ab	1447.83 ab	1759.77 ab	2002.55 ab
$LSD_{(0.05)}$	96.02	164.8	234.0	291.5
Level of significance	0.01	0.01	0.01	0.01
CV(%)	6.62	7.98	10.06	11.46

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

S_0: 0 kg S ha^{-1}
S_4: 4 kg S ha^{-1}
S_8: 8 kg S ha^{-1}
S_{12}: 12 kg S ha^{-1}

B_0: No boron (control)
B_1: 1 kg B ha^{-1}
B_2: 2 kg B ha^{-1}

Sher-e-Bangla Agricultural University
Library
Sher-e-Bangla Nagar, Dhaka

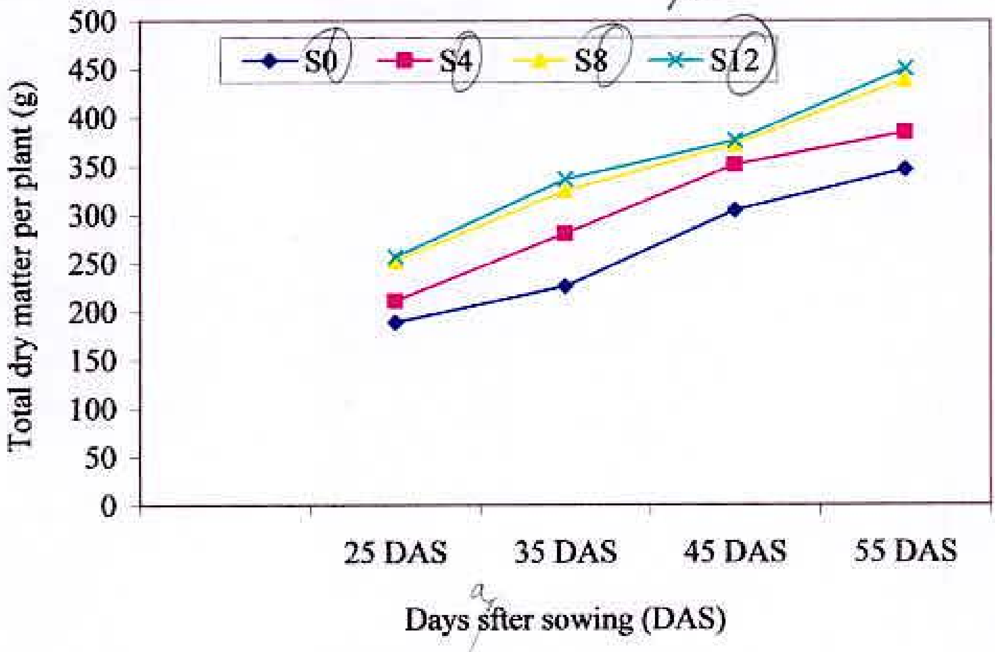


Figure 8. Effect of sulfur on total dry matter per plant of mungbean

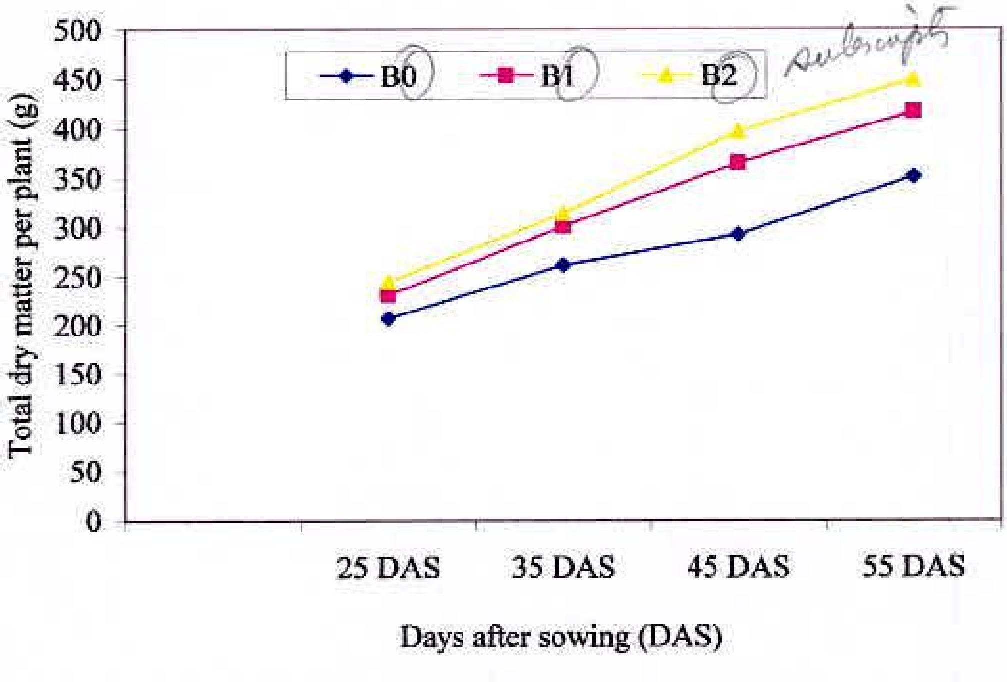


Figure 9. Effect of boron on total dry matter per plant of mungbean

Boron showed significant differences for dry matter content plant^{-1} of mungbean varied significantly due to at 25, 35, 45, 55 DAS (Appendix V). At 25, 35, 45 and 55 DAS the maximum dry matter content plant^{-1} (244.19 g, 313.57 g, 396.29 g and 449.05 g) was obtained from B_2 which was statistically identical (230.30 g, 300.79 g, 364.74 g and 416.05 g) with B_1 and the minimum dry matter content plant^{-1} (206.70 g, 261.27 g, 292.51 g and 350.78 g) was recorded from B_0 as no boron (Figure 9). Results indicated that boron favored the mungbean plants to have better growth and produced the maximum dry matter content plant^{-1}. Verma and Mishra (1999) also reported highest growth parameter when the equivalent of 5 kg borax/ha was applied at flowering.

Interaction effect of sulfur and boron showed statistically significant differences for dry matter content plant^{-1} at 25, 35, 45 and 55 DAS (Appendix V). The maximum dry matter content plant^{-1} (300.88 g, 373.93 g, 459.90 g and 535.79 g) was recorded from S_8B_2 and the minimum (175.87 g, 206.80 g, 292.65 g and 319.70 g) was recorded from S_0B_1 at 25, 35, 45 and 55 DAS (Table 5).

4.5 Number of flowers plant^{-1}

A statistically significant difference was recorded for number of flowers plant^{-1} of mungbean due to the application of different level of sulfur (Appendix VI). The highest number of flowers plant^{-1} (34.20) was recorded from S_{12} which was statistically similar (33.11) with S_8 and closely followed (27.89) by S_4, while the lowest number of flowers plant^{-1} (19.44) was observed from S_0 i.e. control condition (Table 6). Dey and Basu (2004) reported number of flowers plant^{-1} increased with increasing rates of sulfur in green gram.

Table 5. Interaction effect of sulfur and boron on dry matter content plant^{-1} of mungbean

Treatment	Dry matter content (g) plant^{-1} at			
	25 DAS	35 DAS	45 DAS	55 DAS
S_0B_0	199.82 def	234.39 e	321.36 cde	376.03 de
S_0B_1	175.87 f	206.80 e	292.65 de	319.70 e
S_0B_2	190.92 def	236.62 e	299.90 de	344.11 e
S_4B_0	194.95 def	245.60 e	300.82 de	340.13 e
S_4B_1	214.32 de	294.10 d	358.18 bcd	388.96 de
S_4B_2	224.10 cd	301.62 cd	395.25 abc	424.91 cd
S_8B_0	179.15 ef	240.05 e	255.80 e	319.89 e
S_8B_1	275.45 ab	359.75 ab	400.83 ab	462.13 bc
S_8B_2	300.88 a	373.93 a	459.90 a	535.79 a
$S_{12}B_0$	252.90 bc	325.05 bcd	292.05 de	367.07 de
$S_{12}B_1$	255.55 bc	342.50 abc	400.03 ab	468.88 abc
$S_{12}B_2$	260.85 bc	342.13 abc	437.35 a	515.81 ab
$LSD_{(0.05)}$	34.21	38.91	71.40	66.13
Level of significance	0.01	0.01	0.01	0.01
CV(%)	8.90	7.87	12.01	9.64

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

S_0: 0 kg S ha^{-1}
S_4: 4 kg S ha^{-1}
S_8: 8 kg S ha^{-1}
S_{12}: 12 kg S ha^{-1}

B_0: No boron (control)
B_1: 1 kg B ha^{-1}
B_2: 2 kg B ha^{-1}

Number of flowers plant^{-1}of mungbean varied significantly due to different level of boron (Appendix VI). The highest number of flowers plant^{-1} (33.07) was recorded from B_2 which was closely followed (29.32) by B_1 and the lowest number of flowers plant^{-1} (23.60) was found from B_0 as no boron (Table 6). Results indicated that boron favored the mungbean plants to have better growth and produced the maximum number of flowers plant^{-1}. Rizk and Abdo (2001), Verma and Mishra (1999) and Saha *et al.* (1996) also reported highest yield components for highest level of boron.

Interaction effect of sulfur and boron showed statistically significant differences for number of flowers plant^{-1} (Appendix VI). The highest number of flowers plant^{-1} (40.20) was observed from S_8B_2 and the lowest number of flowers plant^{-1} (15.93) was recorded from S_0B_0 (Table 7).

4.6 Number of pods plant^{-1}

Number of pods plant^{-1} of mungbean showed a statistically significant variation due to the application of different level of sulfur (Appendix VI). The highest number of pods plant^{-1} (17.17) was recorded from S_{12} which was statistically similar (16.91 and 16.31) with S_8 and S_4, respectively and the lowest number of pods plant^{-1} (13.20) was found from S_0 i.e. control condition (Table 6). Sulfur increased number of pods plant^{-1} of mungbean upto maximum doses following an increasing trend. Siag and Yadav (2003) and Yadav (2004) reported similar results earlier.

Table 6. Effect of sulfur and boron on yield contributing characters of mungbean

Treatment	Flowers plant^{-1} (No.)	Pods plant^{-1} (No.)	Pod length (cm)	Seeds per pod^{-1}	Weight of 1000 seeds (g)
Sulfur					
S_0	19.44 c	13.20 b	4.94 b	4.47 c	18.19 c
S_4	27.89 b	16.31 a	6.52 a	6.31 b	21.56 b
S_8	33.11 a	16.91 a	7.01 a	7.16 a	24.71 a
S_{12}	34.20 a	17.17 a	7.11 a	7.24 a	25.66 a
$LSD_{(0.05)}$	2.962	1.344	0.569	0.738	1.418
Level of significance	0.01	0.01	0.01	0.01	0.01
Boron					
B_0	23.60 c	13.56 b	5.05 b	5.13 b	19.55 c
B_1	29.32 b	16.69 a	6.92 a	6.68 a	23.28 b
B_2	33.07 a	17.44 a	7.22 a	7.07 a	24.76 a
$LSD_{(0.05)}$	2.565	1.164	0.493	0.639	1.228
Level of significance	0.01	0.01	0.01	0.01	0.01
CV(%)	10.57	8.65	9.10	11.99	6.44

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

S_0: 0 kg S ha^{-1}
S_4: 4 kg S ha^{-1}
S_8: 8 kg S ha^{-1}
S_{12}: 12 kg S ha^{-1}

B_0: No boron (control)
B_1: 1 kg B ha^{-1}
B_2: 2 kg B ha^{-1}

Table 7. Interaction effect of sulfur and boron on yield contributing characters of mungbean

Treatment	Flowers plant^{-1} (No.)	Pods plant^{-1} (No.)	Pod length (cm)	Seeds pod^{-1} (No.)	Weight of 1000 seeds (g)
S_0B_0	15.93 e	12.00 d	4.43 d	4.27 f	15.86 h
S_0B_1	19.80 de	14.00 cd	5.29 cd	4.53 ef	19.09 g
S_0B_2	22.60 d	13.60 cd	5.09 cd	4.60 ef	19.61 fg
S_4B_0	22.60 d	13.73 cd	5.26 cd	5.53 def	19.08 g
S_4B_1	29.13 c	17.00 b	6.91 b	6.60 cd	21.87 ef
S_4B_2	31.93 bc	18.20 ab	7.39 ab	6.80 bcd	23.72 de
S_8B_0	23.73 d	12.47 d	4.90 cd	4.87 ef	18.87 g
S_8B_1	35.40 ab	18.47 ab	7.76 ab	7.87 abc	26.67 abc
S_8B_2	40.20 a	19.80 a	8.36 a	8.73 a	28.57 a
$S_{12}B_0$	32.13 bc	16.03 bc	5.62 c	5.87 de	24.38 cde
$S_{12}B_1$	32.93 bc	17.30 ab	7.70 ab	7.73 abc	25.48 bcd
$S_{12}B_2$	37.53 ab	18.17 ab	8.02 a	8.13 ab	27.13 ab
$LSD_{(0.05)}$	5.130	2.327	0.986	1.278	2.457
Level of significance	0.05	0.05	0.01	0.05	0.01
CV(%)	10.57	8.65	9.10	11.99	6.44

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

S_0: 0 kg S ha^{-1}
S_4: 4 kg S ha^{-1}
S_8: 8 kg S ha^{-1}
S_{12}: 12 kg S ha^{-1}

B_0: No boron (control)
B_1: 1 kg B ha^{-1}
B_2: 2 kg B ha^{-1}

Number of pods plant^{-1} of mungbean varied significantly due to different level of boron (Appendix VI). The highest number of pods plant^{-1} (17.44) was obtained from B_2 which was statistically identical (16.69) with B_1 and the lowest number of pods plant^{-1} (13.56) was found from B_0 as no boron (Table 6). Rizk and Abdo (2001) also reported similar finding. Verma and Mishra (1999) reported highest number of pod from 5 kg borax/ha were applied at flowering stage.

Sulfur and boron showed statistically significant interaction effect for number of pods plant^{-1} (Appendix VI). The highest number of pods plant^{-1} (19.80) was obtained from S_8B_2 and the lowest number of pods plant^{-1} (12.00) was recorded from S_0B_0 (Table 7).

4.7 Pod length

A statistically significant variation was recorded for pod length of mungbean due to the application of different level of sulfur (Appendix VI). The maximum pod length (7.11 cm) was found S_{12} which was statistically similar (7.01 cm and 6.52 cm) with S_8 and S_4, respectively and the minimum pod length (4.94 cm) was recorded from S_0 i.e. control condition (Table 6). Probably, sulfur ensured the availability of other essential nutrients as a result of which maximum growth was occurred and the ultimate results is the maximum pod length. Dey and Basu (2004) reported highest pod length from highest doses of sulfur.

Pod length of mungbean varied significantly due to different level of boron (Appendix VI). The maximum pod length (7.22 cm) was recorded from B_2 which was statistically identical (6.92 cm) with B_1 and the lowest pod length (5.05 cm) was recorded from B_0 (Table 6). Results indicated that boron favored the mungbean plants to have better growth and produced the maximum pod length. Saha *et al.* (1996) also reported similar finding.

Interaction effect of sulfur and boron showed statistically significant differences for pod length (Appendix VI). The highest pod length (8.36 cm) was recorded from S_8B_2 and the lowest pod length (4.43 cm) was recorded from S_0B_0 (Table 7).

4.8 Number of seeds pod^{-1}

Significant variation was recorded for number of seeds pod-1 of mungbean due to the application of different level of sulfur (Appendix VI). The highest number of seeds pod^{-1} (7.24) was observed from S_{12} which was statistically similar (7.16) with S_8 and closely followed (6.31) by S_4. On the other hand, the lowest number of seeds pod^{-1} (4.47) was recorded from S_0 i.e. control condition (Table 6). Sulfur increased number of seeds pod^{-1} of mungbean upto maximum doses following an increasing trend. Probably, sulfur ensured the availability of other essential nutrients as a result of which maximum growth was occurred and the ultimate results is the maximum number of seeds pod^{-1}. Siag and Yadav (2003) reported that number of seeds per pod was not influenced by the application of sulfur.

Number of seeds pod^{-1} of mungbean varied significantly due to different level of boron (Appendix VI). The highest number of seeds pod^{-1} (7.07) was recorded from B_2 which was statistically identical (6.68) with B_1 and the lowest number of seeds pod^{-1} (5.13) was obtained from B_0 as no boron (Table 6). Rizk and Abdo (2001), Verma and Mishra (1999) and Saha *et al.* (1996) also reported similar finding.

Interaction effect of sulfur and boron showed statistically significant differences for number of seeds pod^{-1} (Appendix VI). The highest number of seeds pod^{-1} (8.73) was recorded from S_8B_2 and the lowest number of seeds pod^{-1} (4.27) was recorded from S_0B_0 (Table 7).

4.9 Weight of 1000 seeds

Weight of 1000 seeds of mungbean showed a statistically significant variation due to the application of different level of sulfur (Appendix VI). The highest weight of 1000 seeds (25.66 g) was recorded from S_{12} which was statistically similar (24.71 g) with S_8 and closely followed (21.56 g) by S_4, respectively and the lowest weight of 1000 seeds (18.19 g) was observed from S_0 i.e. control condition (Table 6). Sulfur increased weight of 1000 seeds of mungbean upto maximum doses following an increasing trend. Probably, sulfur ensured the availability of other essential nutrients as a result of which maximum growth was occurred and the ultimate results is the maximum weight of 1000 seeds. Siag and Yadav (2003) reported that weight of 1000 seeds was not influenced by the application of sulfur.

Boron showed significant differences for weight of 1000 seeds of mungbean (Appendix VI). The highest weight of 1000 seeds (24.76 g) was obtained from B_2 which was closely followed (23.28 g) by B_1, while the lowest weight of 1000 seeds (19.55 g) was recorded from B_0 (Table 6). Results indicated that boron favored the mungbean plants to have better growth and produced the maximum weight of 1000 seeds. Rizk and Abdo (2001) and Verma and Mishra (1999) also reported similar finding.

Statistically significant difference was recorded for interaction effect of sulfur and boron in terms of weight of 1000 seeds (Appendix VI). The highest weight of 1000 seeds (28.57 g) was recorded from S_8B_2 and the lowest weight of 1000 seeds (15.86 g) was recorded from S_0B_0 (Table 7).

4.10 Seed yield

A statistically significant difference was recorded for seed yield of mungbean due to the application of different level of sulfur (Appendix VII). The highest seed yield (1.37 t ha^{-1}) was found from S_{12} which was statistically similar (1.32 t ha^{-1}) with S_8 and closely followed (1.06 t ha^{-1}) by S_4. Again, the lowest seed yield (0.89 t ha^{-1}) was recorded from S_0 i.e. control condition (Table 8). Sulfur increased seed yield of mungbean upto maximum doses. Probably, sulfur ensured the availability of other essential nutrients as a result of which maximum reproductive growth was occurred and the ultimate results is the maximum seed yield. Siag and Yadav (2003) reported that grain yield was highest (1095 kg/ha) with a basal dose of 40 kg S/ha.

Seed yield of mungbean varied significantly due to boron (Appendix VII). The highest seed yield (1.26 t ha^{-1}) was recorded from B_2 which was closely followed (1.18 t ha^{-1}) by B_1 and the lowest seed yield (1.04 t ha^{-1}) was observed from B_0 as no boron (Table 8). Rizk and Abdo (2001), Verma and Mishra (1999) and Saha *et al.* (1996) also reported similar finding.

Interaction effect of sulfur and boron showed statistically significant differences for seed yield (Appendix VII). The highest seed yield (1.51 t ha^{-1}) was found from S_8B_2 and the lowest seed yield (0.77 t ha^{-1}) was recorded from S_0B_0 (Table 9).

Table 8. Effect of sulfur and boron on yield of mungbean

Treatment	Seed yield ($t\ ha^{-1}$)	Stover yield ($t\ ha^{-1}$)	Biological yield ($t\ ha^{-1}$)	Harvest Index (%)
Sulfur				
S_0	0.89 c	2.81 c	3.70 c	23.99 b
S_4	1.06 b	3.31 b	4.38 b	24.27 b
S_8	1.32 a	3.62 a	4.94 a	26.62 a
S_{12}	1.37 a	3.69 a	5.06 a	27.12 a
$LSD_{(0.05)}$	0.076	0.169	0.219	1.024
Level of significance	0.01	0.01	0.01	0.01
Boron				
B_0	1.04 c	3.06 c	4.10 c	25.15
B_1	1.18 b	3.40 b	4.58 b	25.60
B_2	1.26 a	3.61 a	4.87 a	25.75
$LSD_{(0.05)}$	0.066	0.147	0.189	--
Level of significance	0.01	0.01	0.01	NS
CV(%)	6.48	5.12	4.93	4.11

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

S_0: 0 kg S ha^{-1}
S_4: 4 kg S ha^{-1}
S_8: 8 kg S ha^{-1}
S_{12}: 12 kg S ha^{-1}

B_0: No boron (control)
B_1: 1 kg B ha^{-1}
B_2: 2 kg B ha^{-1}

Table 9. Interaction effect of sulfur and boron on yield of mungbean

Treatment	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest Index (%)
S_0B_0	0.77 f	2.61 f	3.39 g	22.83 c
S_0B_1	0.92 e	2.84 ef	3.76 fg	24.40 bc
S_0B_2	0.98 de	2.98 e	3.97 f	24.74 bc
S_4B_0	0.97 de	3.01 e	3.98 f	24.41 bc
S_4B_1	1.07 cd	3.39 d	4.46 de	24.08 bc
S_4B_2	1.14 c	3.55 cd	4.69 cd	24.33 bc
S_8B_0	1.07 cd	3.07 e	4.14 ef	25.81 ab
S_8B_1	1.38 ab	3.76 abc	5.14 b	26.83 a
S_8B_2	1.51 a	4.04 a	5.55 a	27.53 a
$S_{12}B_0$	1.35 b	3.56 bcd	4.92 bc	27.21 a
$S_{12}B_1$	1.34 b	3.61 bcd	4.96 bc	27.10 a
$S_{12}B_2$	1.41 ab	3.88 ab	5.29 ab	26.71 a
$LSD_{(0.05)}$	0.131	0.293	0.379	1.774
Level of significance	0.01	0.05	0.01	0.01
CV(%)	6.48	5.12	4.93	4.11

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

S_0: 0 kg S ha^{-1}
S_4: 4 kg S ha^{-1}
S_8: 8 kg S ha^{-1}
S_{12}: 12 kg S ha^{-1}

B_0: No boron (control)
B_1: 1 kg B ha^{-1}
B_2: 2 kg B ha^{-1}

Sher-e-Bangla Agricultural University Library Sher-e-Bangla Nagar Dhaka

4.11 Stover yield

Stover yield of mungbean varied significantly for due to the application of different level of sulfur (Appendix VII). The highest stover yield (3.69 t ha^{-1}) was recorded from S_{12} which was statistically similar (3.62 t ha^{-1}) with S_8 and closely followed (3.31 t ha^{-1}) by S_4. Again, the lowest stover yield (2.81 t ha^{-1}) was recorded from S_0 i.e. control condition (Table 8). Sulfur increased stover yield of mungbean upto maximum doses following an increasing trend. Singh *et al*. (1997) reported that sulfur application significantly improved stover yield and the optimum application rate being 30 kg/ha.

Stover yield of mungbean showed significant differences due to different level of boron (Appendix VII). The highest stover yield (3.61 t ha^{-1}) was recorded from B_2 which was closely followed (3.40 t ha^{-1}) by B_1 and the lowest stover yield (3.06 t ha^{-1}) was recorded from B_0 as no boron (Table 8). Results indicated that boron favored the mungbean plants to have better growth and produced the maximum stover yield. Rizk and Abdo (2001) and Saha *et al*. (1996) also reported similar finding.

Interaction effect of sulfur and boron showed statistically significant variation for stover yield (Appendix VII). The highest stover yield (4.04 t ha^{-1}) was recorded from S_8B_2 and the lowest stover yield (2.61 t ha^{-1}) was recorded from S_0B_0 (Table 9).

4.12 Biological yield

A statistically significant difference was recorded for biological yield of mungbean due to the application of different level of sulfur (Appendix VII). The highest biological yield (5.06 t ha^{-1}) was recorded from S_{12} which was statistically similar

(4.94 t ha^{-1}) with S_8 and closely followed (4.38 t ha^{-1}) by S_4. Again, the lowest biological yield (3.70 t ha^{-1}) was obtained from S_0 i.e. control condition (Table 8). Sulfur increased biological yield of mungbean upto maximum doses following an increasing trend. Probably, sulfur ensured the availability of other essential nutrients as a result of which maximum vegetative and reproductive growth was occurred and the ultimate results is the maximum biological yield.

Due to boron biological yield of mungbean varied significantly (Appendix VII). The highest biological yield (4.87 t ha^{-1}) was recorded from B_2 which was closely followed (4.58 t ha^{-1}) by B_1 and the lowest biological yield (4.10 t ha^{-1}) was found from B_0 as no boron (Table 8). Results indicated that boron favored the mungbean plants to have better growth and produced the maximum biological yield. Rizk and Abdo (2001) also reported similar finding.

Statistically significant difference was observed for interaction effect of sulfur and boron in terms of biological yield (Appendix VII). The highest biological yield (5.55 t ha^{-1}) was observed from S_8B_2 and the lowest biological yield (3.39 t ha^{-1}) was recorded from S_0B_0 (Table 9).

4.13 Harvest index

Significant variation was recorded for harvest index of mungbean due to the application of different level of sulfur (Appendix VII). The highest harvest index (27.12%) was found from S_{12} which was statistically similar (26.62%) with S_8 and closely followed (24.27%) by S_4. Again, the lowest harvest index (23.99%) was recorded from S_0 (Table 8). Probably, sulfur ensured the availability of other essential nutrients as a result of which maximum vegetative and reproductive growth was occurred and the ultimate results is the maximum harvest index. Dey and Basu (2004) reported similar result earlier.

Harvest index of mungbean differed non-significantly due to different level of boron (Appendix VII). The highest harvest index (25.75%) was obtained from B_2 and the lowest harvest index (25.15%) was recorded from B_0 as no boron (Table 8). Results indicated that boron favored the mungbean plants to have better growth and produced the maximum harvest index.

Interaction effect of sulfur and boron showed statistically significant differences for harvest index (Appendix VII). The highest harvest index (27.53%) was recorded from S_8B_2 and the lowest harvest index (22.83%) was recorded from S_0B_0 (Table 9).

4.14 Number of nodules plant^{-1}

Number of nodules plant^{-1} of mungbean showed a statistically significant variation for due to the application of different level of sulfur (Appendix VII). The highest number of nodules plant^{-1} (20.76) was observed from S_{12} which was statistically similar (19.66) with S_8 and closely followed (16.95) by S_4, respectively and the lowest number of nodules plant^{-1} (13.62) was found from S_0 i.e. control condition (Figure 10). Sulfur increased number of nodules plant^{-1} of mungbean upto maximum doses following an increasing trend. Singh *et al.* (1997) reported that sulfur application significantly improved nodule number and the optimum application rate being 30 kg/ha.

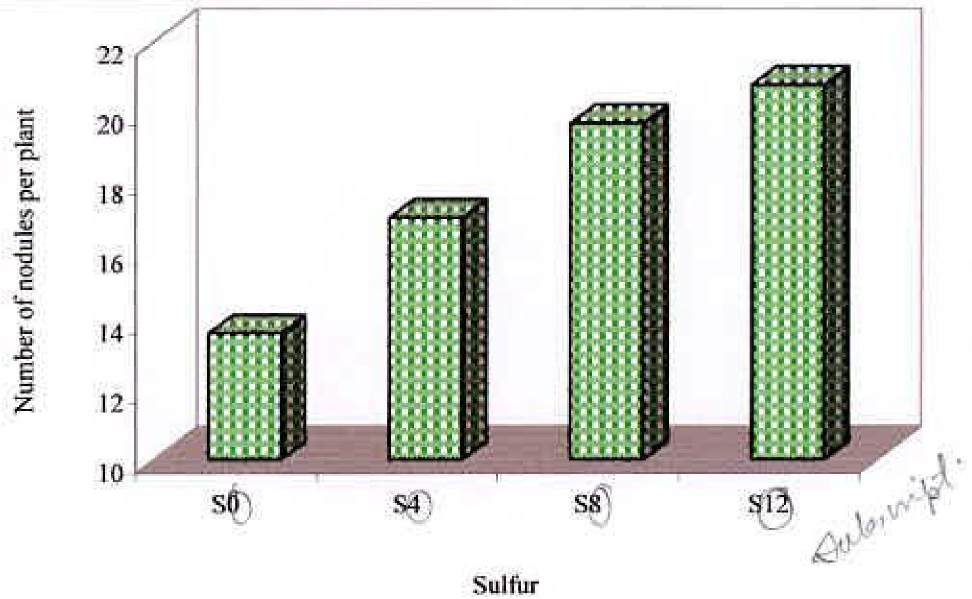


Figure 10. Effect of sulfur on number of nodules per plant of mungbean

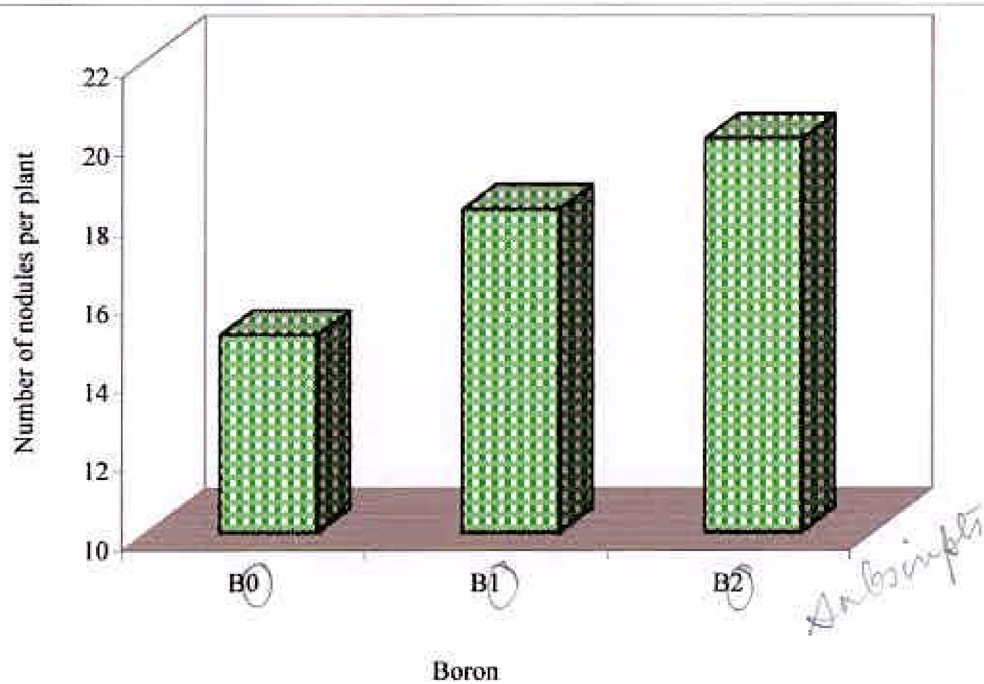


Figure 11. Effect of boron on number of nodule per plant of mungbean

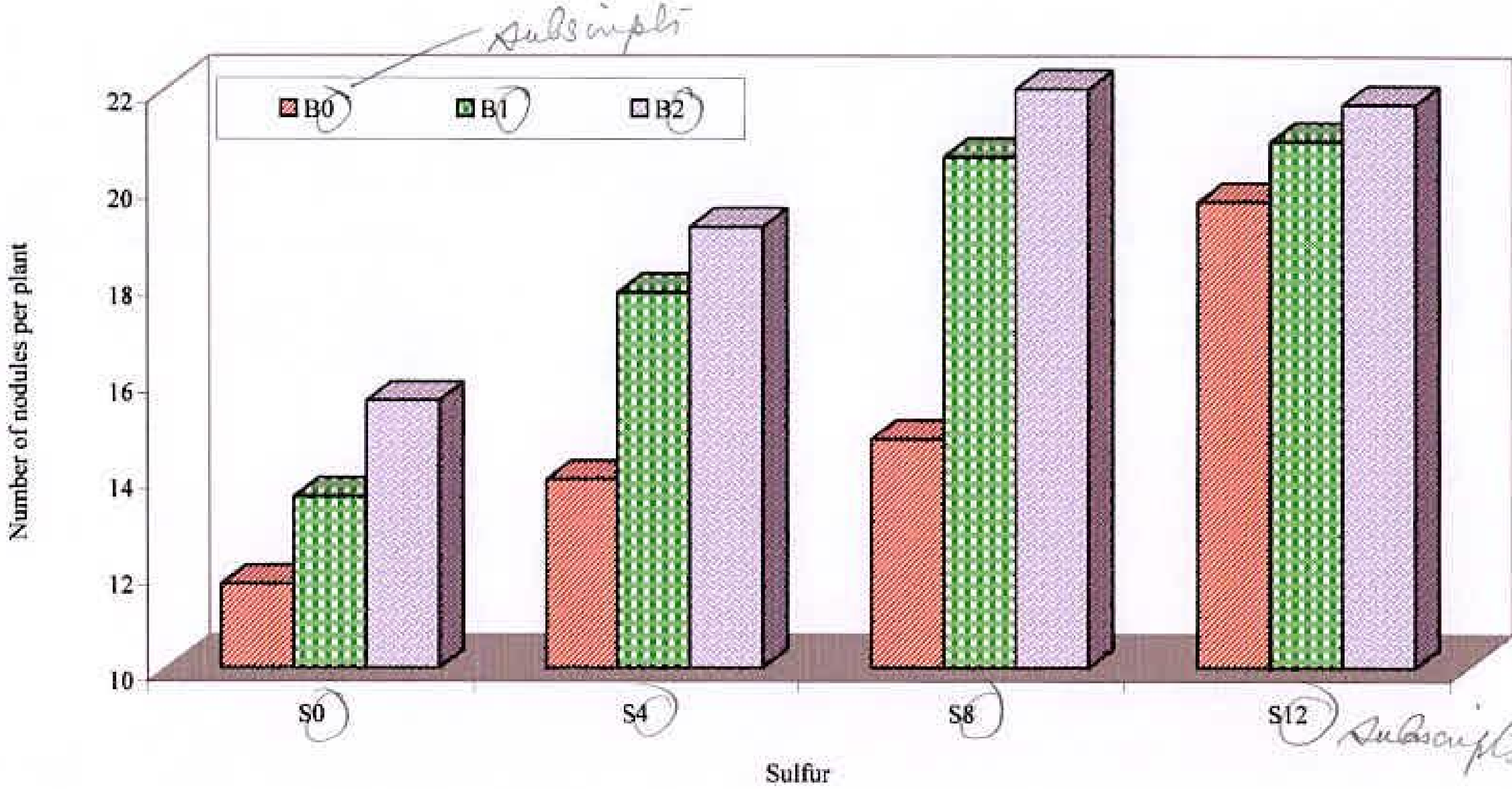


Figure 12. Interaction effect of sulfur and boron on number of nodules per plant of mungbean

Number of nodules plant^{-1} of mungbean varied significantly due to different level of boron (Appendix VII). The highest number of nodules plant^{-1} (20.00) was recorded from B_2 which was statistically identical (18.22) with B_1 and the lowest number of nodules plant^{-1} (15.02) was obtained from B_0 as no boron (Figure 11). Results indicated that boron favored the mungbean plants to have better growth and produced the maximum number of nodules plant^{-1}.

Sulfur and boron showed statistically significant differences for interaction effect in terms of number of nodules plant^{-1} (Appendix VII). The highest number of nodules plant^{-1} (23.63) was found from S_8B_2 and the lowest number of nodules plant^{-1} (11.74) was recorded from S_0B_0 (Figure 12).

4.15 NPKSB concentration in seed and stover

4.15.1 NPKSB concentration in seed

Statistically significant variation was recorded for NPKSB concentration in seed due different levels of sulfur (Appendix VIII). The maximum concentration in seed for N (3.39%), P (1.012%), K (1.005%), S (1.014%) and B (0.086%) was recorded from S_8 and the minimum concentration in seed for N (2.57%), P (0.476%), K(0.382%), S (0.377%) and B (0.050%) was observed from S_0 (Table 10).

A statistically significant variation was recorded for NPKSB concentration in seed due to different levels of boron (Appendix VIII). The maximum concentration in seed for N (3.40%), P (1.045%), K (0.896%), S (0.922%) and B (0.078%) was recorded from B_2 and the minimum concentration in seed for N (2.64%), P (0.541%), K(0.603%), S (0.537%) and B (0.052%) was found from B_0 (Table 10).

Table 10. Effect of sulfur and boron on the concentration of N, P, K, S and B in seed and stover of mungbean

Treatment	Concentration (%) in grain					Concentration (%) in stover				
	N	P	K	S	B	N	P	K	S	B
Sulfur										
S_0	2.57 c	0.476 c	0.382 c	0.377 c	0.066 b	4.46 bc	0.421 b	0.444 b	0.311 c	0.010 b
S_4	3.29 a	1.009 a	0.962 a	0.984 a	0.066 b	4.67 ab	0.428 b	0.450 ab	0.347 ab	0.011 b
S_8	3.39 a	1.012 a	1.005 a	1.014 a	0.086 a	4.89 a	0.430 b	0.457 a	0.355 a	0.013 a
S_{12}	3.07 b	0.674 b	0.594 b	0.658 b	0.061 b	4.31 c	0.471 a	0.460 a	0.339 b	0.013 a
$LSD_{(0.05)}$	0.157	0.083	0.063	0.077	0.065	0.284	0.031	0.010	0.010	0.01
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Boron										
B_0	2.64 c	0.541 c	0.603 c	0.537 c	0.052 c	4.23 c	0.414 b	0.427 c	0.317 b	0.010 b
B_1	3.19 b	0.793 b	0.708 b	0.816 b	0.066 b	4.59 b	0.438 ab	0.458 b	0.344 a	0.012 a
B_2	3.40 a	1.045 a	0.896 a	0.922 a	0.078 a	4.93 a	0.460 a	0.474 a	0.352 a	0.012 a
$LSD_{(0.05)}$	0.136	0.072	0.054	0.066	0.053	0.246	0.027	0.009	0.009	0.09
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
CV(%)	5.13	4.65	8.20	4.47	4.98	6.25	7.54	2.34	6.30	4.56

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

S_0: 0 kg S ha^{-1}
S_4: 4 kg S ha^{-1}
S_8: 8 kg S ha^{-1}
S_{12}: 12 kg S ha^{-1}

B_0: No boron (control)
B_1: 1 kg B ha^{-1}
B_2: 2 kg B ha^{-1}

Table 11. Interaction effect of sulfur and boron on the concentration of N, P, K, S and B in seed and stover of mungbean

Treatment	Concentration (%) in grain					Concentration (%) in stover				
	N	P	K	S	B	N	P	K	S	B
S_0B_0	2.21 g	0.360 e	0.345 g	0.327 e	0.037 e	4.12 e	0.405 b	0.403 e	0.276 e	0.008
S_0B_1	2.65 f	0.464 b	0.372 fg	0.429 e	0.107 b	4.59 bcde	0.434 b	0.467 abc	0.328 d	0.014
S_0B_2	2.84 def	0.605 fgh	0.430 fg	0.374 e	0.053 d	4.67 bcde	0.446 b	0.463 abc	0.329 d	0.011
S_4B_0	2.64 f	0.718 ef	0.885 c	0.658 d	0.054 d	4.27 cde	0.416 b	0.421 d	0.332 cd	0.012
S_4B_1	3.52 b	1.078 c	0.934 c	1.074 b	0.042 e	4.74 bcd	0.425 b	0.450 c	0.349 bc	0.014
S_4B_2	3.71 ab	1.231 b	1.067 b	1.220 a	0.053 d	5.00 b	0.421 b	0.481 a	0.360 ab	0.013
S_8B_0	2.69 ef	0.560 gh	0.716 d	0.716 d	0.058 d	4.34 cde	0.422 b	0.430 d	0.335 cd	0.010
S_8B_1	3.64 ab	0.968 cd	0.941 c	1.081 b	0.057 d	4.76 bc	0.456 b	0.458 bc	0.359 ab	0.012
S_8B_2	3.85 a	1.509 a	1.357 a	1.246 a	0.140 a	5.58 a	0.535a	0.482 a	0.370 a	0.015
$S_{12}B_0$	3.01 cd	0.525 gh	0.467 f	0.446 e	0.059 d	4.19 de	0.413 b	0.455 bc	0.326 d	0.008
$S_{12}B_1$	2.97 cde	0.662 fg	0.583 e	0.681 d	0.058 d	4.26 cde	0.438 b	0.456 bc	0.341 bcd	0.010
$S_{12}B_2$	3.21 c	0.836 de	0.730 d	0.849 c	0.068 d	4.48 bcde	0.438 b	0.470 ab	0.350 bc	0.011
$LSD_{(0.05)}$	0.271	0.144	0.109	0.133	0.087	0.491	0.054	0.017	0.017	0.017
Level of significance	0.01	0.05	0.01	0.05	0.05	0.01	0.01	0.05	0.01	NS
CV(%)	5.13	4.65	8.20	4.47	4.98	6.25	7.54	2.34	6.30	4.56

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

S_0: 0 kg S ha^{-1}
S_4: 4 kg S ha^{-1}
S_8: 8 kg S ha^{-1}
S_{12}: 12 kg S ha^{-1}

B_0: No boron (control)
B_1: 1 kg B ha^{-1}
B_2: 2 kg B ha^{-1}

A statistically significant variation was recorded for NPKSB concentration in seed due to the interaction effect of sulfur and boron (Appendix VIII). The maximum concentration in seed for N (3.85%), P (1.509%), K (1.357%), S (1.246%) and B (0.140%) was recorded from S_8B_2 and the minimum concentration in seed for N (2.21%), P (0.360%), K(0.345%), S (0.327%) and B (0.037%) was observed from S_0B_0 (Table 11).

4.15.2 NPKSB concentration in stover

A statistically significant variation was recorded for NPKSB concentration in stover due to the application of different level of sulfur (Appendix VIII). The maximum concentration in stover for N (4.89%), P (0.471%), K (0.457%), S (0.355%) and B (0.013%) was recorded from S_8 and the minimum concentration in stover for N (4.31%), P (0.421%), K(0.444%), S (0.311%) and B (0.010%) was observed from S_0 (Table 10).

A statistically significant variation was recorded for NPKSB concentration in stover due to the application of different level of boron (Appendix VIII). The maximum concentration in stover for N (4.93%), P (0.460%), K (0.474%), S (0.352%) and B (0.012%) was recorded from B_2 and the minimum concentration in stover for N (4.23%), P (0.414%), K(0.427%), S (0.317%) and B (0.010%) was observed from B_0 (Table 10).

A statistically significant variation was recorded for NPKSB concentration in stover due to the interaction effect of sulfur and boron (Appendix VIII). The maximum concentration in stover for N (5.58%), P (0.535%), K (0.482%), S

(0.370%) and B (0.015%) was recorded from S_8B_2 and the minimum concentration in stover for N (4.12%), P (0.405%), K(0.403%), S (0.276%) and B (0.008%) was observed from S_0B_0 (Table 11).

4.16 NPKS uptake by seed and stover

4.16.1 NPKSB uptake by seed

A statistically significant variation was recorded for NPKSB uptake by seed due to different level of sulfur (Appendix IX). The maximum uptake by seed for N (36.52 kg/ha), P (5.58 kg/ha), K (12.55 kg/ha), S (7.50 kg/ha) and B (0.106 kg/ha) was recorded from S_8 and the minimum uptake by seed for N (24.61 kg/ha), P (3.69 kg/ha), K(8.65 kg/ha), S (4.86 kg/ha) and B (0.089 kg/ha) was observed from S_0 (Table 12). Singh *et al.* (1997) reported that sulfur significantly improved nitrogen & sulfur uptake and the optimum application rate being 30 kg/ha.

A statistically significant variation was recorded for NPKSB uptake by seed due to different levels of boron (Appendix IX). The maximum uptake by seed for N (35.69 kg/ha), P (5.45 kg/ha), K (12.13 kg/ha), S (7.01 kg/ha) and B (0.104 kg/ha) was recorded from B_2 and the minimum N (25.74 kg/ha), P (3.88 kg/ha), K(9.30 kg/ha), S (5.07 kg/ha) and B (0.094 kg/ha) was observed from B_0 (Table 12).

A statistically significant variation was recorded for NPKSB uptake by seed due to the interaction effect of sulfur and boron (Appendix IX). The maximum uptake by seed for N (41.52 kg/ha), P (6.34 kg/ha), K (14.15 kg/ha), S (8.89 kg/ha) and B (0.113 kg/ha) was recorded from S_8B_2 and the minimum uptake by seed for N (21.04 kg/ha), P (3.00 kg/ha), K (7.44 kg/ha), S (4.33 kg/ha) and B (0.079 kg/ha) was observed from S_0B_0 (Table 13).

Table 12. Effect of sulfur and boron on the concentration of N, P, K, S and B in seed and stover of mungbean

Treatment	Uptake by grain (kg/ha)					Uptake by stover (kg/ha)				
	N	P	K	S	B	N	P	K	S	B
Sulfur										
S_0	24.61 d	3.69 d	8.65 d	4.86 d	0.089 b	41.68 d	10.66 d	23.66 d	2.37 c	0.109 c
S_4	32.78 b	5.01 b	11.28 b	6.71 b	0.102 a	63.75 b	14.17 b	32.00 b	2.98 ab	0.115 b
S_8	36.52 a	5.58 a	12.55 a	7.50 a	0.106 a	70.69 a	16.54 a	37.34 a	3.07 a	0.119 a
S_{12}	29.49 c	4.50 c	10.50 c	5.59 c	0.095 a	56.91 c	12.72 c	28.72 c	2.82 b	0.115 b
$LSD_{(0.05)}$	1.873	0.284	0.603	0.578	0.034	2.968	0.751	1.597	0.215	0.021
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Boron										
B_0	25.74 c	3.88 c	9.30 c	5.07 c	0.094 b	45.28 c	12.93 b	28.88 b	2.65 b	0.113 b
B_1	31.12 b	4.75 b	10.81 b	6.42 b	0.096 b	62.49 b	13.61 a	30.74 a	2.85 a	0.113 b
B_2	35.69 a	5.45 a	12.13 a	7.01 a	0.104 a	67.01 a	14.03 a	31.67 a	2.94 a	0.118 a
$LSD_{(0.05)}$	1.622	0.246	0.522	0.501	0.023	2.570	0.650	1.383	0.186	0.013
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
CV(%)	6.13	6.09	5.67	4.47	7.88	5.14	5.61	5.30	7.71	4.88

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

S_0: 0 kg S ha^{-1}
S_4: 4 kg S ha^{-1}
S_8: 8 kg S ha^{-1}
S_{12}: 12 kg S ha^{-1}

B_0: No boron (control)
B_1: 1 kg B ha^{-1}
B_2: 2 kg B ha^{-1}

Table 13. Interaction effect of sulfur and boron on the concentration of N, P, K, S and B in seed and stover of mungbean

Treatment	Uptake by grain (kg/ha)					Uptake by stover (kg/ha)				
	N	P	K	S	B	N	P	K	S	B
S_0B_0	21.04 h	3.00 h	7.44 h	4.33 e	0.079	36.21 f	10.16 f	21.69 g	2.26 e	0.097
S_0B_1	24.28 g	3.71 g	8.87 g	5.04 cde	0.101	44.81 e	10.61 ef	23.97 fg	2.41 de	0.115
S_0B_2	28.52 ef	4.36 ef	9.66 fg	5.22 cde	0.076	44.02 e	11.21 ef	25.32 ef	2.44 de	0.116
S_4B_0	24.89 g	3.80 g	9.83 fg	5.64 bcd	0.104	45.35 e	13.59 bc	30.68 bc	2.76 bcd	0.113
S_4B_1	34.39 cd	5.25 cd	11.03 de	6.63 b	0.102	72.31 b	14.28 bc	32.24 bc	3.04 abc	0.115
S_4B_2	39.08 ab	5.97 ab	12.98 b	7.86 a	0.099	73.60 b	14.64 b	33.07 b	3.16 ab	0.117
S_8B_0	31.10 de	4.75 de	10.74 def	5.40 cde	0.097	53.35 d	16.06 a	36.26 a	2.90 abc	0.119
S_8B_1	36.94 bc	5.64 bc	12.76 bc	8.23 a	0.096	73.09 b	16.52 a	37.30 a	3.14 ab	0.119
S_8B_2	41.52 a	6.34 a	14.15 a	8.89 a	0.113	85.63 a	17.03 a	38.45 a	3.18 a	0.123
$S_{12}B_0$	25.94 fg	3.96 fg	9.19 g	4.93 de	0.106	46.21 e	11.90 de	26.88 de	2.69 cd	0.122
$S_{12}B_1$	28.87 ef	4.41 ef	10.57 ef	5.77 bcd	0.104	59.76 c	13.04 cd	29.44 cd	2.81 abcd	0.122
$S_{12}B_2$	33.66 cd	5.14 cd	11.73 cd	6.08 bc	0.108	64.78 c	13.22 cd	29.85 c	2.96 abc	0.101
$LSD_{(0.05)}$	3.245	0.491	1.045	1.002	--	5.141	1.301	2.765	0.372	--
Level of significance	0.05	0.01	0.05	0.05	NS	0.01	0.01	0.01	0.01	NS
CV(%)	6.13	6.09	5.67	4.47	7.88	5.14	5.61	5.30	7.71	4.88

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

S_0: 0 kg S ha^{-1}

S_4: 4 kg S ha^{-1}

S_8: 8 kg S ha^{-1}

S_{12}: 12 kg S ha^{-1}

B_0: No boron (control)

B_1: 1 kg B ha^{-1}

B_2: 2 kg B ha^{-1}

4.16.2 NPKSB uptake by stover

A statistically significant variation was recorded for NPKSB uptake by stover due to the application of different level of sulfur (Appendix IX). The maximum uptake by stover for N (70.69 kg/ha), P (16.54 kg/ha), K (37.34 kg/ha), S (3.07 kg/ha) and B (0.119 kg/ha) was recorded from S_8 and the minimum uptake by stover for N (41.68 kg/ha), P (10.66 kg/ha), K (23.66 kg/ha), S (2.37 kg/ha) and B (0.109 kg/ha) was observed from S_0 (Table 12).

A statistically significant variation was recorded for NPKSB uptake by stover due to the application of different level of boron (Appendix IX). The maximum uptake by stover for N (67.01 kg/ha), P (14.03 kg/ha), K (31.67 kg/ha), S (2.94 kg/ha) and B (0.118 kg/ha) was recorded from B_2 and the minimum uptake by stover for N (45.28 kg/ha), P (12.93 kg/ha), K (28.88 kg/ha), S (2.65 kg/ha) and B (0.113 kg/ha) was observed from B_0 (Table 12).

A statistically significant variation was recorded for NPKSB uptake by stover due to the interaction effect of sulfur and boron (Appendix IX). The maximum uptake by stover for N (85.63 kg/ha), P (17.03 kg/ha), K (38.45 kg/ha), S (3.18 kg/ha) and B (0.123 kg/ha) was recorded from S_8B_2 and the minimum uptake by stover for N (36.21 kg/ha), P (10.16 kg/ha), K (21.69 kg/ha), S (2.26 kg/ha) and B (0.097 kg/ha) was observed from S_0B_0 (Table 13).

4.17 Post harvest soil

A statistically significant variation was recorded for pH, organic matter, total N, available P, exchangeable K, available S and available B in post harvest soil due to the application of different level of sulfur (Appendix X). The highest pH (5.43), organic matter (1.37%), total N (0.39%), available P (20.39 ppm), exchangeable K (0.16 me%), available S (0.27 ppm) and available B (0.145 ppm) was recorded from S_8 and the lowest pH (4.37), organic matter (1.06%), total N (0.23%), available P (15.51 ppm), exchangeable K (0.12 me%), available S (0.20 ppm) and available B (0.123 ppm) was observed from S_0 (Table 14).

A statistically significant variation was recorded for pH, organic matter, total N, available P, exchangeable K, available S and available B in post harvest soil due to the application of different level of boron (Appendix X). The highest pH (5.05), organic matter (1.25%), total N (0.35%), available P (19.02 ppm), exchangeable K (0.15 me%), available S (0.27 ppm) and available B (0.148 ppm) was recorded from B_2 and the lowest pH (4.61), organic matter (1.12%), total N (0.22%), available P (15.72 ppm), exchangeable K (0.12 me%), available S (0.22 ppm) and available B (0.111 ppm) was observed from B_0 (Table 14).

A statistically significant variation was recorded for pH, organic matter, total N, available P, exchangeable K, available S and available B in post harvest soil due to the interaction effect of sulfur and boron (Appendix X). The highest pH (5.57), organic matter (1.45%), total N (0.45%), available P (22.78 ppm), exchangeable K (0.18 me%), available S (0.30 ppm) and available B (0.162 ppm) was recorded from S_8B_2 and the lowest pH (3.96), organic matter (1.02%), total N (0.16%), available P (13.75 ppm), exchangeable K (0.11 me%), available S (0.17 ppm) and available B (0.086 ppm) was observed from S_0B_0 (Table 15).

Table 14. Effect of sulfur and boron on the pH, organic matter, available phosphorus, exchangeable K, available S and B on post harvest soil

Treatment	pH	Organic matter (%)	Total N (%)	Available P (ppm)	Exchangeable K (me %)	Available S (ppm)	Available B (ppm)
Sulfur							
S_0	4.37 b	1.06 c	0.23 c	15.51 c	0.12 c	0.20 d	0.123 c
S_4	4.62 b	1.16 b	0.28 b	17.39 b	0.14 b	0.26 b	0.133 b
S_8	5.43 a	1.37 a	0.39 a	20.39 a	0.16 a	0.27 a	0.145 a
S_{12}	4.62 b	1.16 b	0.26 bc	16.91 b	0.13 c	0.25 c	0.132 b
$LSD_{(0.05)}$	0.442	0.083	0.031	0.872	0.010	0.010	0.013
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Boron							
B_0	4.61 b	1.12 b	0.22 c	15.72 c	0.12 c	0.22 c	0.111 c
B_1	4.62 b	1.18 ab	0.30 b	17.91 b	0.14 b	0.24 b	0.140 b
B_2	5.05 a	1.25 a	0.35 a	19.02 a	0.15 a	0.27 a	0.148 a
$LSD_{(0.05)}$	0.383	0.072	0.027	0.755	0.009	0.009	0.007
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01	0.01
CV(%)	5.36	6.93	4.98	5.01	7.16	6.32	5.88

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

S_0: 0 kg S ha^{-1}
S_4: 4 kg S ha^{-1}
S_8: 8 kg S ha^{-1}
S_{12}: 12 kg S ha^{-1}

B_0: No boron (control)
B_1: 1 kg B ha^{-1}
B_2: 2 kg B ha^{-1}

Table 15. Interaction effect of sulfur and boron on the pH, organic matter, available phosphorus, exchangeable K, available S and B on post harvest soil

Treatment	pH	Organic matter (%)	Total N (%)	Available P (ppm)	Exchangeable K (me %)	Available S (ppm)	Available B (ppm)
S_0B_0	3.96 d	1.02 e	0.16 g	13.75 f	0.11 e	0.17 g	0.086
S_0B_1	4.17 cd	1.05 de	0.22 ef	16.13 e	0.13 de	0.20 f	0.149
S_0B_2	4.96 abc	1.10 cde	0.29 cd	16.66 de	0.13 d	0.23 e	0.161
S_4B_0	4.35 cd	1.05 de	0.17 fg	15.83 e	0.13 cd	0.23 e	0.135
S_4B_1	4.78 abcd	1.21 bcd	0.34 bc	17.88 cd	0.14 cd	0.27 b	0.153
S_4B_2	4.74 abcd	1.20 bcd	0.33 bc	18.47 c	0.15 bc	0.27 bc	0.147
S_8B_0	5.38 ab	1.33 ab	0.34 bc	17.84 cd	0.13 d	0.24 de	0.121
S_8B_1	5.34 ab	1.32 ab	0.37 b	20.54 b	0.16 b	0.28 b	0.140
S_8B_2	5.57 a	1.45 a	0.45 a	22.78 a	0.18 a	0.30 a	0.162
$S_{12}B_0$	4.55 bcd	1.09 cde	0.19 fg	15.47 e	0.12 de	0.25 cd	0.101
$S_{12}B_1$	4.40 cd	1.14 cde	0.27 de	17.08 cde	0.13 d	0.22 e	0.117
$S_{12}B_2$	4.91 abc	1.24 bc	0.31 cd	18.17 cd	0.13 de	0.26 bc	0.150
$LSD_{(0.05)}$	0.765	0.144	0.054	1.510	0.017	0.017	--
Level of significance	0.05	0.05	0.01	0.05	0.01	0.01	NS
CV(%)	5.36	6.93	4.98	5.01	7.16	6.32	5.88

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

S_0: 0 kg S ha^{-1}
S_4: 4 kg S ha^{-1}
S_8: 8 kg S ha^{-1}
S_{12}: 12 kg S ha^{-1}

B_0: No boron (control)
B_1: 1 kg B ha^{-1}
B_2: 2 kg B ha^{-1}

Sher-e-Bangla Agricultural University Library

Chapter V

SUMMARY AND CONCLUSION

The experiment was conducted in the Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from February to May 2007 to study the effect of sulfur and boron on the growth and yield of mungbean. The variety BARI mash-3 (Hemanta) was used as the test crop. The experiment consists of two factors: Factor A: Sulfur (4 levels); S_0: 0 kg (Control), S_4: 4 kg, S_8: 8 kg and S_{12}: 12 kg S ha^{-1}; Factor B: Boron (3 levels): B_0: No boron (Control), B_1: 1 kg and B_2: 2 kg B ha^{-1}. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications.

Due to application of different level of sulfur at 25, 35, 45 and 55 DAS the longest plant (28.53 cm, 41.11 cm, 55.30 cm and 62.83 cm) was recorded from S_{12}, while the shortest (18.38 cm, 30.20 cm, 41.54 cm and 50.17 cm) was recorded from S_0. The maximum number of leaves $plant^{-1}$ (5.41, 11.64, 19.23 and 21.95) was recorded from S_{12}, while the minimum (3.79, 9.72, 14.62 and 17.21) was recorded from S_0. The highest leaf area (976.01 cm^2, 1338.12 cm^2, 1485.33 cm^2 and 1663.05 cm^2) was recorded from S_{12}, while the lowest leaf area (676.56 cm^2, 994.79 cm^2, 1133.12 cm^2 and 1206.40 cm^2) was recorded from S_0. The maximum dry matter content $plant^{-1}$ (256.43 g, 336.56 g, 376.48 g and 450.59 g) was recorded from S_{12} while the minimum (188.87 g, 225.94 g, 304.64 g and 346.61 g) was recorded from S_0. The highest number of flowers $plant^{-1}$ (34.20) was recorded from S_{12}, while the lowest (19.44) was recorded from S_0. The highest number of pods $plant^{-1}$ (17.17) was recorded from S_{12} and the lowest (13.20) was recorded from S_0. The maximum pod length (7.11 cm) was recorded from S_{12} and the minimum (4.94 cm) was recorded from S_0. The highest number of seeds pod^{-1} (7.24) was recorded from S_{12} on the other hand; the lowest (4.47) was recorded from S_0. The highest weight of 1000 seeds (25.66 g) was recorded from S_{12} and the lowest (18.19 g) was recorded from S_0. The highest seed yield (1.37 t ha^{-1}) was recorded from S_{12} again, the lowest seed yield (0.89 t ha^{-1}) was recorded from S_0. The highest stover yield (3.69 t ha^{-1}) was recorded from S_{12} and the lowest (2.81 t ha^{-1}) was recorded from S_0. The highest biological yield (5.06 t ha^{-1}) was recorded from S_{12} and the lowest biological yield (3.70 t ha^{-1}) was recorded from S_0. The highest harvest index (27.12%) was recorded from S_{12} and the lowest (23.99%) was recorded from S_0. The highest number of nodules $plant^{-1}$ (20.76) was recorded from S_{12} and the lowest (13.62) was recorded from S_0.

However, application of different level of boron at 25, 35, 45 and 55 DAS the longest plant (26.92 cm, 37.36 cm, 52.65 cm and 61.35 cm) was recorded from B_2 and the shortest (21.62 cm, 32.63 cm, 43.60 cm and 49.04 cm) was recorded from B_0. At 25, 35, 45 and 55 DAS the maximum number of leaves $plant^{-1}$ (5.23, 11.81, 20.23 and 22.95) was recorded from B_2 and the minimum (4.20, 9.59, 14.66 and 16.69) was recorded from B_0. At 25, 35, 45 and 55 DAS the highest leaf area (952.98 cm^2, 1333.76 cm^2, 1576.58 cm^2 and 1758.68 cm^2) was recorded from B_2 and the lowest (759.09 cm^2, 1050.58 cm^2, 1094.79 cm^2 and 1216.71 cm^2) was recorded from B_0. At 25, 35, 45 and 55 DAS the maximum dry matter content $plant^{-1}$ (244.19 g, 313.57 g, 396.29 g and 449.05 g) was recorded from B_2 and the minimum (206.70 g, 261.27 g, 292.51 g and 350.78 g) was recorded from B_0. The highest number of flowers $plant^{-1}$ (33.07) was recorded from B_2 and the lowest (23.60) was recorded from B_0. The highest number of pods $plant^{-1}$ (17.44) was recorded from B_2 and the lowest (13.56) was recorded from B_0. The maximum pod length (7.22 cm) was recorded from B_2 and the lowest (5.05 cm) was recorded from B_0. The highest weight of 1000 seeds (24.76 g) was recorded from B_2 and the lowest (19.55 g) was recorded from B_0. The highest seed yield (1.26 t ha^{-1}) was recorded from B_2 and the lowest seed yield (1.04 t ha^{-1}) was recorded from B_0. The highest stover yield (3.61 t

ha^{-1}) was recorded from B_2 and the lowest stover yield (3.06 t ha^{-1}) was recorded from B_0. The highest biological yield (4.87 t ha^{-1}) was recorded from B_2 and the lowest (4.10 t ha^{-1}) was recorded from B_0. The highest harvest index (25.75%) was recorded from B_2 and the lowest harvest index (25.15%) was recorded from B_0. The highest number of nodules $plant^{-1}$ (20.00) was recorded from B_2 and the lowest (15.02) was recorded from B_0.

Interaction effect of different level of sulfur and boron at 25, 35, 45 and 55 DAS the longest plant (33.89 cm, 47.15 cm, 63.52 cm and 75.31 cm) was recorded from S_8B_2 and the shortest (16.90 cm, 28.20 cm, 39.58 cm, 46. 88 cm) was recorded from S_0B_0 at 25, 35, 45 and 55 DAS. The maximum number of leaves $plant^{-1}$ (6.11, 12.97, 23.50 and 26.69) was recorded from S_8B_2 and the minimum (3.46, 9.37, 13.74 and 16.14) was recorded from S_0B_1 at 25, 35, 45 and 55 DAS. The highest leaf area (1172.13 cm^2, 1603.43 cm^2, 1877.39 cm^2 and 2116.60 cm^2) was recorded from S_8B_2 and the lowest (641.26 cm^2, 891.64 cm^2, 1033.24 cm^2 and 1206.61 cm^2) was recorded from S_0B_0 at 25, 35, 45 and 55 DAS. The maximum dry matter content $plant^{-1}$ (300.88 g, 373.93 g, 459.90 g and 535.79 g) was recorded from S_8B_2 and the minimum (175.87 g, 206.80 g, 292.65 g and 319.70 g) was recorded from S_0B_1 at 25, 35, 45 and 55 DAS. The highest number of flowers $plant^{-1}$ (40.20) was recorded from S_8B_2 and the lowest (15.93) was recorded from S_0B_0. The highest number of pods $plant^{-1}$ (19.80) was recorded from S_8B_2 and the lowest (12.00) was recorded from S_0B_0. The highest pod length (8.36 cm) was recorded from S_8B_2 and the lowest (4.43 cm) was recorded from S_0B_0. The highest number of seeds pod^{-1} (8.73) was recorded from S_8B_2 and the lowest (4.27) was recorded from S_0B_0. The highest weight of 1000 seeds (28.57 g) was recorded from S_8B_2 and the lowest (15.86 g) was recorded from S_0B_0. The highest seed yield (1.51 t ha^{-1}) was recorded from S_8B_2 and the lowest (0.77 t ha^{-1}) was recorded from S_0B_0. The highest stover yield (4.04 t ha^{-1}) was recorded from S_8B_2 and the lowest stover yield (2.61 t ha^{-1}) was recorded from S_0B_0. The highest biological yield (5.55 t ha^{-1}) was recorded from S_8B_2 and the lowest (3.39 t ha^{-1}) was recorded from S_0B_0. The highest harvest index (27.53%) was recorded from S_8B_2 and the lowest harvest index (22.83%) was recorded from S_0B_0. The highest number of nodules plant^{-1} (23.63) was recorded from S_8B_2 and the lowest (11.74) was recorded from S_0B_0.

The maximum concentration in seed for N (3.39%), P (1.012%), K (1.005%), S (1.014%) and B (0.086%) was recorded from S_8 and the minimum concentration in seed for N (2.57%), P (0.476%), K(0.382%), S (0.377%) and B (0.050%) was observed from S_0. The maximum concentration in seed for N (3.40%), P (1.045%), K (0.896%), S (0.922%) and B (0.078%) was recorded from B_2 and the minimum concentration in seed for N (2.64%), P (0.541%), K(0.603%), S (0.537%) and B (0.052%) was found from B_0. The maximum concentration in seed for N (3.85%), P (1.509%), K (1.357%), S (1.246%) and B (0.140%) was recorded from S_8B_2 and the minimum concentration in seed for N (2.21%), P (0.360%), K(0.345%), S (0.327%) and B (0.037%) was observed from S_0B_0.

The maximum concentration in stover for N (4.89%), P (0.471%), K (0.457%), S (0.355%) and B (0.013%) was recorded from S_8 and the minimum concentration in stover for N (4.31%), P (0.421%), K (0.444%), S (0.311%) and B (0.010%) was observed from S_0. The maximum concentration in stover for N (4.93%), P (0.460%), K (0.474%), S (0.352%) and B (0.012%) was recorded from B_2 and the minimum concentration in stover for N (4.23%), P (0.414%), K (0.427%), S (0.317%) and B (0.010%) was observed from B_0. The maximum concentration in stover for N (5.58%), P (0.535%), K (0.482%), S (0.370%) and B (0.015%) was recorded from S_8B_2 and the minimum concentration in stover for N (4.12%), P (0.405%), K(0.403%), S (0.276%) and B (0.008%) was observed from S_0B_0.

The highest pH (5.43), organic matter (1.37%), total N (0.39%), available P (20.39 ppm), exchangeable K (0.16 me%), available S (0.27 ppm) and available B (0.145

ppm) was recorded from S_8 and the lowest pH (4.37), organic matter (1.06%), total N (0.23%), available P (15.51 ppm), exchangeable K (0.12 me%), available S (0.20 ppm) and available B (0.123 ppm) was observed from S_0. The highest pH (5.05), organic matter (1.25%), total N (0.35%), available P (19.02 ppm), exchangeable K (0.15 me%), available S (0.27 ppm) and available B (0.148 ppm) was recorded from B_2 and the lowest pH (4.61), organic matter (1.12%), total N (0.22%), available P (15.72 ppm), exchangeable K (0.12 me%), available S (0.22 ppm) and available B (0.111 ppm) was observed from B_0. The highest pH (5.57), organic matter (1.45%), total N (0.45%), available P (22.78 ppm), exchangeable K (0.18 me%), available S (0.30 ppm) and available B (0.162 ppm) was recorded from S_8B_2 and the lowest pH (3.96), organic matter (1.02%), total N (0.16%), available P (13.75 ppm), exchangeable K (0.11 me%), available S (0.17 ppm) and available B (0.086 ppm) was observed from S_0B_0.

It may be concluded that growth, yield and yield contributing characters of mungbean were greatly influenced by the application of sulfur and boron. The application of 8 kg sulfur and 2 kg boron ha^{-1} provide the maximum yields of mungbean.

Considering the situation of the present experiment, further studies in the following areas may be suggested:

1. Such study is needed in different agro-ecological zones (AEZ) of Bangladesh for regional compliance and other performance.
2. Another experiment may be carried out with another S application for maximizing highest benefit.
3. Another level of boron may be included in the future study.

REFERENCE

Anonymous. (1989). Annual Report 1987-88. Bangladesh Agricultural Research Institute. Joydebpur, Gazipur. p. 133.

BARI (Bangladesh Agricultural Research Institute). (2004). Annual Report for 2003. Mungbean in Bangladesh. P. 28.

BBS. (2007). Statistical Yearbook of Bangladesh. Bangladesh Bureau of Statistics. Statistics Division, Ministry of Planning, Govt. of Peoples Republic of Bangladesh. Dhaka. Bangladesh. pp. 71.

Bouyoucos, G. J. (1926). Hydrometer method improved for making particle size analysis of soils. *Agron. J.* **54**: 4661-4665.

Dey, J. and Basu, T. K. (2004). Response of green gram variety (B-1) to different levels of potassium and sulphur with regards to growth, nodulation, yield and quality. *Indian Agriculturist*. **48**(3/4): 161-165.

Edris, K. M., Islam, A. T. M. T., Chowdhury, M. S. and Haque, A. K. M. M. (1979). Detailed Soil Survey of Bangladesh Agricultural University Farm, Mymensingh, Dept. Soil Survey, Govt. People's Republic of Bangladesh. 118 p.

FAO (Food and Agriculture Organization). (1999). Production Yearbook. Basic Data Unit. Statistic Division, FAO. Rome, Italy.

Gomez, K. A. and Gomez, A. A. (1984). Statistical procedures for Agricultural Research. Jhon Wiley and Sons, New York.

Hunter, A. H. (1984). Soil Fertility Analytical Service in Bangladesh. Consultancy Report BARC, Dhaka.

Jackson, M. L. (1962). Soil Chemical Analysis. Constable and Co. Ltd London, First Print.

Lewis, Y. (1980). Effects of nitrogen on leaf area, nodulation and dry matter production in summer greengram. *J. Maharastra Agril. Univ.* **19**(2):211-213.

Nita, C., Mondal, S. S., Arup, G., Brahmachari, K. and Pal, A. K. (2002). Effect of potassium and sulphur on mungbean in relation to growth, productivity and fertility build up of soil. *~~Journal of~~ Interacademicia*. **6**(3): 266-271.

Olsen, S.R., Cole, C. V., Watanabe, F. S. and Dean, L. A. (1954). Estimation of available phosphorus in soils by extraction with sodium bicarbonate, U.S. Dept. Agric. Circ., p. 929.

Page, A. L., Miller, R. H. and Keeney, D. R. (1982). Methods of analysis part 2, Chemical and Microbiological Properties, Second Edition American Society of Agronomy, Inc., Soil Science Society of American Inc. Madson, Wisconsin, USA. pp. 403-430.

Pandey, S. P. and Singh, R. S. (2001). Responses of phosphorus and sulphur on yield and quality of summer moong. *Crop Research Hisar*. **22**(2): 206-209.

Patel, L. R., Salvi, N. M. and Patel, R. H. (1992). Response of greengram (*Phaseolus vulgaris*) varieties to sulphur fertilization under different levels of nitrogen and phosphorus. *Indian J. Agron.* **37**(4): 831-833.

Rizk, W. M. and Abdo, F. A. (2001). The response of two mungbean cultivars to zinc, manganese and boron II. Yield and chemical composition of seeds. *Bulletin of Faculty of Agriculture, Cairo University*. **52**(3): 467-477.

Saha, A., Mandal, B. K. and Mukhopadhyay, P. (1996). Residual effect of boron and molybdenum on the yield of succeeding mungbean in summer. *Indian Agriculturist*. **40**(1): 11-16.

Shahi, D. K., Sharma, A. and Lal S. (2002). Improving protein quality of green gram through use of Rhizobium inoculation, phosphorus and sulphur. Journal of Research Birsa Agricultural University. **14**(2): 171-174.

Sharma, S. C., Tiwari, H. O. and Tiwari, R. J. (1995). Effect of nitrogen, phosphorus and sulphur on the micronutrient content of blackgram. *Crop Res. Hisar*. **9**(1): 54-58.

Siag, R. K. and Yadav, B. S. (2003). Effect of levels and methods of sulphur application on growth and yield of mungbean. *Indian Journal of Pulses Research*. **16**(2): 159-160.

Singh, J. P., Farafdar, J. C. and Gupta, B. R. (1997). Sulphur fertilization for increased production of summer Moong. *Journal of the Indian Society of Soil Science*. **45**(3): 526-528.

Srinivasarao, C., Ganeshamurthy, A. N., Masood, A., Singh, R. N. and Singh, K. K. (2004). Sulphur availability and response of mungbean and urdbean to sulphur on different soil types of pulse growing regions of India. *Communications in Soil Science and Plant Analysis*. **35**(11/12): 1713-1723.

Tisdale, P. P., Poongothai, S., Savithri, R. K. and Bijujoseph, O. P. 1999. Influence of gypsum and green leaf manure application on rice. *J. Indian Soc. Soil Sci*. **47**(1): 96-99.

Tiwari, R. C. and Chaplot, P. C. (1995). Effect of irrigation schedules and sulphur levels on summer mungbean. *Indian J. Pulses Res.*, **8**(2): 149-151.

Trivedi, S. K. (1996). Response of blackgram (*Phaseolus mungo*) to nitrogen, phosphorus and sulphur. *Legume Res*. **19**(1): 7-9.

Trivedi, S. K., Singh, V. and Shinde, C. P. (1997). Effect of nitrogen, phosphorus and sulphur on yield and chemical composition of blackgram (*Phaseolus mungo*). *Gujarat Agric. Univ. Res. J.* **22**(2): 46-50.

Verma, R. J. and Mishra, P. H. (1999). Effect of doses and methods of boron application on growth and yield of mungbean. *Indian Journal of Pulses Research*. **12**(1): 115-118.

Walkley, A. and Black, D. R. 1935. An examination of the digestion method for determining soil organic matter and proposed modification of the chronic acid titration method. *Soil Sci.*, **37**: 29-38.

Yadav, S. S. (2004). Growth and yield of green gram (*Vigna radiata L.*) as influenced by phosphorus and sulphur fertilization. *Haryana Journal of Agronomy*. **20**(1/2): 10-12.

Sher-e-Bangla Agricultural University
Library
Sher-e-Bangla Nagar, Dhaka

APPENDICES

Appendix I. Monthly record of air temperature, relative humidity, rainfall and sunshine of the experimental site during the period from February to May 2008

Month (2008)	Air temperature (^{0}C)		Relative humidity (%)	Rainfall (mm) (total)	*Sunshine (hr)
	Maximum	Minimum			
February	26.4	15.7	56	00	8.1
March	31.4	19.6	54	11	8.2
April	33.6	23.6	69	163	6.4
May	34.7	25.9	70	185	7.8

* Source: Bangladesh Meteorological Department (Climate and weather division) Agargaon, Dhaka - 1212

Appendix II. Analysis of variance of the data on plant height of mungbean as influenced by sulfur and boron

Source of variation	Degrees of freedom	Mean square			
		Plant height (cm)			
		25 DAS	35 DAS	45 DAS	55 DAS
Replication	2	3.346	16.370	20.450	33.356
Sulfur (A)	3	200.571**	235.677**	352.153**	328.291**
Boron (B)	2	84.361**	152.313**	369.192**	739.515**
Interaction (A×B)	6	52.882**	54.617**	162.191**	229.191**
Error	22	4.599	7.056	34.172	39.258

**: Significant at 0.01 level of probability

Appendix III. Analysis of variance of the data on number of leaves per plant of mungbean as influenced by sulfur and boron

Source of variation	Degrees of freedom	Mean square			
		Number of leaves per plant			
		25 DAS	35 DAS	45 DAS	55 DAS
Replication	2	0.221	0.941	7.001	3.711
Sulfur (A)	3	4.558**	6.192**	38.998**	42.196**
Boron (B)	2	3.152**	15.823**	94.753**	123.246**
Interaction (A×B)	6	0.775**	3.120**	22.057**	24.408**
Error	22	0.217	0.834	5.482	6.090

**: Significant at 0.01 level of probability

Appendix IV. Analysis of variance of the data on leaf area of mungbean as influenced by sulfur and boron

Source of variation	Degrees of freedom	Mean square			
		Leaf area (cm^{-2})			
		25 DAS	35 DAS	45 DAS	55 DAS
Replication	2	3209.410	19623.227	36383.79	21481.415
Sulfur (A)	3	156470.33**	215853.07**	237982.03**	393480.76**
Boron (B)	2	112790.62**	267736.79**	749701.20**	889344.904**
Interaction (A×B)	6	60304.475**	121690.79**	200518.74**	216414.127**
Error	22	3215.367	9469.111	19092.265	29642.443

**: Significant at 0.01 level of probability

Appendix V. Analysis of variance of the data on total dry matter per plant of mungbean as influenced by sulfur and boron

Source of variation	Degrees of freedom	Mean square			
		Total dry matter per plant (g) at			
		25 DAS	35 DAS	45 DAS	55 DAS
Replication	2	134.340	1029.925	2236.74	2266.770
Sulfur (A)	3	9566.94**	22634.7**	9741.56**	21224.4**
Boron (B)	2	4309.09**	8920.61**	33966.1**	30008.3**
Interaction (A×B)	6	3069.92**	3735.22**	7888.86**	10432.6**
Error	22	408.087	527.994	1777.870	1525.194

**: Significant at 0.01 level of probability

Appendix VI. Analysis of variance of the data on yield contributing characters of mungbean as influenced by sulfur and boron

Source of variation	Degrees of freedom	Mean square				
		Flowers per plant (No.)	Number of pods per plant	Pod length (cm)	Seeds per pod (No.)	1000 seed weight (g)
Replication	2	7.391	3.008	0.384	0.569	3.376
Sulfur (A)	3	408.075**	30.257**	9.062**	14.954**	103.006**
Boron (B)	2	272.721**	50.921**	16.496**	12.571**	86.410**
Interaction (A×B)	6	23.449*	5.900*	1.079**	1.884*	9.089**
Error	22	9.180	1.889	0.339	0.570	2.105

**: Significant at 0.01 level of probability, *: Significant at 0.05 level of probability

Appendix VII. Analysis of variance of the data on yield and number of nodules per plant of mungbean as influenced by sulfur and boron

Source of variation	Degrees of freedom	Mean square				
		Seed yield (t/ha)	Stover yield (t/ha)	Biological yield (t/ha)	Harvest Index (%)	Number of nodules per plant
Replication	2	0.003	0.012	0.028	0.164	1.566
Sulfur (A)	3	0.453**	1.428**	3.450**	22.930**	91.325**
Boron (B)	2	0.147**	0.923**	1.806**	1.189	76.402**
Interaction (A×B)	6	0.022**	0.083*	0.185**	5.359*	6.938*
Error	22	0.006	0.030	0.050	1.098	2.293

**: Significant at 0.01 level of probability, *: Significant at 0.05 level of probability

Appendix VIII. Analysis of variance of the data on N, P, K, S and B in grain and stover as influenced by sulfur and boron

Source of variation	Degrees of freedom	Mean square				
		Concentration in grain (%)				
		N	P	K	S	B
Replication	2	0.003	0.005	0.002	0.003	0.121
Sulfur (A)	3	1.220**	0.627**	0.806**	0.817**	3.871**
Boron (B)	2	1.860**	0.763**	0.264**	0.476**	5.518**
Interaction (A×B)	6	0.203**	0.081**	0.046**	0.044**	0.098
Error	22	0.025	0.007	0.004	0.006	0.231

**: Significant at 0.01 level of probability

Appendix VIII. Contd.'

Source of variation	Degrees of freedom	Mean square				
		Concentration in stover (%)				
		N	P	K	S	B
Replication	2	0.162	0.0001	0.0001	0.002	0.034
Sulfur (A)	3	0.583**	0.005**	0.0001*	0.003**	1.981**
Boron (B)	2	1.481**	0.006**	0.007**	0.004**	0.981**
Interaction (A×B)	6	0.154**	0.002*	0.001**	0.0001	0.891*
Error	22	0.082	0.001	0.0001	0.0001	0.398

**: Significant at 0.01 level of probability; *: Significant at 0.01 level of probability

Appendix IX. Analysis of variance of the data on N, P, K, S and B uptake by grain and stover as influenced by sulfur and boron

Source of variation	Degrees of freedom	Mean square				
		Uptake by grain (%)				
		N	P	K	S	B
Replication	2	2.376	0.065	0.163	0.294	0.451
Sulfur (A)	3	229.802**	5.781**	23.914**	12.335**	2.564**
Boron (B)	2	297.614**	7.456**	24.084**	11.836**	1.891**
Interaction (A×B)	6	9.534*	0.183*	0.830*	0.310	0.634
Error	22	3.578	0.082	0.371	0.341	0.932

**: Significant at 0.01 level of probability; *: Significant at 0.01 level of probability

Appendix IX. Contd.'

Source of variation	Degrees of freedom	Mean square				
		Uptake by stover (%)				
		N	P	K	S	B
Replication	2	6.202	0.755	4.420	0.005	0.003
Sulfur (A)	3	1384.264**	54.971**	296.782**	0.883**	2.987**
Boron (B)	2	1577.423**	3.698**	24.276**	0.258**	2.910**
Interaction (A×B)	6	108.390**	1.079*	3.535*	0.008	0.061
Error	22	8.981	0.575	2.599	0.047	0.571

**: Significant at 0.01 level of probability; *: Significant at 0.01 level of probability

Appendix X. Analysis of variance of the data on pH, organic matter and N, P, K, S in post harvest soil as influenced by sulfur and boron

Source of variation	Degrees of freedom	Mean square					
		Post harvest soil					
		pH	Organic matter (%)	N (ppm)	P (ppm)	K (meq/100 g soil)	S (ppm)
Replication	2	0.085	0.0001	0.001	1.468	0.0001	0.0001
Sulfur (A)	3	1.917**	0.157**	0.045**	37.891**	0.002**	0.007**
Boron (B)	2	0.732*	0.047**	0.051**	33.781**	0.002**	0.005**
Interaction (A×B)	6	0.272*	0.005	0.003*	1.029*	0.0001**	0.001**
Error	22	0.199	0.007	0.001	0.775	0.0001	0.0001

**: Significant at 0.01 level of probability; *: Significant at 0.01 level of probability

Sher-e-Bangla Agricultural University
Library
Accession No 38721
Sign: Date:

শেরেবাংলা কৃষি বিশ্ববিদ্যালয় গ্রন্থাগার
সংযোজন নং 44
তাং 20/03/10