EFFECT OF SULPHUR AND BORON ON THE GROWTH AND YIELD OF MUNGBEAN VARIETIES

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CERTIFICATE

This is to certify that the thesis entitled **'Effect of Sulphur and Boron on the Growth and Yield of Mungbean Varieties'** 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 **Agronomy**, embodies the result of a piece of *bonafide* research work carried out by **Md. Ruhul Amin**, Registration number: **08-02757** 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 duly been acknowledged.

Dated:
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DEDICATED

TO

MY BELOVED PARENTS

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ABSTRACT

The experiment was conducted during the period from March to June, 2014 at the research farm of Sher-e-Bangla Agricultural University (SAU), Dhaka to find out the effect of sulphur and boron on the growth and yield of mungbean varieties. The experiment comprised of two factors i.e. Factor A: Sulphur and boron (combination-4); F_1= NPK, F_2= NPK+S, F_3= NPK+B and F_4= NPK+S+B; Factor B: Mungbean varieties-4; V_1= BARI Mung-5, V_2= BARI Mung-6, V_3= Binamoog-8 and V_4= BU Mung-4. The two factors experiment was laid out in a split-plot design with three replications. Data on different growth and yield parameters were recorded and significant variation was recorded for different treatments. In case of sulphur and boron, the highest seed yield (1.69 t ha^{-1}) was recorded from $F_{4,}$ whereas the lowest (1.57 t ha^{-1}) from F_1 which may be occurred due to highest and lowest 1000-seed weight, number of pods $plant^{-1}$, number of seeds $plant^{-1}$. For different varieties of mungbean, the highest seed yield (1.79 t ha^{-1}) was recorded from V_3, while the lowest (1.33 t ha^{-1}) from V_4 which may be occurred due to highest and lowest 1000-seed weight, number of pods $plant^{-1}$, number of seeds $plant^{-1}$. Due to the interaction effect of sulphur and boron combination and mungbean varieties, the highest seed yield (1.92 t ha^{-1}) was observed from the treatment combination of F_4V_2, whereas the lowest (1.12 t ha^{-1}) from F_4V_4 which may be occurred due to highest and lowest 1000-seed weight, number of pods $plant^{-1}$, number of seeds $plant^{-1}$. Application of NPK+S+B and Binamoog-8 was more potential in regarding growth and yield of mungbean.

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LIST OF ABBREVIATED TERMS

ABBREVIATION	FULL NAME
AEZ	Agro-Ecological Zone
BBS	Bangladesh Bureau of Statistics
cm	Centimeter
DAS	Days After Sowing
DMRT	Duncan's Multiple Range Test
et al.	and others
etc	Etcetera
FAO	Food and Agriculture Organization
LSD	Least Significance Difference
m^2	Square meter
MoP	Muriate of Potash
RCBD	Randomized Complete Block Design
SAU	Sher-e-Bangla Agricultural University
SRDI	Soil Resources Development Institute
TSP	Triple Super Phosphate
UNDP	United Nations Development Program
^0C	Degree Celsius

CHAPTER I

INTRODUCTION

Mungbean (*Vigna radiata* L.) belongs to family Leguminosae and sub-family Papilionaceae, is an important pulse crop and ranks fourth position considering both acreage and production in Bangladesh (MoA, 2014). It is composed of more than 150 cultivated species and originated mainly from Africa and Asia and the Asian tropical regions have the greatest magnitude of genetic diversity of mungbean (USDA-ARS GRIN, 2012). Mungbean contains 1-3% fat, 50.4% carbohydrates, 3.5-4.5% fibers and 4.5-5.5% ash, while calcium and phosphorus are 132 and 367 mg 100 grams of seed^{-1}, respectively (Frauque *et al*., 2000). It plays a significant role in sustaining crop productivity by adding nitrogen through rhizobial symbiosis and crop residues (Sharma and Behera, 2009). The total production of mungbean in Bangladesh in 2013-14 was 1.81 lac metric tons from the area of 1.73 lac hectares with an average yield 1.04 t ha^{-1} (MoA, 2014). It grows well all over the country except Rangamati district (BBS, 2013).

Mungbean plays an important role to supplement protein in the cereal-based low-protein diet of the people of Bangladesh, although the land for it cultivation and acreage production is gradually declining (BBS, 2013). According to FAO (2013) recommendation, a minimum intake of pulse by a human should be 80 gm day^{-1}, whereas it is 24.19 g in Bangladesh. It is cultivated with minimum tillage, use of local varieties with no or minimum fertilizers especially nitrogen, no pesticides or insecticides and very early or very late sowing, no practicing of irrigation and drainage facilities etc. All these factors are responsible for low yield of mungbean which is incomparable with the yields of developed countries of the World (FAO, 1999). The low yield of mungbean besides other factors may partially be due to lack of knowledge regards to suitable production technology (Hussain *et al*., 2008). Use of sulphur and boron and suitable variety is prerequisite for increasing the production of mungbean.

Sulphur (S) plays a remarkable role in protein metabolism. It is required for the synthesis of proteins, vitamins and chlorophyl and also S containing amino acids 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 induces chlorosis in young leaves and decrease seed yield by 45% (BARI, 2004). Sulphur (S) deficiency in these soils is widespread and extended up to 60% of total pulse area (Ganeshamurthy and Saha, 1999). Deficiency of S is progressively increasing due to intensive cropping systems and use of S free fertilizers. An insufficient supply of S can affect yield and quality of the crop adversely (Scherer *et al*., 2006); because S is required for protein and enzyme synthesis as well it is a constituent of the amino acids methionine and cysteine (Scherer, 2001). Application of 30 kg S ha^{-1} in mungbean was found optimum and this dose can increase plant height, primary branches, functional leaves, dry matter, nodule number and nodule weight $plant^{-1}$ and seed yield (Singh and Yadav, 1997).

Boron (B) ranks third place among micronutrients in its concentration in seed and stem as well as its total amount after zinc. It 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). Studies revealed that deficiency of boron cause prominent reduction of growth, nodulation, yield percentage, vigour and viability in legume and cereal crops (Ahmad *et al*., 2012). Boron supply increases the uptake and reutilization of N, P, K, Na, Ca and other (Yaseen *et al*., 2004). Mungbean yield was significantly increased due to the application of B (Quddus *et al*., 2011). Boron is a naturally occurring micronutrient on the earth along with other elements in the form of borates. It has principal role in plant cell wall and membrane constancy (Bassil *et al*., 2004). Application of boron has significant effect of yield of mungbean (Ashraf, 2009).

Variety plays an important role in producing high yield of mungbean because different varieties perform differently for their genotypic characters also vary from genotype to genotype. Improved variety is the first and foremost requirement for initiation and accelerated crop production program. Worldwide, a total of 43,027 mungbean accessions are available at core collections or Gene Bank at different stations of the World. Up to date, over 110 mungbean cultivars have been released by AVRDC in South and Southeast Asia and around the world (Ali and Gupta, 2012). AVRDC has developed several mungbean with superior lines for production in the tropics and subtropics which are early and uniformly maturing (55-65 days), disease resistant, and high yielding. Research findings revealed that different variety produced different seed yield of mungbean (Tripathi *et al*., 2012; Islam *et al*., 2006; Rahman *et al*., 2005; Hossain and Solaiman, 2004). The yield of mungbean in Bangladesh has been increased obviously by using high yielding mungbean varieties and improvement of management practices.

Under the above mention context and situation, the present experiment was conducted to find out the growth and yield of mungbean varieties as affected by sulphur and boron with the following objectives:

- To examine the effect of S and B on the yield and yield attributes of mungbean,
- To investigate the performance of different mungbean variety, and
- To observe the combined effect of S and B and variety on the growth and yield of mungbean.

CHAPTER II

REVIEW OF LITERATURE

Mungbean is an important pulse crop in Bangladesh and as well as many countries of the world although the crop has conventional less attention by the researchers on various aspects because basically it grows in fallow land or as intercropped without or minimum care or management practices. Although sulphur & boron and variety of mungbean play an important role in improving yield but research works related to sulphur & boron and variety on mungbean are limited and not conclusive in context of Bangladesh. However, some of the important and informative works and research findings related to sulphur & boron and variety on mungbean so far been done at home and abroad have been reviewed in this chapter under the following headings-

2.1 Influence of sulphur on growth and yield of mungbean

A field experiment was conducted by Sipai *et al*. (2016) for four consecutive years at Centers of Excellence for Research on Organic Farming S. D. Agricultural University, Bhachau, Kutch, to study the effect of P, S and Rhizobium on yield, yield attributes and nodulation of Mungbean. The experiment consisting of three levels of phosphorus, three levels of sulphur (0, 20, 40 kg ha^{-1}) and two levels of Rhizobium, total 18 treatment combinations with three replications were comprised in factorial randomized block design. Application of 40 kg P_2O_5 ha^{-1} and 40 kg S ha^{-1} along with Rhizobium inoculation significantly increased the yields, yield attributes and nodulation of Mungbean as compared to control, but it remained at par with 20 kg P_2O_5 ha^{-1} and 20 kg S ha^{-1}.

Mazed *et al.* (2015) carried out a field experiment at the experimental farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh to study the growth and yield of Mungbean as influenced by potassium (K) and sulphur (S). Four levels of K and three levels of S (0, 3 and 6 kg ha^{-1}) were used in the study. The results revealed that grain and stover yield of mungbean increased with increasing levels of S. The maximum significant grain and stover yield were obtained with the treatment combinations K_2S_2 (25 kg K ha^{-1} + 6 kg S ha^{-1}) and the same treatments combinations gave the highest plant height, number of branch plant^{-1}, yield attributes like number of pods plant^{-1}, number of grains pod^{-1}, weight of 1000 seeds.

Ram & Katiyar (2013) carried out a field experiment was conducted under Instructional Farm of N.D. University of Agriculture & Technology, Kumarganj, Faizabad (U.P.), to evaluate the influence of sulphur and zinc on mungbean for two consecutive summer seasons. The experiment was conducted with four levels of sulphur (0, 20, 40 and 60 kg S ha^{-1}) and four levels of zinc (0, 5, 7.5 and 10 kg Zn ha^{-1}). The results revealed that application of 40 kg S ha^{-1} and 10 kg Zn ha^{-1} significantly increased the plant height, number of branches plant^{-1}, number of nodules plant^{-1}, number of pods plant^{-1}, number of seeds pod^{-1}, seed yield, protein content (%) and test weight was non-significant. The control (0 kg S × 0 kg Zn ha^{-1}) had the poorest performance in respect of yield and protein content of mungbean seed. The increasing dose of zinc increased the seed yield with increasing dose of sulphur up to 40 kg S ha^{-1}. The highest seed yield (13.69 and 14.40 q ha^{-1}) was observed in combination with 40 kg S ha^{-1} and 10 kg Zn ha^{-1} which was significantly superior over rest of the combinations except 60 kg S ha^{-1} and 10 kg Zn ha^{-1}. The minimum seed yield (9.56 and 10.06 q ha^{-1}) was achieved with treatment having 20 kg S ha^{-1} and 5 kg Zn ha^{-1} and least was in control.

A field experiment was conducted by Tripathi *et al.* (2012) to find out the effect of rhizobial strains and sulphur (S) levels (15, 30 and 45 kg ha^{-1}) on mungbean cultivars (SML-668, Pusa Vishal, and HUM-1). Application of 45 kg S ha^{-1} recorded higher plant height, primary branches, green trifoliates, leaf area index, dry matter accumulation, nodule numbers and nodule dry weight, increased days to maturity, number of pod and higher grain and straw yield as compared to cultivars Pusa Vishal and SML-668, and S application at 15 and 30 kg ha^{-1}, respectively. Nodule number was highest in HUM-1 × MO 5 and application of 45 kg S ha^{-1} in Pusa Vishal and HUM^{-1}.

A study was conducted by Dey and Basu (2009) in West Bengal, India to determine the effects of potassium and sulphur fertilizer on the growth, nodulation, yield and quality of green gram cv. B-1. Treatments comprised: 0, 20 and 40 kg K ha^{-1}, and 0, 20 and 40 kg S ha^{-1}. 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^{-1} along with 40 kg S ha^{-1}. The number of nodules and dry weight of nodules increased with increasing rates of sulphur and potassium. Yield components (i.e. number of pods plant^{-1}, number of seeds pod^{-1} and 1000-seed weight) increased with increasing rates of sulphur and potassium. The increment in yield components further contributed to increased seed yield. Protein content also increased with increasing rates of sulphur and potassium.

Yadav (2007) conducted an experiment to find out the effects of phosphorus and sulphur (0, 20, 40 and 60 kg ha^{-1}) on the growth and yield of green gram cv. RMG-62 in a field experiment conducted in Rajasthan, India during the *Kharif* seasons. Plant height, number of branches plant^{-1}, number of pods plant^{-1}, number of seeds pod^{-1}, seed yield, stover yield and biological yield increased with increasing rates of phosphorus and sulphur up to 40 kg ha^{-1} and decreased thereafter.

Srinivasarao *et al.* (2004) conducted an experiment with available sulphur (S) extracted in five extractants, crop response to S application and use efficient use of S by mungbean and urdbean 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 under irrigated conditions to study the response of mungbean cv. MUM 2 to sulphur (applied as gypsum) with different application methods in sandy loam soil of Rajasthan, India. Treatments comprised: two sulphur rates (20 and 40 kg ha^{-1}) 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 sulphur). The number of pods $plant^{-1}$ increased with increasing sulphur rates. Basal dose of 40 kg S ha^{-1} recorded the highest number of pods $plant^{-1}$ (34.2). Plant heights, number of seeds pod^{-1} and 1000-seed weight were not influenced by different treatments in any year. Grain yield obtained at basal dose of 20 kg S ha^{-1} (973 kg ha^{-1}) was 42.9% higher than that of the control treatment (681 kg ha^{-1}). Grain yield was highest with a basal dose of 40 kg S ha^{-1} (1095 kg ha^{-1}), but did not differ significantly from 20 kg S ha^{-1}. A side dressing of 20 kg S ha^{-1} 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^{-1}, 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^{-1}), sulphur (0, 10, 20 and 30 kg ha^{-1}) 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. Application of P and S, and inoculation with *Rhizobium* enhanced the protein content in the grains of green gram, with 60 kg P ha^{-1} and 30 kg S ha^{-1} 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^{-1}. The methionine, cystine and cysteine content of the grains were highest with the application of 30 kg S ha^{-1}, which was similar with the application of 20 kg S ha^{-1}.

Pandey and Singh (2001) conducted an experiment with P_2O_5 the rate of 0, 25 or 50 kg ha^{-1} and S at 0, 20 and 40 kg ha^{-1} were applied as basal in Pura, Jammu and Kashmir, India. Mungbean 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^{-1} and 40 kg S ha^{-1}. The protein and sulphur-containing amino acid contents of the grains linearly increased with increasing rates of phosphorus and sulphur. The highest protein and sulphur-containing amino acid contents were observed at 50 kg P_2O_5 ha^{-1} and 40 kg S ha^{-1} and the lowest contents were observed in the control, during both the years.

Summer mungbean was grown in the field in India for two years with the application of elemental sulphur (0, 15, 30 and 45 kg ha^{-1}) by Singh *et al*. (1997). Sulphur application significantly improved plant biomass, nodule number and weight, seed grain and stover yield, nitrogen and sulphur uptake, the optimum application rate being 30 kg ha^{-1}. Application of sulphur up to 15 kg ha^{-1} increased the population of total bacteria and *Azotobacter*. However, addition of sulphur decreased the population of fungi and actinomycetes.

Trivedi *et al*. (1997) carried out a field experiment to study the effects of nitrogen, phosphorus and sulphur on yield and nutrient uptake of blackgram (*Vigna mungo*) at Gwalior, Madhya Pradesh, India in *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 trial in the rainy seasons at Gwalior, Madhya Pradesh, India with *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 increasing rates of N, P and S applications.

In a field experiment conducted by Tiwari and Chaplot (1995) during the summer seasons at Udaipur, Rajasthan and they studied the effects 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^{-1} 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 sulphur rate up to 100 kg ha^{-1}.

Sharma *et al*. (1995) carried out a field trial in the monsoon season at Gwalior, Madhya Pradesh with *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. 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 with 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 $ha^{1}$and 0, 10, 20 or 30 kg S ha^{-1} as gypsum and found that plant growth with highest doses. Seed yield with 20 kg N + 40 kg P ha^{-1} was 1.2 and 1.24 t ha^{-1} in Gujrarat 2 and K 851, respectively.

2.2 Influence of boron on growth and yield of mungbean

A study was conducted by Tahir *et al*. (2013) at Agronomic Research Area, University of Agriculture, Faisalabad to evaluate the production potential of mungbean (*Vigna radiata* L.) in response to sulphur and boron on the genotype NIAB Mung-2006. The treatments were comprised of four sulphur levels i.e. 0, 12, 24 and 36 kg ha^{-1} and three boron levels i.e. 0, 4 and 8 kg ha^{-1}. Gypsum was used as sulphur source and boric acid for boron. It appeared that sulphur at 24 kg ha^{-1} and boron at 4 kg ha^{-1} significantly increased plant height (58.30 cm), number of pods $plant^{-1}$ (21.33), 1000-seed weight (35 g), number of nodules $plant^{-1}$ (13.33), biological yield (7688 kg ha^{-1}) and seed yield (1200 kg ha^{-1}).

An experiment was carried out by Quddus *et al*. (2011) in Calcareous Low Ganges River Floodplain Soil (AEZ 12) at Pulses Research Sub-Station (PRSS), Madaripur during Kharif I to evaluate the effect of zinc (Zn) and boron (B) on the yield and yield contributing characters of mungbean (*Vigna radiata* L.) and to find out the optimum dose of Zn and B for yield maximization. There were four levels of zinc (0, 0.75, 1.5, and 3.0 kg ha^{-1} and boron (0, 0.5, 1.0, and 2 kg ha^{-1}) along with a blanket dose of N_{20} P_{25} K_{35} S_{20} kg ha^{-1}. Results showed that the combination of $Zn_{1.5}B_{1.0}$ produced significantly higher yield (3058 kg ha^{-1}) and (2631 kg ha^{-1}). The lowest yield (2173 kg ha^{-1}) and (1573 kg ha^{-1}, were found in control (Zn_0B_0) combination.

A field experiment was conducted by Patra and Bhattacharya (2009) in kharif (rainy) season in a sandy loam soil (mixed hyperthermic paleudalfs) at Jhargram, Paschim Medinipur in the Red and Laterite zone of West Bengal to investigate the effect of four levels of boron and three levels of molybdenum on growth and yield of Mungbean [*Vigna radiata* (L.) Wilczek (cv. Baisakhi Mung)]. Boron, molybdenum and their combined application significantly improved all the growth and yield attributing characters of Mungbean. The synergistic influence of these two micronutrients helped augmenting growth and yield of the crop.

Rizk and Abdo (2001) conducted two field experiments at Giza Experimental Station, ARC, Egypt to investigate the response of mungbean (*Vigna radiata*) with some micronutrients. Two cultivars of mungbean (V-2010 and VC-1000) were used in those investigations. Zn (0.2 or 0.4 g l^{-1}), Mn (1.5 or 2.0 g l^{-1}), B (3.0 or 5.0 g l^{-1}) and a mixture of Zn, Mn, and B (0.2, 1.5 and 3.0 g l^{-1}, 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^{-1}) 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 the 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 for seed treatment, soil application (basally or at flowering) or foliar spraying. It increased yield and growth parameters with the best results in terms of seed yield plant^{-1} when the equivalent of 5 kg borax ha^{-1} was applied at flowering stage.

Saha *et al*. (1996) carried out a field trial in pre-*Kharif* seasons at Pundibari, India, yellow sarson was given 0, 2.5 or 5.0 kg borax and 0, 1 or 2 kg ha^{-1} of sodium molybdate was applied in 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.

2.3 Influence of variety on growth and yield of mungbean

A field experiment was conducted by Tripathi *et al.* (2012) to find out the effect of rhizobial strains and sulphur (S) levels (15, 30 and 45 kg ha^{-1}) on mungbean cultivars (SML-668, Pusa Vishal, and HUM-1). Cultivar HUM-1 and application of 45 kg S ha^{-1} recorded higher plant height, primary branches, green trifoliates, leaf area index, dry matter accumulation, nodule numbers and nodule dry weight, increased days to maturity, number of pod and higher grain and straw yield as compared to cultivars Pusa Vishal and SML-668. Nodule number was highest in HUM-1 × MO 5. Strain MO 5 showed maximum grain protein irrespective of cultivars and sulphur levels.

A field trial was conducted by Rasul *et al*. (2012) to establish the proper inter-row spacing and suitable variety evaluation in Faisalabad, Pakistan. Three mung bean varieties V_1, V_2, V_3 (NM-92, NM-98, and M-1) were grown at three inter-row spacings respectively. Highest seed yield was obtained for variety V_2 at 30 cm spacing. Among varieties V_2 exhibited the highest yield 727.02 kg ha^{-1}, while the lowest seed yield 484.79 kg ha^{-1} was obtained with V_3.

Agugo *et al*. (2010) grown four mungbean accessions collected from the Asian Vegetable Research and Development Centre (AVRDC) and reported a significant difference in the yield of the varieties with VC 6372 (45-8-1) producing the highest seed yield of 0.53 t ha^{-1}. This was followed by NM 92, 0.48 t ha^{-1}; NM 94, 0.40 t ha^{-1}; and VC 1163 with 0.37 t ha^{-1}. The variety, VC 6372 (45-8-1), also formed good agronomic characters.

Field studies were carried out by Kumar *et al*. (2009) in Haryana, India to determine the growth behaviour of mungbean genotypes sown on different dates under irrigated conditions. The treatments consisted of 2 genotypes (SML 668 and MH 318) and 6 sowing dates starting from 1 March to 19 April, at of 10-day intervals. Results showed that SML 668 had higher plant height than MH 318 and the less height of both the genotypes during summer was due to low average temperature during the initial growth stage. SML 668 accumulated more dry matter than MH 318. The contribution of leaves and stem was more in SML 668, whereas the contribution of pods towards total aboveground biomass at harvest was higher in MH 318.

Quaderi *et al*. (2006) conducted an experiment in the Field Laboratory of the Department of Crop Botany, Bangladesh Agricultural University, Mymensingh to evaluate the influence of seed treatment with Indole Acetic Acid (IAA) on the growth, yield and yield contributing characters of two modern mungbean (*Vigna radiata* L.) varieties viz. BARI moog 4 and BARI moog 5. The two-factor experiment was laid out in Randomized Complete Block Design (RCBD) (factorial) with 3 replications. Among the mungbean varieties, BARI mung 5 performed better than that of BARI mung 4.

To study the nature of association between *Rhizobium phaseoli* and mungbean an experiment was conducted by Muhammad *et al*. (2006). Inocula of two Rhizobium strains, Tal-169 and Tal-420 were applied to four mungbean genotypes viz., NM-92, NMC-209, NM-98 and Chakwal Mung-97. A control treatment was also included for comparison. The experiment was carried out at the University of Arid Agriculture, Rawalpindi, Pakistan, during kharif. Both the strains in association with NM-92 had higher nodule dry weight, which was 13% greater than other strains × mungbean genotypes combinations. Strain Tal-169 was specifically more effective on genotype NCM-209 and NM-98 compared with NM-92 and Chakwal Mung-97. Strain Tal-420 increased branches plant^{-1} of all the genotypes. Strain Tal-169 in association with NCM-209 produced the highest yield of 670 kg ha^{-1} which was similar (590 kg ha^{-1}) in case of NCM-209 either inoculated with strain Tal-420 or uninoculated. Variety NM-92 produced the lowest grain yield (330 kg ha^{-1}) either inoculated with strain Tal-420 or uninoculated.

Islam *et al*. (2006) carried out an experiment at the field laboratory of the Department of Crop Botany, Bangladesh Agricultural University, Mymensingh to evaluate the effect of biofertilizer (*Bradyrhizobium*) and plant growth regulators (GA_3 and IAA) on growth of 3 cultivars of summer mungbean (*Vigna radiata* L.). Among the mungbean varieties, Binamoog-5 performed better than that of Binamoog 2 and Binamoog 4.

Mungbean cultivars Pusa 105 and Pusa Vishal were sown at 22.5 and 30 cm spacing and supplied with 36-46 and 58-46 kg NP ha^{-1} in a field experiment conducted in Delhi, India during the kharif season by Tickoo *et al*. (2006). Cultivar Pusa Vishal recorded higher biological and grain yield (3.66 and 1.63 t ha^{-1}, respectively) compared to cv. Pusa 105.

To evaluate the effects of crop densities (10, 13, 20 and 40 plants m^{-2}) on yield and yield components of two cultivars (Partow and Gohar) and a line of mungbean (VC-1973A), a field experiment was conducted by Aghaalikhani *et al*. (2006) at the Seed and Plant Improvement Institute of Karaj, Iran, in the summer of 1998. The results indicated that VC-1973A had the highest grain yield. This line was superior to the other cultivars due to its early and uniform seed maturity and easy mechanized harvest.

Rahman *et al*. (2005) carried out an experiment with mungbean in Jamalpur, Bangladesh, involving 2 planting methods, i.e. line sowing and broadcasting; 5 mungbean cultivars, namely Local, BARI mung 2, BARI mung 3, Binamoog 2 and BINA moog 5. Significantly the highest dry matter production ability was found in 4 modern mungbean cultivars, and dry matter partitioning was found highest in seeds of Binamoog 2 and lowest in Local. However, the local cultivar produced the highest portion of dry matter in leaf and stem.

Studies were conducted by Bhati *et al*. (2005) to evaluate the effects of cultivars and nutrient management strategies on the productivity of different kharif legumes (mungbean, mothbean and clusterbean) in the arid region of Rajasthan, India. The experiment with mungbean showed that K-851 gave better yield than Asha and the local cultivar. In another experiment, mungbean cv. PDM-54 showed 56.9% higher grain yield and 13.7% higher fodder yield than the local cultivar.

A field experiment was conducted by Raj and Tripathi (2005) in Jodhpur, Rajasthan, India, during the kharif seasons, to evaluate the effects of cultivar (K-851 and RMG-62) as well as nitrogen and phosphorus on the productivity of mungbean. K-851 produced significantly higher values for seed and straw yields as well as yield attributes (plant height, pods plant^{-1}, seeds pod^{-1} and 1000-seed weight) compared with RMG-62. Higher net return and benefit:cost (B:C) ratio were also obtained with K-851 (Rs. 6544 ha^{-1} and 1.02, respectively) than RMG-62 (Rs. 4833 ha^{-1} and 0.76, respectively).

Chaisri *et al*. (2005) conducted a yield trial involving 6 recommended cultivars (KPS 1, KPS 2, CN 60, CN 36, CN 72 and PSU 1) and 5 elite lines (C, E, F, G, H) under Kasetsart mungbean breeding project in Lopburi Province, Thailand, during the dry (February-May 2002), early rainy (June-September 2002) and late rainy season (October 2002-January 2003). Line C, KPS 1, CN 60, CN 36 and CN 72 gave high yields in the early rainy season, while line H, line G, line E, KPS 1 and line C gave high yields in the late rainy session. Yield trial of the 6 recommended mungbean cultivars was also conducted in the farmer's field.

Two summer mungbean cultivars, i.e. BINA moog 2 and BINA moog 5, were grown during the kharif-1 season (February-May), in Mymensingh, Bangladesh, under no irrigation or with irrigation once at 30 days after sowing (DAS), twice at 30 and 50 DAS, and thrice at 20, 30 and 50 DAS by Shamsuzzaman *et al*. (2004). Data were recorded for days to first flowering, days to first leaf senescence, days to pod maturity, flower + pod abscission, root, stem+leaf, pod husk and seed dry matter content, pods plant^{-1}, seeds pod^{-1}, 100-seed weight, seed yield, biological yield and harvest index. The two cultivars tested were synchronous in flowering, pod maturity and leaf senescence, which were significantly delayed under different irrigated frequencies. BINA moog 2 performed slightly better than BINA moog 5 for most of the growth and yield parameters studied.

An experiment was conducted by Abid *et al*. (2004) in Peshawar, Pakistan to study the effect of sowing dates on the agronomic traits and yield of mungbean cultivars NM-92 and M-1. Data were recorded for days to emergence, emergence m^{-2}, days to 50% flowering, days to physiological maturity, plant height at maturity and grain yield. Sowing on 15 April took more number of days to emergence but showed maximum plant height. The highest emergence m^{-2} and higher mean grain yield was recorded in NM-92 than M-1.

A field experiment was conducted by Apurv and Tewari (2004) during kharif season in Uttaranchal, India, to investigate the effect of *Rhizobium* inoculation and fertilizer on the yield and yield components of three mungbean cultivars (Pusa 105, Pusa 9531 and Pant mung 2). Pusa 9531 showed higher yield components and grain yield than Pusa 105 and Pant mung 2.

To find out the effects of *Rhizobium* inoculation on the nodulation, plant growth, yield attributes, seed and stover yields, and seed protein content of six mung bean (*Vigna radiata*) cultivars were investigated by Hossain and Solaiman (2004). The mungbean cultivars were BARI mung-2, BARI mung-3, BARI mung-4, BARI mung-5, Binamoog-2 and BU mung-1. Among the cultivars, BARI mung-4 performed the best in all aspects showing the highest seed yield of 1135 kg ha^{-1}. *Rhizobium* strain TAL169 did better than TAL441 in most of the studied parameters. It was concluded that BARI mung 4 in combination with TAL169 performed the best in terms of nodulation, plant growth, seed and stover yields, and seed protein content.

The performance of 20 mungbean cultivars were evaluated by Madriz-Isturiz and Luciani-Marcano (2004) in a field experiment conducted in Venezuela. Data on plant height, clusters $plant^{-1}$, pods $plant^{-1}$, pod length, seeds pod^{-1}, grain yield by plant and yield ha^{-1} were recorded. Significant differences in the values of the parameters measured due to cultivar were recorded. The average yield was 1342.58 kg ha^{-1}. VC 1973C, Creole VC 1973A, VC 2768A, VC 1178B and Mililiter 267 were the most promising cultivars for cultivation in the area.

Effect of sowing rates on the growth and yield of mungbean cultivars NM-92, NARC mung-1 and NM-98 was evaluated by Riaz *et al*. (2004) in Faisalabad, Pakistan. NM-98 produced the maximum pod number of 77.30, grain yield of 983.75 kg ha^{-1} and harvest index value of 24.91%. NM-92 also produced the highest seed protein content of 24.64%.

Brar *et al*. (2004) introduced SML 668 high yielding variety of summer mungbean selection from AVRDC line NM 94, is a cultivar recommended for general cultivation in irrigated areas of Punjab, India. This early maturing cultivar flowers in 34 days and matures in 60 days. It has an average plant height of 44.6 cm and bears an average of 16 pods plant^{-1} and 10.4 seeds pod^{-1}. Seeds are bold with 100-seed weight of 5.7 g and devoid of hard seeds. Protein content is 22.7% and water absorption capacity is high (91%).

Seed treatment with biofertilizers in controlling foot and root rot of mungbean cultivars BINA moog-3 and BINA moog-4 was investigated by Mohammad and Hossain (2003) under field conditions in Pakistan. Treatment of seeds of BINA moog-3 with biofertilizer showed a 5.67% increase in germination over the control, but in case of BINA moog-4 10.81% increase in germination over the control was achieved by treating seeds with biofertilizer. The biofertilizers caused 77.79% reduction of foot and root rot disease incidence over the control along with BINA moog-3 and 76.78% reduction of foot and rot disease in BINA moog-4. Seed treatment with biofertilizer also produced up to 20.83% higher seed yield in BINA moog-3 and 12.79% higher seed yield BINA moog-4 over the control.

Three mungbean cultivars (LGG 407, LGG 450 and LGG 460) and two urd bean [black gram] cultivars (LBG 20 and LBG 623) were sown in Lam, Guntur, Andhra Pradesh, India, by Durga *et al*. (2003) and subjected to severe moisture stress during the first 38 days after sowing (DAS) and only a rainfall of 21.4 mm was received during this period. Mungbean registered higher root length (11.83%), root volume (37.50), root weight (31.43%), lateral roots (81.71%), shoot length (13.04%), shoot weight (84.62%), leaf number (25.75%), leaf weight (122.86%) and leaf area (108.60%) than the urd bean. Mungbean recorded better leaf characters than urd bean, but root and shoot characters were better in the latter. Among the mungbean cultivars, LGG 407 recorded the highest yield. Between the urd bean cultivars, LBG 20 had a higher yield than LBG 623. Among the mung bean cultivars, LGG 407 was the most tolerant, while in urd bean, LBG 20 was more efficient in avoiding early drought stress than LBG 623.

Taj *et al*. (2003) carried out an experiment to find out the effects of sowing rates (10, 20, 30 and 40 kg seed ha^{-1}) on the performance of 5 mungbean cultivars (NM-92, NM 19-19, NM 121-125, N/41 and a local cultivar) were studied in Ahmadwala, Pakistan, during the summer season. Among the cultivars, NM 121-125 recorded the highest average pods $plant^{-1}$ (18.18), grains pod^{-1} (9.79), 1000-grain weight (28.09 g) and grain yield (1446.07 kg ha^{-1}).

Satish *et al*. (2003) conducted an experiment in Haryana, India to investigate the response of mung bean cultivars Asha, MH 97-2, MH 85-111 and K 851 to different P levels. Results revealed that the highest dry matter content in the leaves, stems and pods was obtained in Asha and MH 97-2. The total above-ground dry matter as well as the dry matter accumulation in leaves, stems and pods increased with increasing P level up to 60 kg P ha^{-1}. MH 97-2 and Asha produced significantly more number of pods and branches $plant^{-1}$ compared to MH 85-111 and K 851.

The development phases and seed yield were evaluated by Infante *et al*. (2003) in mungbean cultivars ML 267, Acriollado and VC 1973C under the agroecological conditions of Maracay, Venezuela. The differentiation of the development phases and stages, and the morphological changes of plants were studied. The variable totals of pod clusters, pods plant^{-1}, seeds pods^{-1} and pod length were also studied. The earliest cultivar was ML 267 with 34.87 days to flowering and 61.83 to maturity. There were significant differences for total pod clusters plant^{-1} and pods plant^{-1}, where ML 267 and Acriollado had the highest values. The total seeds pod^{-1} of VC 1973C and Acriollado were significantly greater than ML 267. Acriollado showed the highest yield with 1438.33 kg ha^{-1}.

Seeds of mungbean cultivars BM-4, S-8 and BM-86 were inoculated with *Rhizobium* strains M-11-85, M-6-84, GR-4 and M-6-65 before sowing in a field experiment conducted by Navgire *et al*. (2001) in Maharashtra, India during the kharif season. S-8, BM-4 and BM-86 recorded the highest mean nodulation (16.66), plant biomass (8.29 q ha^{-1}) and grain yield (4.79 q ha^{-1}).

Hamed (1998) carried out two field experiments in Shalakan, Egypt, to evaluate mung bean cultivars Giza 1 and Kawny 1 under 3 irrigation intervals after flowering and 4 fertilizer treatments. Kawny 1 surpassed Giza 1 in pod number plant^{-1} (24.3) and seed yield (0.970 t ha^{-1}), while Giza 1 was superior in 100-seed weight (7.02 g), biological and straw yields (5.53 and 4.61 t ha^{-1}, respectively). While Kawny 1 surpassed Giza 1 in oil yield (35.78 kg ha^{-1}), the latter cultivar recorded higher values of protein percentage and yield (28.22% and 264.6 kg ha^{-1}).

From the above cited reviews, it may be concluded that application of sulphur and boron and variety are the prerequisite for attaining optimum growth and highest yield of mungbean. The literature revealed that the influence of sulphur & boron and variety have not been studied well and have no definite conclusion for the production of mungbean under the agro climatic condition of Bangladesh.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted to find out the effect of sulphur and boron on the growth and yield of mungbean varieties. The materials and methods that were used for conducting the experiment have been presented in this chapter. It includes a short description of the location of experimental site, soil and climatic condition of the experimental area, materials used for the experiment, design of the experiment, data collection and data analysis procedure.

3.1 Description of the experimental site

3.1.1 Experimental period

The experiment was conducted during the period from March to June, 2014.

3.1.2 Experimental location

The experiment was conducted at the Research Farm of Sher-e-Bangla Agricultural University (SAU), Dhaka and it was located in 24.09^0N latitude and 90.26^0E longitudes. As per the Bangladesh Meteorological Department, Agargaon, Dhaka-1207 the altitude of the location was 8 m from the sea level.

3.1.3 Characteristics of 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 Shallow Red Brown Terrace soil. 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, grind and passed through 2 mm sieve and analyzed at Soil Resources Development Institute (SRDI), Farmgate, Dhaka for some important physical and chemical properties. The soil was having a texture of silty clay with pH and organic matter 5.7 and 1.13%, respectively. The results showed that the soil composed of 27% sand, 43% silt and 30% clay, which have been presented in Appendix I.

3.1.4 Climatic condition

The climate of experimental site is subtropical, characterized by three distinct seasons, the rabi from November to February and the kharif-I, pre-monsoon period or hot season from March to April and the kharif-II monsoon period from May to October. The monthly average temperature, relative humidity and rainfall during the crop growing period were collected from Weather Yard, Bangladesh Meteorological Department, and presented in Appendix II. During the experimental period the maximum temperature (35.4^0C), highest relative humidity (80%) and highest rainfall (227 mm) was recorded in the month of June 2014, whereas the minimum temperature (19.5^0C), minimum relative humidity (65%) and no rainfall was recorded for the month of March 2014.

3.2 Experimental details

3.2.1 Treatments of the experiment

The experiment comprised of two factors

Factor A: Sulphur and boron (combination-4)

i) F_1= NPK (control)
ii) F_2= NPK+S
iii) F_3= NPK+B
iv) F_4= NPK+S+B

* S, B and other fertilizers applied at recommended dose.

Factor B: Mungbean varieties-4

i) V_1= BARI Mung-5
ii) V_2= BARI Mung-6
iii) V_3= Binamoog-8
iv) V_4= BU Mung-4

There were total 16 (4×4) treatment combinations as, F_1V_1, F_1V_2, F_1V_3, F_1V_4, F_2V_1, F_2V_2, F_2V_3, F_2V_4, F_3V_1, F_3V_2, F_3V_3, F_3V_4, F_4V_1, F_4V_2, F_4V_3 and F_4V_4.

3.2.2 Planting material

Mungbean varieties of BARI Mung-5, BARI Mung-6, Binamoog-8 and BU Mung-4 were used as planting materials for the study. The seeds of BARI Mung-5 and BARI Mung-6 were collected from the Pulse Seed Division of Bangladesh Agricultural Research Institute, Joydebpur, Gazipur, Binamoog-8 and BU Mung-4 was collected from Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh and Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, respectively.

3.2.3 Land preparation

The land was opened on the 12th March, 2014 with the tractor drawn disc plough. Ploughed soil was brought into desirable tilth by cross-ploughing, harrowing and laddering. The stubble and weeds were removed. The first ploughing and the final land preparation were done on the 16th and 22nd March, 2014, respectively. Experimental land was divided into unit plots following experimental design.

3.2.4 Fertilizer application

Urea, Triple super phosphate (TSP), Muriate of potash (MoP), gypsum and boric acid were used as a source of nitrogen (N), phosphorous (P), potassium (K), sulphur (S) and boron (B), respectively. Urea, TSP, MoP, gypsum and boric acid were applied at the rate of 120, 133, 62, 90 and 1 kg hectare^{-1}, respectively following the Bangladesh Agricultural Research Institute (BARI) recommendation. All of the fertilizers were applied during final land preparation.

3.2.5 Experimental design and layout

The two factors experiment was laid out in a split-plot design with three replications. An area of 26.5 m × 14.6 m was divided into three blocks. S and B fertilizer were assigned in the main plot and four variety of mungbean assigned in sub-plot. The size of the each unit plot was 2.4 m × 1.5 m. The space between two blocks and two plots were 1.0 m and 0.5 m, respectively. The layout of the experimental plot is shown in Figure 1.

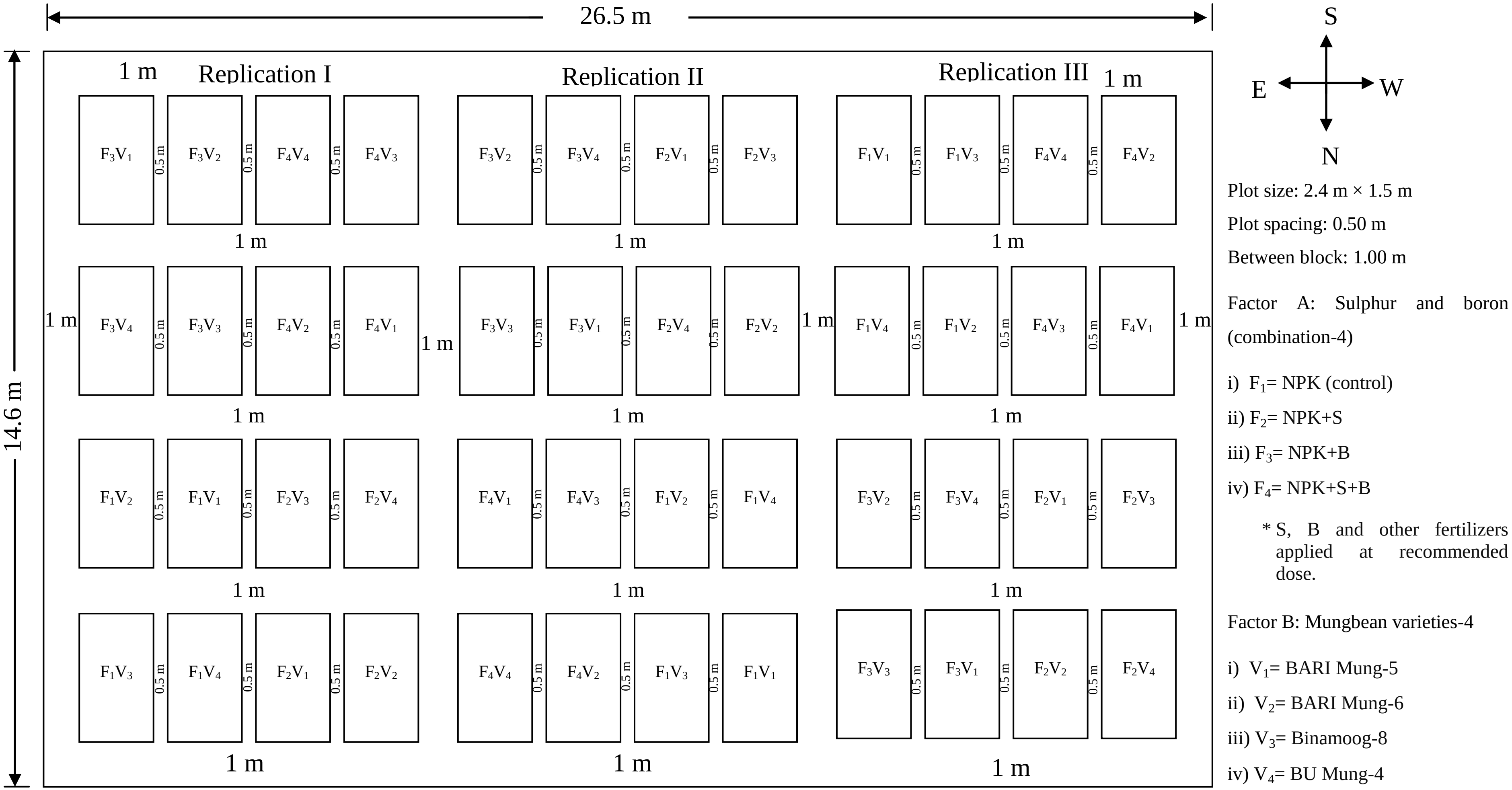


Figure 1. Layout of the experimental plot

3.3 Growing of crops

3.3.1 Sowing of seeds in the field

The seeds of mungbean were sown on March 23, 2014 in solid rows in the furrows having a depth of 2-3 cm with maintaining row to row distance 30 cm and plant to plant 10 cm.

3.3.2 Intercultural operations

3.3.2.1 Thinning

Seeds started germination of 4 Days after sowing (DAS). Thinning was done two times; first thinning was done at 10 DAS and second was done at 18 DAS to maintain optimum plant population in each plot.

3.3.2.2 Irrigation, drainage and weeding

Irrigation was provided before 15 and 30 DAS for optimizing the vegetative growth of mungbean for the all experimental plots equally. Proper drain also made for drained out excess water from irrigation and also rainfall from the experimental plot. The crop field was weeded at 15 and 30 DAS by hand weeding.

3.3.2.3 Plant protection measures

At early stage of growth few worms (*Agrotis ipsilon*) infested the young plants and at later stage of growth pod borer (*Maruca testulalis*) attacked the plant. Ripcord 10 EC was sprayed at the rate of 1 ml with 1 litre water to 5 decimal lands for two times at 15 days interval after seedlings germination to control the insects. Before sowing seeds were treated with Bavistin 50 WP to protect seed borne disease.

3.4 Crop sampling and data collection

Five plants from each treatment were randomly selected and marked with sample card. Plant height, number of branches and dry matter content plant^{-1} were recorded from selected plants at an interval of 15 days started from 15 DAS (days after sowing) and continued to 45 DAS and at harvest of pod. Number of nodules and dry weight of nodules plant^{-1} were recorded from selected plants at an interval of 15 days started from 15 DAS and continued to 45 DAS.

3.5 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 each plot.

3.6 Data collection

The following data were recorded

i. Plant height at 15, 30, 45 days after sowing (DAS) and at harvest
ii. Number of branches plant^{-1} at 15, 30, 45 DAS and at harvest
iii. Dry matter content plant^{-1} at 15, 30, 45 DAS and at harvest
iv. Number of nodules plant^{-1} at 15, 30 and 45 DAS
v. Dry weight of nodules plant^{-1} at 15, 30 and 45 DAS
vi. Number of plants m^{-2} at flowering stage
vii. Days to flowering
viii. Days to maturity
ix. Number of pods plant^{-1}
x. Pod length
xi. Number of seeds pod^{-1}
xii. Weight of 1000-seeds
xiii. Seed yield hectare^{-1}
xiv. Stover yield hectare^{-1}

3.7 Procedure of data collection

3.7.1 Plant height (cm)

The height of plant was recorded in centimeter (cm) at 15, 30, 45 DAS and at harvest. Data were recorded from 5 plants from each plot and average plant height plant^{-1} was recorded as per treatment. The height was measured from the ground level to the tip of the plant by a meter scale.

3.7.2 Number of branches plant^{-1}

The number of branches plant^{-1} was counted at 15, 30, 45 DAS and at harvest. Data were recorded from 5 plants from each plot and average number of branches plant^{-1} was recorded as per treatment.

3.7.3 Dry matter content plant^{-1}

Five plants were collected randomly from each plot at 15, 30, 45 DAS and at harvest. Fresh plant samples from each plot were put into envelop and placed in oven maintained at 70^{0}C for 72 hours. The sample was then transferred into desiccators and allowed to cool down at room temperature. The final dry weight of the sample was taken and recorded in gram.

3.7.4 Number of nodules plant^{-1}

Five plants from each plot was uprooted carefully with soil at 15, 30 and 45 DAS then washed out with water and make clean. The number of nodules plant^{-1} was observed and counted from each plot and average number of nodules plant^{-1} was recorded as per treatment.

3.7.5 Dry weight of nodules plant^{-1}

Nodules from five plants were collected randomly from each plot at 15, 30 and 45 DAS. Fresh nodules from each plot were put into envelop and placed in oven maintained at 70^{0}C for 72 hours. The sample was then transferred into desiccators and allowed to cool down at room temperature. The final dry weight of the sample was taken and recorded in gram.

3.7.6 Number of plants m^{-2} at flowering stage

Numbers of total plants m^{-2} was counted from each plot.

3.7.7 Days to flowering

Days to 1st flowering were recorded by counting the number of days required to start flower initiation of mungbean plant in each plot.

3.7.8 Days to maturity

Days to maturity were recorded by counting the number of days required to maturity of mungbean plant in each plot.

3.7.9 Number of pods plant^{-1}

Numbers of total pods of 10 plants from each plot were counted and the mean numbers were expressed as plant^{-1} basis.

3.7.10 Pod length

Pod length was taken from randomly selected 10 pods and the mean length was expressed on pod^{-1} basis.

3.7.11 Number of seeds pod^{-1}

The number of seeds pods^{-1} was recorded randomly from selected pods at the time of harvest. Data were recorded as the average of 10 pods from each plot.

3.7.12 Weight of 1000-seeds

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

3.7.13 Seed yield

The seeds collected from 3.6 (2.4 m ×1.5 m) square meter of each plot were sun dried properly. The weight of seeds was taken and converted the yield in t ha^{-1}.

3.7.14 Stover yield

The stover collected from 3.6 (2.4 m ×1.5 m) square meter of each plot was sun dried properly. The weight of stover was taken and converted the yield in t ha^{-1}.

3.8 Statistical analysis

The data obtained for different parameters were analyzed to find out the effect of sulphur and boron, and mungbean varieties. The mean values of all the characters were calculated and the analysis of variance (ANOVA) was performed by the 'F' (variance ratio) test using MSTAT-C software. The significance of the difference among the treatment means was estimated by the Duncan Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

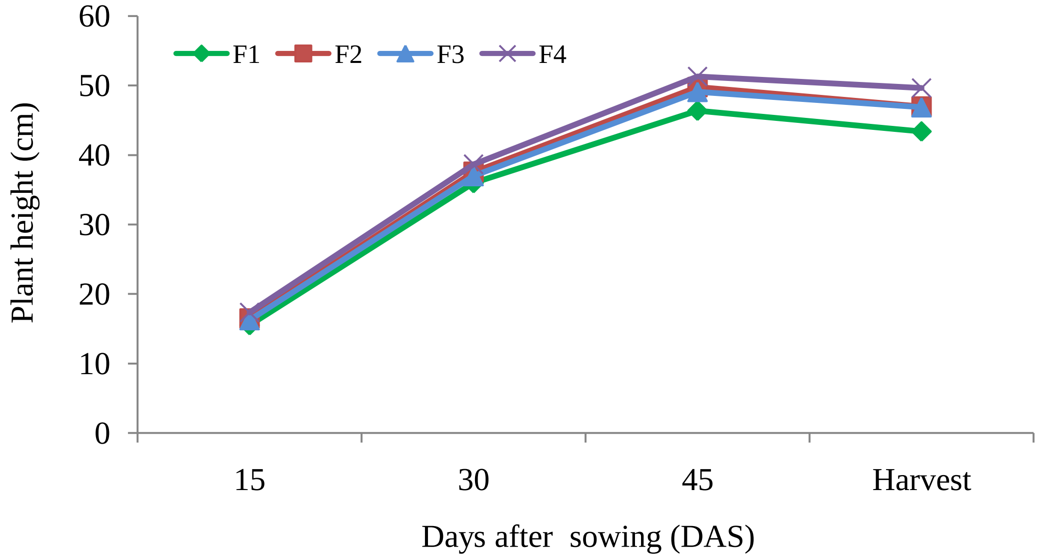
CHAPTER IV

RESULTS AND DISCUSSION

This chapter comprised presentation and discussion of the results obtained from the study on the effect of sulphur and boron on the growth and yield of mungbean varieties. The analyses of variance (ANOVA) of the data on different growth parameters and yield of mungbean are presented in Appendix III-IX. The results have been presented and discussed in the different tables and graphs and possible interpretations are given under the following headings:

4.1 Plant height

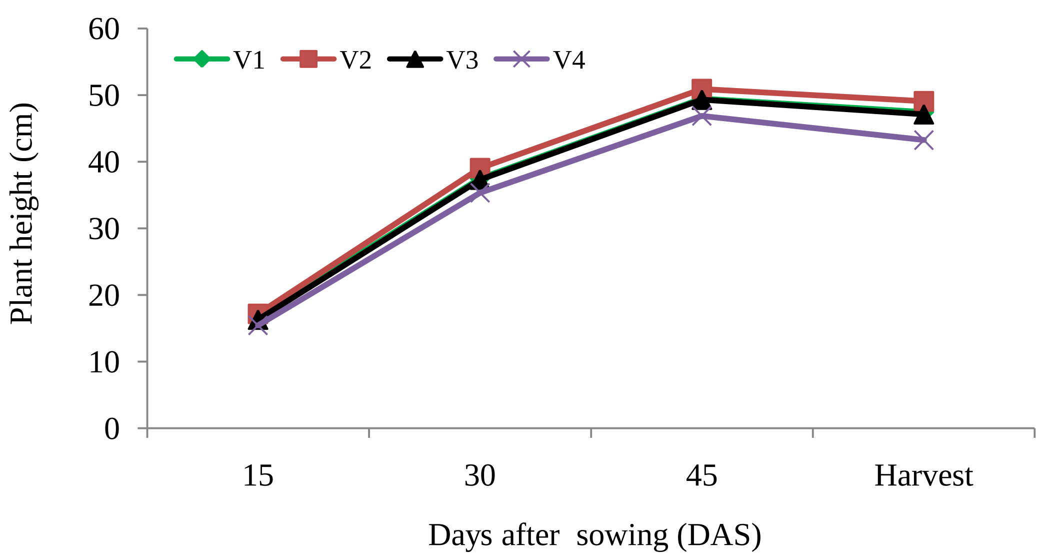
Plant height of mungbean at 15, 30, 45 DAS and at harvest showed statistically significant variation due to sulphur and boron (Appendix III). The tallest plant at the four stages (17.36, 38.66, 51.28 and 49.6 cm, respectively) was recorded from F_4 (NPK+S+B) which was statistically similar (16.47, 37.56, 49.78 and 46.97 cm, respectively) to F_2 (NPK+S) and followed (16.24, 36.97, 49.09 and 46.88 cm, respectively) by F_3 (NPK+B), while the shortest plant (15.52, 35.95, 46.36 and 43.38 cm, respectively) was observed from F_1 (NPK) at 15, 30, 45 DAS and at harvest (Figure 2). Generally plant height is a gentical characters and it is controlled by the genetic make up of the varieties. Sulphur (S) plays a remarkable role in protein metabolism and it help to synthesis of proteins, vitamins and chlorophyl and also S containing amino acids such as cystine, cysteine and methionine which leads to producing tallest plant. Boron also 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 which also helps to produced tallest plant (Lewis, 1980). Tripathi *et al*. (2012) reported that application of 45 kg S ha^{-1} recorded higher plant height as compared to control. Yadav (2007) reported that plant height increased with increasing rates of sulphur up to 40 kg ha^{-1}. Tahir *et al*. (2013) reported that boron at 4 kg ha^{-1} significantly increased plant height (58.30 cm).



F_1= NPK F_2= NPK+S

F_3= NPK+B F_4= NPK+S+B

Figure 2. Effect of sulphur and boron combination treatment on plant height of mungbean. (Sx = 0.331, 0.493, 0.838 and 1.153 for 15, 30, 45 DAS and at harvest).



V_1= BARI Mung-5 V_2= BARI Mung-6

V_3= Binamoog-8 V_4= BU Mung-4

Figure 3. Effect of different variety on plant height of mungbean ($S\bar{x}$ = 0.366, 0.810, 0.937 and 1.242 for 15, 30, 45 DAS and at harvest).

Statistically significant variation was recorded due to different variety of mungbean in terms of plant height at 15, 30, 45 DAS and at harvest (Appendix III). The tallest plant (17.16, 39.01, 50.89 and 49.05 cm, respectively) was found from V_2 (BARI Mung-6), which was statistically similar (16.66, 37.49, 49.44 and 47.43 cm, respectively) to V_1 (BARI Mung-5) and followed (16.31, 37.32, 49.33 and 47.14 cm, respectively) by V_3 (Binamoog-8), whereas the shortest plant (15.45, 35.32, 46.85 and 43.23 cm, respectively) was observed from V_4 (BU Mung-4) at 15, 30, 45 DAS and at harvest, respectively (Figure 3). Variety plays an important role in producing longest plant of mungbean because different varieties perform differently for their genotypic characters also vary from genotype to genotype. Quaderi *et al*. (2006) reported that BARI Mung-5 performed better than that of BARI Mung-4 in terms of plant height.

Interaction effect of sulphur and boron and mungbean varieties showed significant differences on plant height at 15, 30, 45 DAS and at harvest (Appendix III). The tallest plant (20.39, 43.77, 58.17 and 56.22 cm, respectively) was recorded from the treatment combination of F_4V_2 (NPK+S+B and BARI Mung-6), while the shortest plant (12.01, 31.38, 38.65 and 38.23 cm, respectively) was found from F_4V_4 (NPK+S+B and BU Mung-4) at 15, 30, 45 DAS and at harvest (Table 1).

4.2 Number of branches plant^{-1}

Number of branches plant^{-1} of mungbean at 15, 30, 45 DAS and at harvest showed statistically significant variation due to sulphur and boron (Appendix IV). The maximum number of branches plant^{-1} (1.68, 2.88, 4.07 and 4.48, respectively) was observed from F_4 which was statistically similar (1.60, 2.73, 3.88 and 4.08, respectively) to F_2 and closely followed (1.58, 2.75, 3.77 and 4.03, respectively) by F_3, whereas the minimum number of branches plant^{-1} (1.43, 2.52, 3.65 and 3.85, respectively) was found from F_1 at 15, 30, 45 DAS and at harvest (Figure 4). Tahir *et al*. (2013) reported that boron at 4 kg ha^{-1} significantly increased number of branches plant^{-1}.

Table 1. Interaction effect of sulphur and boron combination and different variety on plant height of mungbean

Treatment	Plant height (cm) at			
	15 DAS	30 DAS	45 DAS	Harvest
F_1V_1	15.20 c-e	35.24 b-d	41.59 de	40.82 de
F_1V_2	14.58 de	35.84 b-d	47.07 cd	43.47 c-e
F_1V_3	17.27 bc	37.94 bc	47.51 cd	43.74 c-e
F_1V_4	15.06 c-e	34.79 b-d	49.27 bc	45.47 b-e
F_2V_1	16.83 b-d	38.54 a-c	51.31 bc	48.35 a-d
F_2V_2	17.24 bc	39.68 a-c	50.37 bc	49.59 a-c
F_2V_3	15.05 c-e	37.18 bc	47.77 c	46.31b-e
F_2V_4	16.76 b-d	34.83 b-d	49.68 bc	43.61 c-e
F_3V_1	16.36 b-e	36.64 b-d	51.40 bc	48.97 a-d
F_3V_2	16.45 b-e	36.75 b-d	47.94 c	46.90 b-d
F_3V_3	14.14 e	34.21 cd	47.23 cd	46.05 b-e
F_3V_4	18.00 b	40.30 ab	49.78 bc	45.61 b-e
F_4V_1	18.23 ab	39.54 a-c	53.46 a-c	51.57 a-c
F_4V_2	20.39 a	43.77 a	58.17 a	56.22 a
F_4V_3	18.80 ab	39.96 ab	54.82 ab	52.47 ab
F_4V_4	12.01 f	31.38 d	38.65 e	38.23 e
$S\bar{x}$	0.732	1.621	1.874	2.484
CV(%)	7.73	7.53	6.61	9.21

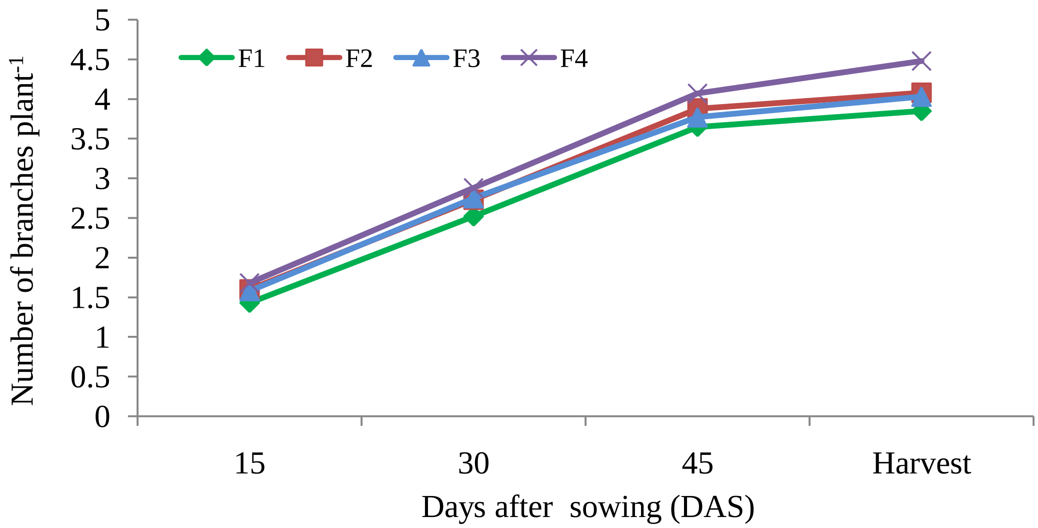
In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

F_1= NPK | V_1= BARI Mung-5

F_2= NPK+S | V_2= BARI Mung-6

F_3= NPK+B | V_3= Binamoog-8

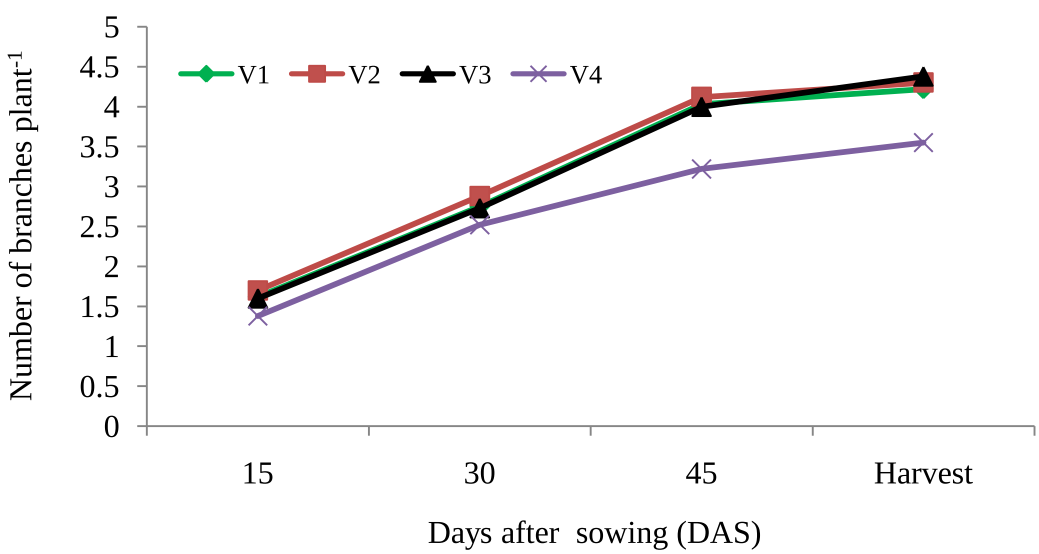
F_4= NPK+S+B | V_4= BU Mung-4



F_1= NPK F_2= NPK+S

F_3= NPK+B F_4= NPK+S+B

Figure 4. Effect of sulphur and boron combination treatment on number of branches plant^{-1} of mungbean. (Sx= 0.034, 0.033, 0.064 and 0.072 for 15, 30, 45 DAS and at harvest).



V_1= BARI Mung-5 V_2= BARI Mung-6

V_3= Binamoog-8 V_4= BU Mung-4

Figure 5. Effect of different variety on number of branches plant^{-1} of mungbean (Sx = 0.028, 0.035, 0.060 and 0.060 for 15, 30, 45 DAS and at harvest).

Statistically significant variation was recorded due to different variety of mungbean in terms of number of branches plant^{-1} at 15, 30, 45 DAS and at harvest (Appendix IV). The maximum number of branches plant^{-1} (1.70, 2.88, 4.12 and 4.30, respectively) was recorded from V_2, which was statistically similar (1.62, 2.75, 4.03 and 4.22, respectively) to V_1 and closely followed (1.60, 2.73, 4.00 and 4.38, respectively) by V_3, while the minimum number of branches plant^{-1} (1.38, 2.52, 3.22 and 3.55, respectively) was observed from V_4 at 15, 30, 45 DAS and at harvest, respectively (Figure 5). Islam *et al*. (2006) reported from their earlier experiment that Binamoog-5 performed better than that of Binamoog-2 and Binamoog-4.

Interaction effect of sulphur and boron and mungbean varieties showed significant differences on number of branches plant^{-1} at 15, 30, 45 DAS and at harvest (Appendix IV). The maximum number of branches plant^{-1} (1.93, 3.20, 4.53 and 4.93, respectively) was recorded from the treatment combination of F_4V_2 and the minimum number of branches plant^{-1} (1.20, 2.27, 3.13 and 3.53, respectively) was recorded from F_1V_4 at 15, 30, 45 DAS and at harvest (Table 2).

4.3 Dry matter content plant^{-1}

Dry matter content plant^{-1} of mungbean at 15, 30, 45 DAS and at harvest showed statistically significant variation due to sulphur and boron treatment (Appendix V). The highest dry matter content plant^{-1} (1.66, 4.53, 6.20 and 7.75 g, respectively) was observed from F_4 which was statistically similar (1.57, 4.27, 6.05 and 7.50 g, respectively) to F_2 and followed (1.56, 4.22, 5.93 and 7.40 g, respectively) by F_3 and the lowest dry matter content plant^{-1} (1.49, 4.03, 5.45 and 6.91 g, respectively) was observed from F_1 at 15, 30, 45 DAS and at harvest (Figure 6). Tripathi *et al*. (2012) reported that application of 45 kg S ha^{-1} recorded higher dry matter accumulation as compared to control. Tahir *et al*. (2013) reported that boron at 4 kg ha^{-1} significantly increased dry matter content plant^{-1} in mungbean (13.33).

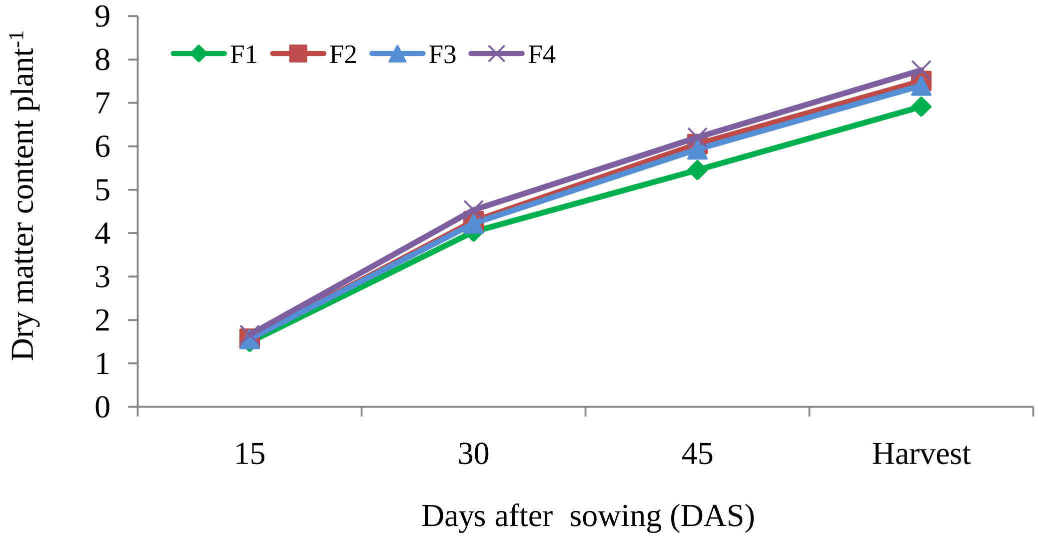
Table 2. Interaction effect of sulphur and boron combination and different variety on number of branches plant^{-1} of mungbean

Treatment	Number of branches plant^{-1} at			
	15 DAS	30 DAS	45 DAS	Harvest
F_1V_1	1.53 c-e	2.53 e	3.73 de	3.60 e
F_1V_2	1.53 c-e	2.67 c-e	3.93 cd	3.80 de
F_1V_3	1.47 de	2.60 de	3.73 de	4.40 bc
F_1V_4	1.20 f	2.27 f	3.13 f	3.53 e
F_2V_1	1.67 bc	2.73 b-e	4.13 b-d	4.33 c
F_2V_2	1.67 bc	2.80 b-d	4.07 b-d	4.27 c
F_2V_3	1.67 bc	2.80 b-d	3.93 cd	4.13 cd
F_2V_4	1.40 e	2.60 de	3.40 ef	3.60 e
F_3V_1	1.60 b-d	2.80 b-d	4.00 b-d	4.20 c
F_3V_2	1.67 bc	2.87 bc	3.93 cd	4.20 c
F_3V_3	1.53 c-e	2.67 c-e	4.00 b-d	4.27 c
F_3V_4	1.53 c-e	2.67 c-e	3.13 f	3.47 e
F_4V_1	1.67 bc	2.93 b	4.27 a-c	4.73 ab
F_4V_2	1.93 a	3.20 a	4.53 a	4.93 a
F_4V_3	1.73 b	2.87 bc	4.33 ab	4.73 ab
F_4V_4	1.40 e	2.53 e	3.20 f	3.60 e
$S\bar{x}$	0.055	0.069	0.120	0.119
CV(%)	6.08	4.42	5.42	5.01

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

F_1= NPK
F_2= NPK+S
F_3= NPK+B
F_4= NPK+S+B

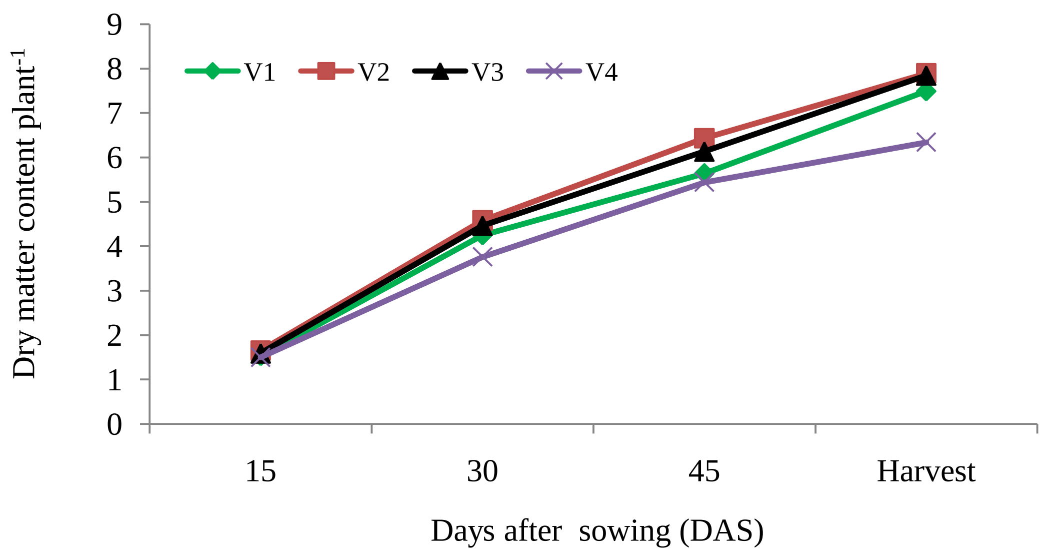
V_1= BARI Mung-5
V_2= BARI Mung-6
V_3= Binamoog-8
V_4= BU Mung-4



F_1= NPK F_2= NPK+S

F_3= NPK+B F_4= NPK+S+B

Figure 6. Effect of sulphur and boron treatment combination on dry matter content plant^{-1} of mungbean. (Sx = 0.031, 0.093, 0.133 and 0.133 for 15, 30, 45 DAS and at harvest).



V_1= BARI Mung-5 V_2= BARI Mung-6

V_3= Binamoog-8 V_4= BU Mung-4

Figure 7. Effect of different variety on dry matter content plant^{-1}of mungbean (Sx = 0.032, 0.055, 0.092 and 0.101 for 15, 30, 45 DAS and at harvest).

Significant differences was observed due to different variety of mungbean in terms of dry matter content plant^{-1} at 15, 30, 45 DAS and at harvest (Appendix V). The highest dry matter content plant^{-1} (1.65, 4.58, 6.43 and 7.89 g, respectively) was found from V_2, which was statistically similar (1.59, 4.46, 6.13 and 7.44 g, respectively) to V_3 and followed (1.53, 4.25, 5.64 and 7.49 g, respectively) by V_1, while the lowest dry matter content plant^{-1} (1.50, 3.76, 5.44 and 6.34 g, respectively) from V_4 at 15, 30, 45 DAS and at harvest, respectively (Figure 7).

Interaction effect of sulphur and boron combination and mungbean varieties showed significant differences on dry matter content plant^{-1} at 15, 30, 45 DAS and at harvest (Appendix V). The highest dry matter content plant^{-1} (1.89, 5.16, 6.60 and 8.80 g, respectively) was recorded from the treatment combination of F_4V_2, whereas the lowest dry matter content plant^{-1} (1.31, 3.36, 4.92 and 5.60 g, respectively) was recorded from F_4V_4 at 15, 30, 45 DAS and at harvest (Table 3).

4.4 Number of nodules plant^{-1}

Number of nodules plant^{-1} of mungbean at 15, 30 and 45 DAS showed statistically significant variation due to sulphur and boron (Appendix VI). The highest number of nodules plant^{-1} (93.73, 152.38 and 217.77, respectively) was recorded from F_4 which was statistically similar (91.30, 146.93 and 212.82, respectively) to F_2 and followed (91.03, 146.33 and 212.22, respectively) by F_3, whereas the lowest number (87.18, 140.00 and 204.17, respectively) observed from F_1 at 15, 30 and 45 DAS (Table 4). Tripathi *et al*. (2012) reported that application of 45 kg S ha^{-1} recorded higher nodule numbers as compared to control.

Statistically significant variation was found due to different variety of mungbean in terms of number of nodules plant^{-1} at 15, 30 and 45 DAS (Appendix VI). The highest number of nodules plant^{-1} (93.78, 149.03 and 215.68, respectively) was found from V_3, which was statistically similar (91.02, 148.17 and 213.95, respectively) to V_2 and followed (90.18, 146.92 and 211.42, respectively) by V_1, while the lowest number (88.27, 141.53 and 205.92, respectively) was observed from V_4 at 15, 30 and 45 DAS, respectively (Table 4).

Table 3. Interaction effect of sulphur and boron combination and different variety on dry matter content plant^{-1} of mungbean

Treatment	Dry matter content plant^{-1} (g) at			
	15 DAS	30 DAS	45 DAS	Harvest
F_1V_1	1.58 c-e	3.91 hi	5.18 ef	6.66 hi
F_1V_2	1.48 d-g	4.05 f-i	5.72 de	6.86 gh
F_1V_3	1.54 c-f	4.35 c-f	5.98 cd	7.46 d-g
F_1V_4	1.31 g	3.36 j	4.92 f	5.60 j
F_2V_1	1.59 c-e	4.23 e-h	5.52 de	7.90 b-d
F_2V_2	1.63 cd	4.63 b-d	7.05 a	8.10 b-d
F_2V_3	1.45 d-g	4.27 d-h	6.12 b-d	7.90 b-d
F_2V_4	1.58 c-e	3.95 g-i	5.52 de	6.10 ij
F_3V_1	1.67 b-d	4.19 e-h	5.80 cd	7.20 e-h
F_3V_2	1.59 c-e	4.49 c-e	6.33 bc	7.80 b-e
F_3V_3	1.35 fg	4.29 d-g	5.80 cd	7.60 c-f
F_3V_4	1.71 a-c	3.93 hi	5.80 cd	7.00 f-h
F_4V_1	1.53 c-f	4.67 bc	6.07 b-d	8.20 a-c
F_4V_2	1.89 a	5.16 a	6.60 ab	8.80 a
F_4V_3	1.83 ab	4.91 ab	6.60 ab	8.40 ab
F_4V_4	1.38 e-g	3.80 i	5.53 de	6.66 hi
$S\bar{x}$	0.064	0.110	0.183	0.202
CV(%)	7.09	4.46	5.37	4.74

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

F_1= NPK	V_1= BARI Mung-5
F_2= NPK+S	V_2= BARI Mung-6
F_3= NPK+B	V_3= Binamoog-8
F_4= NPK+S+B	V_4= BU Mung-4

Table 4. Effect of sulphur and boron combination and different variety on number of nodules plant^{-1} of mungbean

Treatment	Number of nodule plant^{-1} at		
	15 DAS	30 DAS	45 DAS
Sulphur and boron			
F_1	87.18 b	140.00 c	204.17 c
F_2	91.30 a	146.93 b	212.82 b
F_3	91.03 a	146.33 b	212.22 b
F_4	93.73 a	152.38 a	217.77 a
$S\bar{x}$	1.107	1.020	0.920
CV(%)	4.22	2.41	1.50
Different variety			
V_1	90.18 b	146.92 a	211.42 a
V_2	91.02 ab	148.17 a	213.95 a
V_3	93.78 a	149.03 a	215.68 a
V_4	88.27 b	141.53 b	205.92 b
$S\bar{x}$	1.171	1.557	1.497
CV(%)	4.47	3.68	2.45

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

F_1= NPK
F_2= NPK+S
F_3= NPK+B
F_4= NPK+S+B

V_1= BARI Mung-5
V_2= BARI Mung-6
V_3= Binamoog-8
V_4= BU Mung-4

Interaction effect of sulphur and boron combination and mungbean varieties showed significant differences on number of nodules plant^{-1} at 15, 30 and 45 DAS (Appendix VI). The highest number of nodules plant^{-1} (97.40, 157.33 and 225.00, respectively) was recorded from the treatment combination of F_4V_3 and the lowest number of nodules plant^{-1} (83.87, 136.40 and 199.87, respectively) was recorded from F_1V_1 at 15, 30 and 45 DAS (Table 5).

4.5 Dry weight of nodules plant^{-1}

Dry weight of nodules plant^{-1}of mungbean at 15, 30 and 45 DAS showed statistically significant variation due to sulphur and boron (Appendix VII). The highest dry weight of nodules plant^{-1} (0.014, 0.150 and 0.333 g, respectively) was found from F_4 which was statistically similar (0.013, 0.145 and 0.314 g, respectively) to F_2 and followed (0.013, 0.138 and 0.307 g, respectively) by F_3, while the lowest dry weight of nodules plant^{-1} (0.011, 0.123 and 0.272 g, respectively) was observed from F_1 at 15, 30 and 45 DAS (Table 6). Tripathi *et al.* (2012) reported higher dry matter accumulation as compared to control by the application of 45 kg S ha^{-1}.

Statistically significant variation was observed due to different variety of mungbean in terms of dry weight of nodules plant^{-1} at 15, 30 and 45 DAS (Appendix VII). The highest dry weight of nodules plant^{-1} (0.014, 0.152 and 0.332 g, respectively) was found from V_3, which was statistically similar (0.014, 0.145 and 0.326 g, respectively) to V_2 and followed (0.013, 0.137 and 0.317 g, respectively) by V_1, whereas the lowest dry weight (0.011, 0.121 and 0.250 g, respectively) was observed from V_4 at 15, 30 and 45 DAS, respectively (Table 6).

Interaction effect of sulphur and boron and mungbean varieties showed significant differences on dry weight of nodules plant^{-1} at 15, 30 and 45 DAS (Appendix VII). The tallest dry weight of nodules plant^{-1} (0.016, 0.178 and 0.382 g, respectively) was recorded from the treatment combination of F_4V_3, while the lowest dry weight of nodules plant^{-1} (0.010, 0.108 and 0.241 g) was found from F_4V_4 at 15, 30 and 45 DAS (Table 7).

Table 5. Interaction effect of sulphur and boron combination and different variety on number of nodules plant^{-1} of mungbean

Treatment	Number of nodule plant^{-1} at		
	15 DAS	30 DAS	45 DAS
F_1V_1	83.87 c	136.40 f	199.87 f
F_1V_2	87.47 bc	142.13 c-f	208.53 c-f
F_1V_3	90.53 a-c	138.53 ef	203.53 ef
F_1V_4	86.87 bc	142.93 c-f	204.73 d-f
F_2V_1	90.20 a-c	148.93 a-e	213.13 b-e
F_2V_2	92.07 ab	149.27 a-d	214.40 b-d
F_2V_3	93.87 ab	150.47 a-c	217.07 a-c
F_2V_4	89.07 bc	139.07 d-f	206.67 d-f
F_3V_1	90.47 a-c	147.47 a-e	213.13 b-e
F_3V_2	90.67 a-c	146.40 b-f	212.80 b-e
F_3V_3	93.33 ab	149.80 a-c	217.13 a-c
F_3V_4	89.67 a-c	141.67 c-f	205.80 d-f
F_4V_1	93.20 ab	154.87 ab	219.53 ab
F_4V_2	93.87 ab	154.87 ab	220.07 ab
F_4V_3	97.40 a	157.33 a	225.00 a
F_4V_4	90.47 a-c	142.47 c-f	206.47 d-f
$S\bar{x}$	2.342	3.114	2.994
CV(%)	4.47	3.68	2.45

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

F_1= NPK
F_2= NPK+S
F_3= NPK+B
F_4= NPK+S+B

V_1= BARI Mung-5
V_2= BARI Mung-6
V_3= Binamoog-8
V_4= BU Mung-4

Table 6. Effect of sulphur and boron combination and different variety on dry weight of nodules plant^{-1} of mungbean

Treatment	Dry weight of nodules plant^{-1} (g) at		
	15 DAS	30 DAS	45 DAS
Sulphur and boron			
F_1	0.011 c	0.123 c	0.272 b
F_2	0.013 ab	0.145 ab	0.314 a
F_3	0.013 b	0.138 b	0.307 a
F_4	0.014 a	0.150 a	0.333 a
$S\bar{x}$	0.0002	0.003	0.007
CV(%)	7.69	7.19	10.33
Different variety			
V_1	0.013 b	0.137 b	0.317 a
V_2	0.014 a	0.145 ab	0.326 a
V_3	0.014 a	0.152 a	0.332 a
V_4	0.011 c	0.121 c	0.250 b
$S\bar{x}$	0.0001	0.004	0.008
CV(%)	3.95	10.51	9.51

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

F_1= NPK
F_2= NPK+S
F_3= NPK+B
F_4= NPK+S+B

V_1= BARI Mung-5
V_2= BARI Mung-6
V_3= Binamoog-8
V_4= BU Mung-4

Table 7. Interaction effect of sulphur and boron combination and different variety on dry weight of nodules plant^{-1} of mungbean

Treatment	Dry weight of nodules plant^{-1} (g) at		
	15 DAS	30 DAS	45 DAS
F_1V_1	0.011 fg	0.117 fg	0.250 e
F_1V_2	0.013 c-e	0.120 e-g	0.301 c-e
F_1V_3	0.013 c-e	0.130 ef	0.267 de
F_1V_4	0.011 fg	0.124 e-g	0.270 de
F_2V_1	0.013 cd	0.139 c-e	0.331 a-c
F_2V_2	0.014 a-d	0.167 ab	0.340 a-c
F_2V_3	0.013 cd	0.151 b-d	0.341 a-c
F_2V_4	0.012 d-f	0.122 e-g	0.243 e
F_3V_1	0.013 c-e	0.139 c-e	0.321 b-d
F_3V_2	0.014 b-d	0.133 d-f	0.321 b-d
F_3V_3	0.013 cd	0.150 b-d	0.339 a-c
F_3V_4	0.011 e-g	0.130 ef	0.248 e
F_4V_1	0.014 a-c	0.155 bc	0.364 ab
F_4V_2	0.016 ab	0.160 b	0.343 a-c
F_4V_3	0.016 a	0.178 a	0.382 a
F_4V_4	0.010 g	0.108 g	0.241 e
$S\bar{x}$	0.0003	0.008	0.017
CV(%)	3.95	10.51	9.51

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

F_1= NPK
F_2= NPK+S
F_3= NPK+B
F_4= NPK+S+B

V_1= BARI Mung-5
V_2= BARI Mung-6
V_3= Binamoog-8
V_4= BU Mung-4

4.6 Number of plants m^{-2} at flowering stage

Number of plants m^{-2} at flowering stage showed statistically significant variation due to sulphur and boron treatment (Appendix VIII). The highest number of plants m^{-2} at flowering stage (26.75) was recorded from F_4 which was statistically similar (26.50 and 26.17) to F_2 and F_3, whereas the lowest number of plants m^{-2} at flowering stage (24.33) was observed from F_1 (Figure 8).

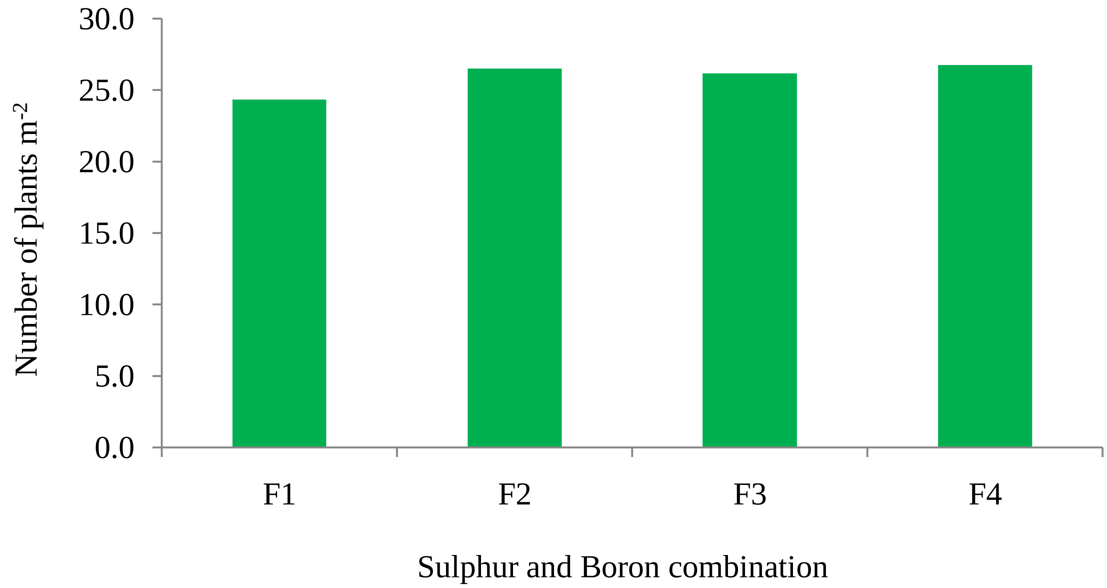
Statistically significant variation was recorded due to different variety of mungbean in terms of number of plants m^{-2} at flowering stage (Appendix VIII). The highest number of plants m^{-2} at flowering stage (26.92) was found from V_3, which was statistically similar (26.92) to V_3 and closely followed (25.50) by V_1, while the lowest number of plants m^{-2} at flowering stage (24.58) was found from V_4 (Figure 9).

Interaction effect of sulphur and boron and mungbean varieties showed significant differences on number of plants m^{-2} at flowering stages (Appendix VIII). The highest number of plants m^{-2} at flowering stage (29.00) was recorded from the treatment combination of F_4V_2, whereas the lowest number of plants m^{-2} at flowering stage (22.67) was recorded from F_4V_4 (Figure 10).

4.7 Days to flowering

Days to flowering of mungbean showed statistically significant variation due to sulphur and boron (Appendix VIII). The maximum days to flowering (39.00) was observed from F_1 which was statistically similar (37.92) to F_3 and followed (37.50) by F_2 and the minimum days to flowering (35.33) was observed from F_4 (Table 8).

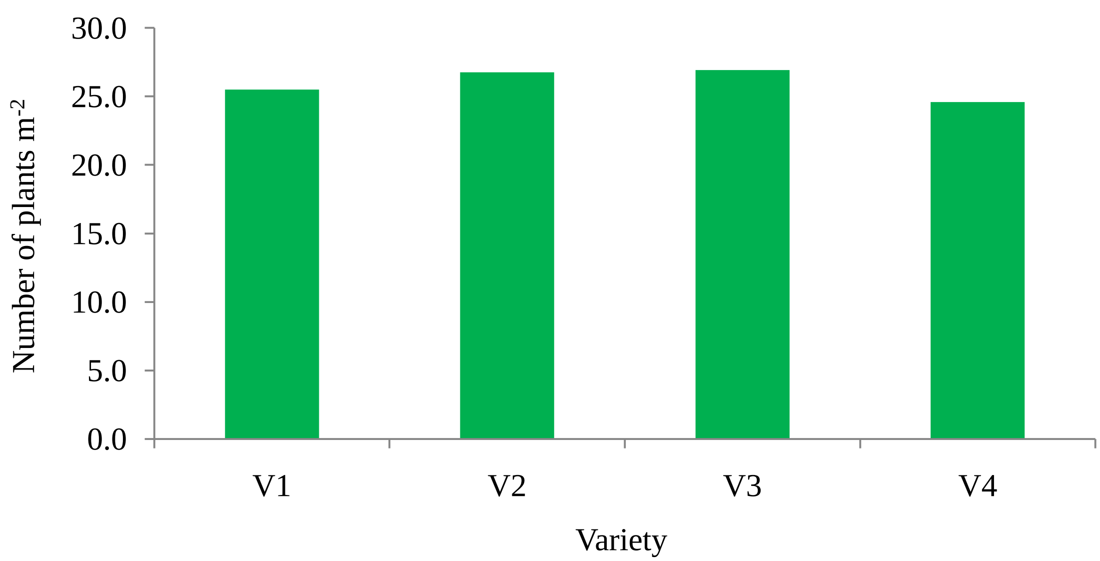
Statistically significant variation was recorded due to different variety of mungbean in terms of days to flowering (Appendix VIII). The maximum days to flowering (40.25) was found from V_4, which was statistically similar (38.25) to V_1. On the other hand, the minimum days to flowering (35.42) was observed from V_2 which was statistically similar (35.83) to V_3 (Table 8).



F_1= NPK F_2= NPK+S

F_3= NPK+B F_4= NPK+S+B

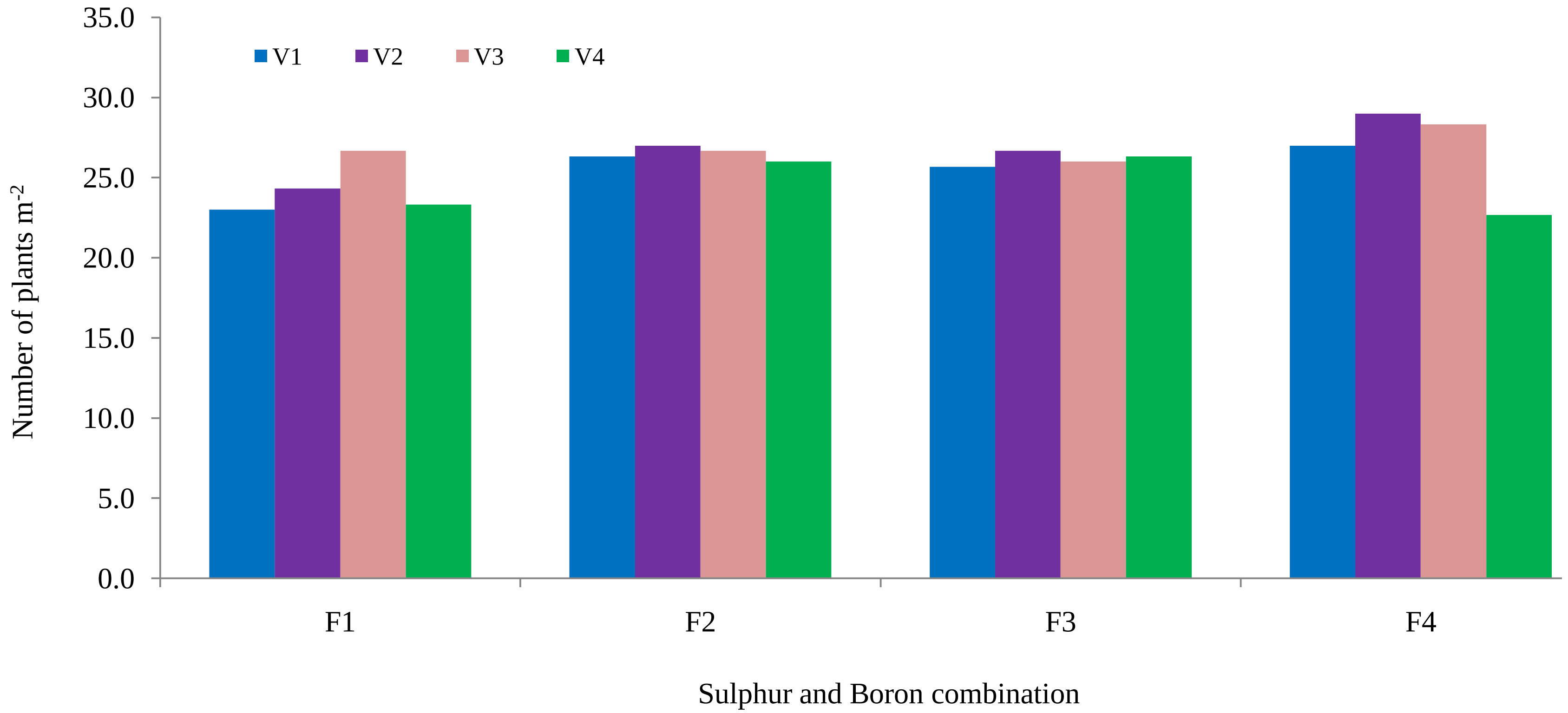
Figure 8. Effect of sulphur and boron combination on number of plants m^{-2} at flowering stage ($S\bar{x}$ = 0.348).



V_1= BARI Mung-5 V_2= BARI Mung-6

V_3= Binamoog-8 V_4= BU Mung-4

Figure 9. Effect of different variety on number of plants m^{-2} at flowering stage ($S\bar{x}$ = 0.436).



F_1= NPK F_2= NPK+S V_1= BARI Mung-5 V_2= BARI Mung-6

F_3= NPK+B F_4= NPK+S+B V_3= Binamoog-8 V_4= BU Mung-4

Figure 10. Interaction effect of sulphur and boron combination and different variety on number of plants m^{-2} at flowering stage (S$\bar{x}$ = 0.873).

Table 8. Effect of sulphur and boron combination and different variety on days to flowering, days to maturity, number of pods plant^{-1} and pod length of mungbean

Treatment	Days to flowering	Days to maturity	Pods plant^{-1} (No.)	Pod length (cm)
Sulphur and boron				
F_1	39.00 a	67.92 a	32.68 b	7.88 b
F_2	37.50 ab	65.67 ab	33.51 b	8.09 ab
F_3	37.92 a	67.00 ab	33.28 b	8.01 b
F_4	35.33 b	64.75 b	34.35 a	8.55 a
$S\bar{x}$	0.720	0.766	0.233	0.133
CV(%)	6.66	4.01	2.41	5.65
Different variety				
V_1	38.25 a	66.92 b	33.25 b	8.11 b
V_2	35.42 b	64.33 c	34.63 a	8.54 a
V_3	35.83 b	64.83 c	35.23 a	8.56 a
V_4	40.25 a	69.25 a	30.71 c	7.31 c
$S\bar{x}$	0.812	0.712	0.343	0.098
CV(%)	7.52	3.72	3.55	4.16

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

F_1= NPK

F_2= NPK+S

F_3= NPK+B

F_4= NPK+S+B

V_1= BARI Mung-5

V_2= BARI Mung-6

V_3= Binamoog-8

V_4= BU Mung-4

Interaction effect of sulphur and boron and mungbean varieties showed significant differences on days to flowering (Appendix VIII). The maximum days to flowering (43.00) was recorded from the treatment combination of F_3V_4, whereas the minimum days to flowering (31.67) was found from F_4V_1 (Table 9).

4.8 Days to maturity

Statistically significant variation was observed in terms of days to maturity due to sulphur and boron (Appendix VIII). The maximum days to maturity (67.92) was found from F_1 which was statistically similar (67.00 and 65.67) to F_3 and F_2, while the minimum days to maturity (64.75) from F_4 (Table 8). Tripathi *et al*. (2012) reported that application of 45 kg S ha^{-1} recorded increased days to maturity.

Statistically significant variation was recorded due to different variety of mungbean in terms of days to maturity (Appendix VIII). The maximum days to maturity (69.25) was found from V_4, which was closely followed (66.92) by V_1, whereas the minimum days to maturity (64.33) was observed from V_2 which was statistically similar (64.83) to V_3 (Table 8).

Interaction effect of sulphur and boron and mungbean varieties showed significant differences on days to maturity (Appendix VIII). The maximum days to maturity (72.00) was observed from the treatment combination of F_3V_4, while the minimum days to maturity (60.33) was recorded from F_4V_1 (Table 9).

4.9 Number of pods plant^{-1}

Number of pods plant^{-1} showed statistically significant variation due to sulphur and boron (Appendix VIII). The maximum number pods plant^{-1} (34.35) was recorded from F_4, whereas the minimum number of pods plant^{-1} (32.68) was observed from F_1 which was statistically similar (33.28 and 33.51) to F_3 and F_2 (Table 8). Dey and Basu (2009) reported that yield components i.e. number of pods plant^{-1} increased with increasing rates of sulphur. Tahir *et al*. (2013) reported that boron at 4 kg ha^{-1} significantly increased number of pods plant^{-1} (21.33).

Table 9. Interaction effect of sulphur and boron combination and different variety on days to flowering, days to maturity, number of pods plant^{-1} and pod length of mungbean

Treatment	Days to flowering	Days to maturity	Pods plant^{-1} (No.)	Pod length (cm)
F_1V_1	40.00 a-c	69.00 ab	32.00 e-g	7.73 d-f
F_1V_2	35.33 c-f	64.00 c-f	33.87 c-e	7.90 c-f
F_1V_3	38.00 a-e	67.00 b-e	35.53 a-c	8.48 bc
F_1V_4	42.67 a	71.67 a	29.33 h	7.42 f
F_2V_1	40.33 a-c	68.67 a-c	33.53 c-e	7.85 c-f
F_2V_2	35.00 c-f	62.67 ef	33.60 c-e	8.46 bc
F_2V_3	35.00 c-f	63.33 d-f	34.40 b-d	8.47 bc
F_2V_4	39.67 a-d	68.00 a-d	32.50 d-f	7.59 ef
F_3V_1	41.00 ab	69.67 ab	33.07 d-f	7.97 c-f
F_3V_2	34.33 d-f	64.00 c-f	34.80 a-d	8.37 b-d
F_3V_3	33.33 ef	62.33 ef	34.27 b-e	8.15 c-e
F_3V_4	43.00 a	72.00 a	31.00 f-h	7.53 ef
F_4V_1	31.67 f	60.33 f	34.40 b-d	8.90 ab
F_4V_2	37.00 b-f	66.67 b-e	36.27 ab	9.45 a
F_4V_3	37.00 b-f	66.67 b-e	36.73 a	9.16 a
F_4V_4	35.67 b-f	65.33 b-e	30.00 gh	6.69 g
$S\bar{x}$	1.625	1.423	0.686	0.195
CV(%)	7.52	3.72	3.55	4.16

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

F_1= NPK

F_2= NPK+S

F_3= NPK+B

F_4= NPK+S+B

V_1= BARI Mung-5

V_2= BARI Mung-6

V_3= Binamoog-8

V_4= BU Mung-4

Statistically significant variation was found due to different variety of mungbean in terms of number of pods plant^{-1} (Appendix VIII). The maximum number of pods plant^{-1} (35.23) was found from V_3, which was statistically similar (34.63) to V_2, while the minimum number of pods plant^{-1} (30.71) was observed from V_4 which was closely followed (33.25) by V_1 (Table 8). Quaderi *et al*. (2006) reported that BARI Mung-5 performed better than that of BARI Mung-4 in terms of number of pods plant^{-1}.

Interaction effect of sulphur and boron and mungbean varieties showed significant differences on number of pods plant^{-1} (Appendix VIII). The maximum number of pods plant^{-1} (36.73) was recorded from the treatment combination of F_4V_3 and the minimum number of pods plant^{-1} (29.33) was recorded from F_1V_4 (Table 9).

4.10 Pod length

Pod length of mungbean showed statistically significant variation due to sulphur and boron (Appendix VIII). The longest pod (8.55 cm) was observed from F_4 which was statistically similar (8.09 cm) to F_2, while the shortest pod (7.88 cm) was observed from F_1 which was statistically similar (8.01 cm) to F_3 (Table 8).

Statistically significant variation was recorded due to different variety of mungbean in terms of pod length (Appendix VIII). The longest pod (8.56 cm) was found from V_3, which was statistically similar (8.54 cm) to V_2, whereas the shortest pod (7.31 cm) was observed from V_4 which was closely followed (8.11 cm) by V_3 (Table 8). Islam *et al*. (2006) reported that Binamoog-5 performed better than that of Binamoog-2 and Binamoog-4.

Interaction effect of sulphur and boron and mungbean varieties showed significant differences on pod length (Appendix VIII). The longest pod (9.45 cm) was found from the treatment combination of F_4V_2, while the shortest pod (6.69 cm) was recorded from F_4V_4 (Table 9).

4.11 Number of seeds pod^{-1}

Number of seeds pod^{-1} of mungbean showed statistically significant variation due to sulphur and boron combination treatments (Appendix IX). The maximum number of seeds pod^{-1} (11.99) was found from F_4. On the other hand, the minimum number (10.61) was observed from F_1 which was statistically similar (10.82) to F_2 F_3 (Table 10). Dey and Basu (2009) reported that yield components i.e. number of seeds pod^{-1} increased with increasing rates of sulphur.

Statistically significant variation was observed due to different variety of mungbean in terms of number of seeds pod^{-1} (Appendix IX). The maximum number of seeds pod^{-1} (11.68) was found from V_3, which was statistically similar (11.53) to V_2, while the minimum number of seeds pod^{-1} (10.20) was observed from V_4 (Table 10).

Interaction effect of sulphur and boron combination and mungbean varieties varied significantly on number of seeds pod^{-1} (Appendix IX). The maximum number of seeds pod^{-1} (12.93) was found from the treatment combination of F_4V_3, whereas the minimum number (10.07) was found from F_1V_4 (Table 11).

4.12 Weight of 1000 seeds

Weight of 1000 seeds of mungbean showed statistically significant variation due to sulphur and boron combination treatment (Appendix IX). The highest weight of 1000 seeds (41.72 g) was recorded from F_4, while the lowest weight of 1000 seeds (38.68 g) was found from F_1 which was statistically similar (39.12 g and 39.60 g) to F_3 and F_2 (Table 10). Dey and Basu (2009) reported that yield components i.e. 1000-seed weight increased with increasing rates of sulphur. Tahir *et al*. (2013) reported that boron at 4 kg ha^{-1} significantly increased 1000-seed weight (35 g).

Significant variation was observed due to different variety of mungbean in terms of weight of 1000 seeds (Appendix IX). The highest weight of 1000 seeds (41.63 g) was found from V_3, which was statistically similar (41.53 g and 39.79 g) to V_2 and V_1, whereas the lowest weight (36.17 g) from V_4 (Table 10).

Table 10. Effect of sulphur and boron combination and different variety on number of seeds pod^{-1}, weight of 1000 seeds, seed ayield nd stover yield of mungbean

Treatment	Seeds pod^{-1} (No.)	Weight of 1000 seeds (g)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})
Sulphur and boron				
F_1	10.61 b	38.68 b	1.57 b	2.36 c
F_2	10.82 b	39.60 b	1.64 ab	2.49 ab
F_3	10.82 b	39.12 b	1.63 ab	2.45 b
F_4	11.99 a	41.72 a	1.69 a	2.56 a
$S\bar{x}$	0.162	0.371	0.020	0.025
CV(%)	5.09	3.23	4.33	3.31
Different variety				
V_1	10.83 b	39.79 a	1.67 b	2.54 b
V_2	11.53 a	41.53 a	1.74 ab	2.62 a
V_3	11.68 a	41.63 a	1.79 a	2.52 b
V_4	10.20 c	36.17 b	1.33 c	2.17 c
$S\bar{x}$	0.123	0.797	0.025	0.026
CV(%)	3.87	6.94	5.29	3.61

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

F_1= NPK

F_2= NPK+S

F_3= NPK+B

F_4= NPK+S+B

V_1= BARI Mung-5

V_2= BARI Mung-6

V_3= Binamoog-8

V_4= BU Mung-4

Table 11. Interaction effect of sulphur and boron combination and different variety on number of seeds pod^{-1}, weight of 1000 seeds, seed yield and stover yield of mungbean

Treatment	Seeds pod^{-1} (No.)	Weight of 1000 seeds (g)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})
F_1V_1	10.23 f	35.50 d-f	1.50 e	2.28 ef
F_1V_2	11.30 d	41.10 a-c	1.67 b-d	2.54 cd
F_1V_3	10.83 d-f	37.41c-f	1.82 ab	2.43 de
F_1V_4	10.07 f	40.73 a-d	1.30 f	2.19 fg
F_2V_1	10.50 ef	39.78 b-e	1.75 bc	2.67 a-c
F_2V_2	10.83 d-f	40.78 a-d	1.61 c-e	2.58 b-d
F_2V_3	11.43 cd	41.14 a-c	1.61 c-e	2.43 de
F_2V_4	10.50 ef	36.70 c-f	1.58 de	2.28 ef
F_3V_1	10.43 f	40.02 b-d	1.68 b-d	2.54 cd
F_3V_2	11.27 de	39.80 b-e	1.75 bc	2.60 b-d
F_3V_3	11.50 cd	42.08 a-c	1.76 bc	2.51 cd
F_3V_4	10.10 f	34.60 ef	1.32 f	2.17 fg
F_4V_1	12.17 bc	43.84 ab	1.76 bc	2.68 a-c
F_4V_2	12.73 ab	44.46 ab	1.92 a	2.78 a
F_4V_3	12.93 a	45.91 a	1.96 a	2.71 ab
F_4V_4	10.13 f	32.67 f	1.12 g	2.06 g
$S\bar{x}$	0.247	1.594	0.050	0.051
CV(%)	3.87	6.94	5.29	3.61

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

F_1= NPK
F_2= NPK+S
F_3= NPK+B
F_4= NPK+S+B

V_1= BARI Mung-5
V_2= BARI Mung-6
V_3= Binamoog-8
V_4= BU Mung-4

Interaction effect of sulphur and boron and mungbean varieties showed significant differences on weight of 1000 seeds (Appendix IX). The highest weight of 1000 seeds (45.91 g) was recorded from the treatment combination of F_4V_3, while the lowest weight of 1000 seeds (32.67 g) was recorded from F_4V_4 (Table 11).

4.13 Seed yield

Seed yield of mungbean showed statistically significant variation due to sulphur and boron combination treatments (Appendix IX). The highest seed yield (1.69 t ha^{-1}) was recorded from F_4 which was statistically similar (1.64 t ha^{-1} and 1.63 t ha^{-1}) to F_2 and F_3, whereas the lowest seed yield (1.57 t ha^{-1}) was observed from F_1 which was statistically similar to F_3 and F_2 (Table 10). Tripathi *et al*. (2012) reported that application of 45 kg S ha^{-1} recorded higher grain yield as compared to control. Tahir *et al*. (2013) reported that boron at 4 kg ha^{-1} significantly increased seed yield (1200 kg ha^{-1}).

Statistically significant variation was found due to different variety of mungbean in terms of seed yield (Appendix IX). The highest seed yield (1.79 t ha^{-1}) was recorded from V_3, which was statistically similar (1.74 t ha^{-1}) to V_2, while the lowest (1.33 t ha^{-1}) was found from V_4 (Table 10). Quaderi *et al*. (2006) reported that BARI Mung-5 performed better than that of BARI Mung-4 for seed yield.

Interaction effect of sulphur and boron combination and mungbean varieties showed significant differences on seed yield (Appendix IX). The highest seed yield (1.92 t ha^{-1}) was observed from the treatment combination of F_4V_2, whereas the lowest seed yield (1.12 t ha^{-1}) was recorded from F_4V_4 (Table 11).

4.14 Stover yield

Stover yield of mungbean showed statistically significant variation due to sulphur and boron (Appendix IX). The highest stover yield (2.56 t ha^{-1}) was found from F_4 which was statistically similar (2.49 t ha^{-1}) to F_2 and closely followed (2.45 t ha^{-1}) by F_3, while the lowest stover yield (2.36 t ha^{-1}) from F_1 (Table 10). Tripathi *et al*. (2012) reported that application of 45 kg S ha^{-1} recorded higher straw yield.

Statistically significant variation was found due to different variety of mungbean in terms of stover yield (Appendix IX). The highest stover yield (2.62 t ha^{-1}) was found from V_2, which was closely followed (2.54 t ha^{-1} and 2.52 t ha^{-1}) by V_1 and V_3 and they were statistically similar, whereas the lowest stover yield (2.17 t ha^{-1}) was observed from V_4 (Table 10). Islam *et al.* (2006) reported that Binamoog-5 performed better than that of Binamoog-2 and Binamoog-4.

Interaction effect of sulphur and boron combination treatment and mungbean varieties showed significant differences on stover yield (Appendix IX). The highest stover yield (2.78 t ha^{-1}) was found from the treatment combination of F_4V_2, while the lowest stover yield (2.06 t ha^{-1}) was observed from F_4V_4 (Table 11).

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted during the period from March to June, 2014 at the Agronomy research farm of Sher-e-Bangla Agricultural University (SAU), Dhaka to find out the effect of sulphur and boron on the growth and yield of mungbean varieties. The experiment comprised of two factors i.e. Factor A: Sulphur and boron (combination-4); F_1= NPK, F_2= NPK+S, F_3= NPK+B and F_4= NPK+S+B; Factor B: Mungbean varieties-4; V_1= BARI Mung-5, V_2= BARI Mung-6, V_3= Binammog-8 and V_4= BU Mung-4. The two factors experiment was laid out in a split-plot design with three replications. Data on different growth parameters and yield was recorded and significant variation was recorded for different treatments.

In case of sulphur and boron combination treatment, at 15, 30, 45 DAS and at harvest, the tallest plant (17.36, 38.66, 51.28 and 49.6 cm, respectively) was recorded from F_4, while the shortest plant (15.52, 35.95, 46.36 and 43.38 cm, respectively) from F_1. The maximum number of branches plant^{-1} (1.68, 2.88, 4.07 and 4.48, respectively) was observed from $F_{4,}$ whereas the minimum number (1.43, 2.52, 3.65 and 3.85, respectively) from F_1 at 15, 30, 45 DAS and at harvest. The highest dry matter content plant^{-1} (1.66, 4.53, 6.20 and 7.75 g, respectively) was observed from $F_{4\,,}$ and the lowest (1.49, 4.03, 5.45 and 6.91 g, respectively) from F_1 at 15, 30, 45 DAS and at harvest. The maximum number of nodules plant^{-1} (93.73, 152.38 and 217.77, respectively) was recorded from $F_{4,}$ whereas the minimum number (87.18, 140.00 and 204.17, respectively) from F_1 at 15, 30 and 45 DAS. The highest dry weight of nodules plant^{-1} (0.014, 0.150 and 0.333 g, respectively) was found from $F_{4,}$ while the lowest dry weight (0.011, 0.123 and 0.272 g, respectively) from F_1 at 15, 30 and 45 DAS. The highest number of plants m^{-2} at flowering stage (26.75) was recorded from $F_{4,}$ whereas the lowest number (24.33) from F_1. The maximum days to flowering

(39.00) was observed from F_1 and the minimum days to flowering (35.33) from F_4. The maximum days to maturity (67.92) was found from $F_{1,}$ while the minimum days (64.75) from F_4. The maximum number pods plant^{-1} (34.35) was recorded from F_4, whereas the minimum number (32.68) from F_1. The longest pod (8.55 cm) was observed from $F_{4,}$ while the shortest pod (7.88 cm) from F_1. The maximum number of seeds pod^{-1} (11.99) was found from F_4, and the minimum number (10.61) from F_1. The highest weight of 1000 seeds (41.72 g) was recorded from F_4, while the lowest weight (38.68 g) from F_1. The highest seed yield (1.69 t ha^{-1}) was recorded from $F_{4,}$ whereas the lowest (1.57 t ha^{-1}) from F_1. The highest stover yield (2.56 t ha^{-1}) was found from $F_{4,}$ while the lowest (2.36 t ha^{-1}) from F_1.

For different varieties of mungbean, at 15, 30, 45 DAS and at harvest, the tallest plant (17.16, 39.01, 50.89 and 49.05 cm, respectively) was found from V_2, whereas the shortest plant (15.45, 35.32, 46.85 and 43.23 cm, respectively) from V_4. The maximum number of branches plant^{-1} (1.70, 2.88, 4.12 and 4.30, respectively) was recorded from V_2, while the minimum number (1.38, 2.52, 3.22 and 3.55, respectively) from V_4 at 15, 30, 45 DAS and at harvest. The highest dry matter content plant^{-1} (1.65, 4.58, 6.43 and 7.89 g, respectively) was found from V_2, while the lowest (1.50, 3.76, 5.44 and 6.34 g, respectively) from V_4 at 15, 30, 45 DAS and at harvest. The maximum number of nodules plant^{-1} (93.78, 149.03 and 215.68, respectively) was found from V_3, while the minimum number (88.27, 141.53 and 205.92, respectively) from V_4 at 15, 30 and 45 DAS. The highest dry weight of nodules plant^{-1} (0.014, 0.152 and 0.332 g, respectively) was found from V_3, whereas the lowest (0.011, 0.121 and 0.250 g, respectively) from V_4 at 15, 30 and 45 DAS. The highest number of plants m^{-2} at flowering stage (26.92) was found from V_3, while the lowest number (24.58) from V_4. The maximum days to flowering (40.25) was found from V_4, and the minimum days (35.42) from V_2. The maximum days to maturity (69.25) was found from V_4, whereas the minimum days to maturity (64.33) from V_2. The maximum number of pods plant^{-1} (35.23) was found from V_3, while the minimum number (30.71) from V_4. The longest pod (8.56 cm) was found from V_3, whereas the shortest pod (7.31 cm) from V_4. The maximum number of seeds pod^{-1} (11.68) was found from V_3, while the minimum number (10.20) from V_4. The highest weight of 1000 seeds (41.63 g) was found from V_3, whereas the lowest (36.17 g) from V_4. The highest seed yield (1.79 t ha^{-1}) was recorded from V_3, while the lowest (1.33 t ha^{-1}) from V_4. The highest stover yield (2.62 t ha^{-1}) was found from V_2, whereas the lowest (2.17 t ha^{-1}) from V_4.

Due to the interaction effect of sulphur and boron and mungbean varieties, at 15, 30, 45 DAS and at harvest, the tallest plant (20.39, 43.77, 58.17 and 56.22 cm, respectively) was recorded from the treatment combination of F_4V_2, while the shortest plant (12.01, 31.38, 38.65 and 38.23 cm, respectively) from F_4V_4. The maximum number of branches plant^{-1} (1.93, 3.20, 4.53 and 4.93, respectively) was recorded from the treatment combination of F_4V_2 and the minimum number (1.20, 2.27, 3.13 and 3.53, respectively) from F_1V_4 at 15, 30, 45 DAS and at harvest. The highest dry matter content plant^{-1} (1.89, 5.16, 6.60 and 8.80 g, respectively) was recorded from the treatment combination of F_4V_2, whereas the lowest (1.31, 3.36, 4.92 and 5.60 g, respectively) from F_4V_4 at 15, 30, 45 DAS and at harvest. The maximum number of nodules plant^{-1} (97.40, 157.33 and 225.00, respectively) was recorded from the treatment combination of F_4V_3 and the minimum number (83.87, 136.40 and 199.87, respectively) from F_1V_1 at 15, 30 and 45 DAS. The tallest dry weight of nodules plant^{-1} (0.016, 0.178 and 0.382 g, respectively) was recorded from the treatment combination of F_4V_3, while the lowest (0.010, 0.108 and 0.241 g) from F_4V_4 at 15, 30 and 45 DAS. The highest number of plants m^{-2} at flowering stage (29.00) was recorded from the treatment combination of F_4V_2, whereas the lowest number (22.67) from F_4V_4. The maximum days to flowering (43.00) was recorded from the treatment combination of F_3V_4, whereas the minimum days to flowering (31.67) from F_4V_1. The maximum days to maturity (72.00) was observed from the treatment combination of F_3V_4, while the minimum days (60.33) from F_4V_1. The maximum number of pods plant^{-1} (36.73) was recorded from the treatment combination of F_4V_3 and the minimum number (29.33) from F_1V_4. The longest pod (9.45 cm) was found from the treatment combination of F_4V_2, while the shortest pod (6.69 cm) from F_4V_4. The maximum number of seeds pod^{-1} (12.93) was found from the treatment combination of F_4V_3, whereas the minimum number (10.07) from F_1V_4. The highest weight of 1000 seeds (45.91 g) was recorded from the treatment combination of F_4V_3, while the lowest weight (32.67 g) from F_4V_4. The highest seed yield (1.92 t ha^{-1}) was observed from the treatment combination of F_4V_2, whereas the lowest (1.12 t ha^{-1}) from F_4V_4. The highest stover yield (2.78 t ha^{-1}) was found from the treatment combination of F_4V_2, while the lowest (2.06 t ha^{-1}) from F_4V_4.

Conclusion

It was revealed that application of NPK+S+B was more potential in regarding growth and yield of mungbean. Binamoog-8 followed by BARI Mung-6 was superior among the mungbean varieties.

Considering the above results of this 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 performances.

2. Another experiment may be conducted with other organic, inorganic nutrients and also other management practices.

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APPENDICES

Appendix I. Characteristics of the soil of experimental field

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Agronomy field , SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled

B. Physical and chemical properties of the initial soil

Characteristics	Value
% Sand	27
% Silt	43
% clay	30
Textural class	Silty-clay
pH	5.7
Organic matter (%)	1.13
Total N (%)	0.061
Available P (ppm)	5.46
Exchangeable K (me/100 g soil)	0.13
Available S (ppm)	12.7
Available B (ppm)	0.41

Source: Soil Resources Development Institute (SRDI), Farmgate, Dhaka

Appendix II. Monthly average of air temperature, relative humidity and total rainfall of the experimental site during the period from March to June, 2014

Month (2014)	*Air temperature (^{o}C)		*Relative humidity (%)	Rainfall (mm) (total)
	Maximum	Minimum		
March	28.1	19.5	65	00
April	33.4	23.2	67	78
May	34.7	25.9	70	185
June	35.4	22.5	80	277

* Monthly average, **Source:** Bangladesh Meteorological Department, Agargoan, Dhaka - 1212

Appendix III. Analysis of variance of the data on plant height of mungbean as influenced by sulphur and boron and different variety

Source of variation	Degrees of freedom	Mean square			
		Plant height at			
		15 DAS	30 DAS	45 DAS	Harvest
Replication	2	0.230	0.601	3.085	4.508
Sulphur and Boron (A)	3	6.856*	15.395*	50.868*	78.789**
Error	6	1.312	2.920	8.418	15.965
Variety (B)	3	6.201*	27.496*	33.787*	73.053**
Interaction (A×B)	9	16.373**	30.626**	80.327**	50.107*
Error	24	1.607	7.880	10.540	18.515

** Significant at 0.01 level of probability; * Significant at 0.05 level of probability

Appendix IV. Analysis of variance of the data on number of branches plant^{-1} of mungbean as influenced by sulphur and boron and different variety

Source of variation	Degrees of freedom	Mean square			
		Number of branches plant^{-1} at			
		15 DAS	30 DAS	45 DAS	Harvest
Replication	2	0.007	0.001	0.011	0.183
Sulphur and Boron (A)	3	0.130*	0.276**	0.379*	0.854**
Error	6	0.014	0.013	0.050	0.062
Variety (B)	3	0.219*	0.276**	2.112**	1.743**
Interaction (A×B)	9	0.023*	0.033*	0.085*	0.227**
Error	24	0.009	0.014	0.043	0.042

** Significant at 0.01 level of probability; * Significant at 0.05 level of probability

Appendix V. Analysis of variance of the data on dry matter content plant^{-1} of mungbean as influenced by sulphur and boron and different variety

Source of variation	Degrees of freedom	Mean square			
		Dry matter content plant^{-1} at			
		15 DAS	30 DAS	45 DAS	Harvest
Replication	2	0.006	0.033	0.141	0.052
Sulphur and Boron (A)	3	0.060*	0.508*	1.267*	1.489*
Error	6	0.011	0.103	0.212	0.212
Variety (B)	3	0.047*	1.571**	2.411**	6.260**
Interaction (A×B)	9	0.092**	0.309**	0.290*	1.187**
Error	24	0.012	0.036	0.101	0.122

** Significant at 0.01 level of probability; * Significant at 0.05 level of probability

Appendix VI. Analysis of variance of the data on number of nodule plant^{-1} of mungbean as influenced by sulphur and boron and different variety

Source of variation	Degrees of freedom	Mean square		
		Number of nodule plant^{-1} at		
		15 DAS	30 DAS	45 DAS
Replication	2	1.323	6.917	23.663
Sulphur and Boron (A)	3	87.954*	308.194**	380.250**
Error	6	14.706	12.494	10.147
Variety (B)	3	62.978*	136.025**	217.799**
Interaction (A×B)	9	34.943*	48.772*	44.641*
Error	24	16.451	29.094	26.898

** Significant at 0.01 level of probability; * Significant at 0.05 level of probability

Appendix VII. Analysis of variance of the data on dry weight of nodules plant^{-1} of mungbean as influenced by sulphur and boron and different variety

Source of variation	Degrees of freedom	Mean square		
		Dry weight of nodules plant^{-1} at		
		15 DAS	30 DAS	45 DAS
Replication	2	0.0001	0.0001	0.0001
Sulphur and Boron (A)	3	0.0001**	0.002**	0.008**
Error	6	0.0001	0.0001	0.001
Variety (B)	3	0.0001**	0.002**	0.017**
Interaction (A×B)	9	0.0001**	0.001**	0.003**
Error	24	0.00001	0.0001	0.001

** Significant at 0.01 level of probability;

Appendix VIII. Analysis of variance of the data on number of plants m^{-2} at flowering stage days to flowering, days to maturity, number of pods plant^{-1} and pod length of mungbean as influenced by sulphur and boron and different variety

Source of variation	Degrees of freedom	Mean square				
		Number of plants m^{-2} at flowering stage	Days to flowering	Days to maturity	Number of pods plant^{-1}	Pod length (cm)
Replication	2	0.563	1.000	3.271	0.094	0.081
Sulphur and Boron (A)	3	14.410**	28.410*	23.611*	5.715**	1.019*
Error	6	1.451	6.222	7.049	0.649	0.211
Variety (B)	3	14.576**	60.910**	60.389**	48.549**	4.144**
Interaction (A×B)	9	6.354*	27.169**	30.000**	3.764*	0.728**
Error	24	2.285	7.917	6.076	1.413	0.114

** Significant at 0.01 level of probability; * Significant at 0.05 level of probability

Appendix IX. Analysis of variance of the data on number of seeds pod^{-1}, weight of 1000-seeds, seed and stover yield of mungbean as influenced by sulphur and boron and different variety

Source of variation	Degrees of freedom	Mean square			
		Number of seeds pod^{-1}	Weight of 1000-seeds (g)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})
Replication	2	0.023	4.733	0.002	0.006
Sulphur and Boron (A)	3	4.746**	21.711**	0.029*	0.082**
Error	6	0.317	1.655	0.005	0.007
Variety (B)	3	5.573**	78.071**	0.521**	0.478**
Interaction (A×B)	9	0.741**	32.609**	0.079**	0.046**
Error	24	0.183	7.621	0.007	0.008

** Significant at 0.01 level of probability; * Significant at 0.05 level of probability