EFFECTS OF BORON ON THE GROWTH AND YIELD OF MUNGBEAN

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This is to certify that the thesis entitled "**Effects of Boron on the Growth and Yield of Mungbean**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **Master of Science** in **Agricultural Chemistry**, embodies the result of a piece of bonafide research work carried out by **S. M. Hasanuzzaman**, Registration number: **03-01210** 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.

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ABSTRACT

An experiment was carried out at the farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh, during the period from March to July 2010 to study the effect of boron on the growth and yield of mungbean. The experiment consisted of two factors, viz., Factor A: Mungbean varieties (2) V_1: BARI mung-1 and V_2: BARI mung-5; Factor B: Levels of boron (4 level); B_0: Control (0 kg H_3BO_3 ha^{-1}); B_1: 1.0 kg H_3BO_3 ha^{-1}; B_2: 1.5 kg H_3BO_3 ha^{-1} and B_3: 2.0 kg H_3BO_3 ha^{-1}. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data on different growth parameters, yield attributes and yield were recorded. The plant height of both varieties were measured at 20, 30, 40, 50, 60 DAS and at harvest, the height of V_2 were found significantly higher than V_1 in each day of measurement. In V_2 the higher plant heights were recorded at 20, 30, 40, 50, 60 DAS and at harvest which were 10.60, 21.65, 33.28, 41.41, 51.64 and 57.83 cm, respectively, whereas the shorter height of 9.01, 19.63, 29.56, 36.88, 48.96 and 54.80 cm were found from variety V_1. Variety V_2 produced significantly higher no. of pods/plant (18.91), seed yield (1.5 t ha^{-1}), stover yield (2.3 t ha^{-1}) which were found superior to those of V_1 (18.03, 1.29 t ha^{-1}, 2.04 t ha^{-1}, respectively). The highest available boron in seeds (18.83 μg gm^{-1}) was recorded from V_1 and lower (18.36 μg gm^{-1}) from V_2. At 20, 30, 40, 50, 60 DAS and at harvest, the taller plant (11.06, 23.37, 35.04, 41.86, 53.64 and 59.52 cm) were observed from B_3, while the shorter plants (8.33, 17.50, 26.56, 35.00, 45.25 and 51.67 cm) from B_0. The higher No. of seed yield, stover yield (1.53 t ha^{-1} and 2.40 t ha^{-1},) in B_3 which was statistically significant to B_2 whereas the lowest values were (17.22, 1.18 t ha^{-1} and 1.88 t ha^{-1}) observed in B_0. At 20, 30, 40, 50, 60 DAS and at harvest the tallest plant (11.51, 24.01, 37.28, 44.46, 54.33 and 60.96 cm, respectively) were observed from V_2B_3, while the shortest (6.63, 15.43, 22.90, 31.85, 41.51 and 48.53 cm, respectively) from V_1B_0. The highest number of pods $plant^{-1}$ (19.75) was recorded from V_2B_2 and the lowest number (16.91) from V_1B_0. The highest seed yield (1.79 t ha^{-1}) was found from V_2B_2 and the lowest (1.04 t ha^{-1}) from V_1B_0. The highest stover yield (2.49 t ha^{-1}) was observed from V_2B_3, whereas the lowest (1.56 t ha^{-1}) from V_1B_0. The highest available boron in seeds (24.33 μg gm^{-1}) was observed from V_2B_3, whereas the lowest (13.33 μg gm^{-1}) from V_1B_0. Considering performance and expenditure the cultivar BARI mung-5 and 1.5.0 kg H_3BO_3 ha^{-1} was identified as proper in achieving potential growth and yield of mungbean.

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CHAPTER I

INTRODUCTION

Various types of pulse crops namely grass pea, lentil, mungbean, blackgram, chickpea, field pea and cowpea are grown in Bangladesh. Mungbean (*Vigna radiata* L.) is one of the most important pulse crops of Bangladesh. It ranks fifth considering both acreage and production. The area under pulse crops in Bangladesh is 0.406 million hectares with a production of 0.322 million tones where mungbean is cultivated in the area of 0.108 million hectares with production of 0.03 million tons (BBS, 2005). It is considered as a quality pulse in the country but production per unit area is very low (736 kg ha^{-1}) as compared to other countries of the world (BBS, 2007). The total cultivated area of mungbean in acreage-57462, 351 kgs, yield/acre, and production (in M.Ton) 20177 (Source-agriculture statistics wing, BBS, 2009-10)

Pulse plays an important role in human nutrition and it is called poor man's meat because it is the cheapest source of protein for the poor people. It contains almost double amount of protein as compared to cereals. It has good digestibility and flavor. Pulses, being leguminous crops, are capable of fixing atmospheric nitrogen in the soil and enriching soil fertility. Thus they are considered as soil fertility building crops (Kumar *et al.*, 1963*)*. Some of the pulse seeds are consumed when they are at green stage. But it is taken mostly in the form of soup and "dal". Sometimes it is grown as green manuring crops and cover crops (Shaikh, 1997*)*.

The green plants, the dried stems and leaves after separation of grain and the husks of seeds are the valuable food to the livestock. It is an excellent source of easily digestible protein.

Among the pulses Mungbean contains crude fibre 5.2%, protein 26%, total ash 4.4%, Ca 0.2% and P 0.5% (Gowda and Kaul, 1982). Hence, on the point of nutrition value, mungbean is perhaps the best of all other pulses. But unfortunately there is an acute shortage of grain legumes production in the country. According to FAO (1999) a minimum intact of pulse by a human should be 8 g/day/capacity for a balance diet. Annually import of pulses in Bangladesh is approximately 55000 tons (BBS, 1994). This crops, like other pulses, also has minimize the scarcity of fodder because the whole plant or it's by-products can be used as good animal feed. So increase of pulse production is urgently needed to meet up the domestic demand and to increase pulse consumption as well as to minimize the scarcity of fodder.

Agro – ecological condition of Bangladesh is favorable for growing mungbean. The crop is usually cultivated during kharif season and can also be fitted well into the existing cropping system of many areas in Bangladesh .The average yield of mungbean in this country is 550 kg ha^{-1} (BBS, 2006) which are much lower than in India (1320 kg $ha^{-1)}$ and some other countries (Daisy, 1979). It is partly due to low yielding potentially and partly due to lack of appropriate agronomic practices. There are many reasons of low yield of mungbean. Among the different reasons variety is the important factor that greatly affects the growth, development and yield of this crop.

Micronutrients play an important role in yield of pulse and oilseed legume through their effects on the plant itself and also on the boron availability. But deficiencies of these nutrients have been very much pronounced under multiple cropping systems due to excess removal thereby necessity their exogenous supply. Boron is essential micronutrient for cell division especially in the process of nodule formation in legumes. The deficiency of B affects some grain legume (Rerkasem *et al.,* 1987). The deficiency of boron and response of different grain legume have been reported by some researchers (Rerkasem *et al.*, 1987; Bhuiyan, 1999). The soil of different parts of Bangladesh is more or less deficient in boron as well as nitrogen fixing bacteria *(Rhizobium* spp.) which causes poor yield of pulse (Bhuiyan *et al.,* 1999; Khanam *et al.,* 1994). Field studies revealed that deficiency of B causes considerable reduction of growth and nodulation in mungbean. In Bangladesh, hardly any attempt has so far been made on the application of B in mungbean for bringing about the improvement of nodulation and yield in relation to economic return. Considering the above circumstances, the present investigation has been undertaken with the following objectives:

1. To investigate the effect of boron on two varieties at different growth stages of mungbean.
2. To determine the yield performance of mungbean varieties by using different doses of boron fertilizer.
3. To know the optimum doses of boron fertilizer for economic yield of mungbean varieties.

CHAPTER II

REVIEW OF LITERATURE

In Bangladesh along with many countries of the world mungbean is an important pulse crop. The crop has been given comparatively less attention by the researchers on various aspects because normally it is grown without care or management practices. Based on this a very few research work related to growth, yield and development of mungbean have been carried out in our country. However, researches are going on at home and abroad to maximize the yield of mungbean. Variety and levels of boron play an important role in improving mungbean yield. But research works related to variety and levels of boron on mungbean are limited in Bangladesh. However, some of the important and informative works related to the variety and level of boron so far been done at home and abroad on this crop that have been reviewed and presented in this chapter under the following headings-

2.1 Effects of varieties on plant characters of mungbean

An experiment was conducted by Muhammad *et al*. (2006) to study the nature of association between *Rhizobium phaseoli* and mungbean. 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, 2003. Both the strains in association with NM-92 had higher nodule dry weight, which was 13% greater than other strains x 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} but grain yield of NCM-209 was same (590 kg ha^{-1}) either inoculated with strain Tal-420 or without inoculated. Variety NM-92 produced the lowest grain yield (330 kg ha^{-1}) and had almost same yield either inoculated with strain Tal-420 or without inoculated.

Another study was carried out in the Field Laboratory of the Department of Crop Botany, Bangladesh Agricultural University, Mymensingh during the period from October 2000 to February 2001 by Quaderi *et al.* (2006) to evaluate the influence of seed treatment with Indole Acetic Acid (IAA) by the concentration of 50 ppm, 100 ppm and 200 ppm on the growth, yield and yield contributing characters of two modern mungbean (*Vigna radiata* L.) varieties viz. Binamoog-4and Binamoog-5. The two-factor experiment was laid out by Randomized Complete Block Design (RCBD) with 3 replications. Among the mungbean varieties, Binamoog-5 performed better than that of Binamoog-4.

Islam *et al.* (2006) carried out an experiment at the field laboratory of the Department of Crop Botany, Bangladesh Agricultural University, Mymensingh during the period from March 2002 to June 2002 to evaluate the effect of biofertilizer (*Bradyrhizobium*) and plant growth regulators (GA3 and IAA) on growth of 3 cultivars of summer mungbean (*Vigna radiata* L.). The experiment was laid out in RCBD with three replications testing two factors (variety and treatment). There were altogether 12 treatment combinations. 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 m spacing and supplied with 36 - 46 and 58 - 46 kg NP/ha in a field experiment conducted in Delhi, India during the kharif season of 2000 by Tickoo *et al.* (2006). Cultivar Pusa Vishal recorded higher biological and grain yield (3.66 and 1.63 t/ha, 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.* (2002) conducted an experiment with mungbean in Jamalpur, Bangladesh, from February to June 1999, involving 2 planting methods, i.e. line sowing and broadcasting; 5 mung bean cultivars, namely Local, BARI mung-2, BARI mung-3, Binamung-2 and Binamung-5; and 5 sowing dates, i.e. 5 February, 20 February, 5 March, 20 March and 5 April. Significantly the highest dry matter production ability was found in 4 modern mung bean cultivars, and dry matter partitioning was found highest in seeds of Binamung-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) from 2000 to 2003 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. The experiment with mothbean showed that RMO-40 gave 34.8-35.2% higher grain yield and 30.2-33.4% higher fodder yield over the local cultivar as well as 11.8% higher grain yield and 9.2% higher fodder yield over RMO-257. The experiment with clusterbean showed that improved cultivars of RGC-936 gave 136.0 and 73.5% higher grain yield and 124.0 and 67.3% higher fodder yield over the local cultivar and Maru Guar, respectively.

A field experiment was conducted by Raj and Tripathi (2005) in Jodhpur, Rajasthan, India, during the kharif seasons of 2003 and 2004, to evaluate the effects of cultivar (K-851 and RMG-62) as well as nitrogen (0 and 20 kg/ha) and phosphorus levels (0, 20 and 40 kg/ha) on the productivity of mungbean. K-851 produced significantly higher values for seed and straw yields as well as yield attributes (plant height, pods per plant, seeds per pod 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 and 1.02, respectively) than RMG-62 (Rs. 4833/ha 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) form Kasetsart mungbean breeding project was conducted 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. Binamung-2 and Binamung-5, were grown during the kharif-1 season (February-May) of 2001, 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, number of pods per plant, number of seeds per pod, 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. Binamung-2 performed slightly better than Binamung-5 for most of the growth and yield parameters studied.

An experiment was conducted by Abid *et al*. (2004) in Peshawar, Pakistan, during the 2002 summer season to study the effect of sowing dates (15 April, 15 May, 15 June, 15 July and 15 August) 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 was recorded in 15 June-sown plants. Sowing on 15 August gave the highest number of days to 50% flowering and to physiological maturity, while 15 April-sown plants gave the highest mean grain yield. NM-92 gave higher mean grain yield than M-1. The highest grain yield was observed in 15 April-sown M-1 plants.

A field experiment was conducted by Apurv and Tewari (2004) during kharif season of 2003 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) alone and under poplar. 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, BINA Moog-2 and BU Mung-1. *Rhizobium* strains TAL169 and

TAL441 were used for inoculation of the seeds. Two-thirds of seeds of each cultivar were inoculated with *Rhizobium* inoculants and the remaining one-third of seeds were kept uninoculated. Among the cultivars, BARI Mung-4 performed the best in all aspects showing the highest seed yield of 1135 kg/ha. *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 during the rainy season of 1994-95 and dry season of 1995. Data on plant height, number of clusters per plant, number of pods per plant, pod length, number of seeds per pod, grain yield by plant and yield/ha. Significant differences in the values of the parameters due to cultivar were recorded. The average yield was 1342.58 kg/ha. VC 1973C, Creole VC 1973A, VC 2768A, VC 1178B and Mililiter 267 were the most promising cultivars for cultivation in the area.

The effects of sowing rates (15, 20 and 25 kg/ha) on the growth and yield of mungbean cultivars NM-92, NARC-Mung-1 and NM-98 was investigated in Faisalabad, Pakistan during 2002-03 by Riaz *et al.* (2004). NM-98 produced the maximum pod number of 17.30, grain yield of 983.75 kg/ha and harvest index value of 24.91%. NM-92 also produced the highest seed protein content of 24.64%.

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

Three mungbean cultivars (LGG 407, LGG 450 and LGG 460) and two urd bean [black gram] cultivars (LBG 20 and LBG 623) were sown on 15 June 2001 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/ha) 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 of 1998. Among the cultivars, NM 121-125 recorded the highest average number of pods per plant (18.18), number of grains per pod (9.79), 1000-grain weight (28.09 g) and grain yield (446.07 kg/ha).

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, during May-July 1997. The differentiation of the development phases and stages, and the morphological changes of plants were studied. The variable totals of pod clusters, number of pods per plant, seeds per pods 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 per plant and number of pods per plant, where ML 267 and Acriollado had the highest values. The total seeds per pod of VC 1973C and Acriollado were significantly greater than ML 267. Acriollado showed the highest yield with 1438.33 kg/ha.

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 of 1993-94 and 1995-96. S-8, BM-4 and BM-86 recorded the highest mean nodulation (16.66), plant biomass (8.29 q/ha) and grain yield (4.79 q/ha) during the experimental years. S-8, BM-4 and BM-86 recorded the highest nodulation, plant biomass and grain yield when their seeds were inoculated with *Rhizobium* strains M-6-84, M-6-65 and M-11-85, respectively.

Hamed (1998) carried out two field experiments during 1995 and 1996 in Shalakan, Egypt, to evaluate mungbean cultivars Giza 1 and Kawny 1 under 3 irrigation intervals after flowering (15, 22 and 30 days) and 4 fertilizer treatments: inoculation with *Rhizobium* (R) + Azotobacter (A) + 5 (N_1) or 10 kg N/feddan (N_2), and inoculation with R only + 5 (N_3) or 10 kg N/feddan (N_4). Kawny 1 surpassed Giza 1 in pod number per plant (24.3) and seed yield (0.970 t/feddan), while Giza 1 was superior in 100-seed weight (7.02 g), biological and straw yields (5.53 and 4.61 t/feddan, respectively). While Kawny 1 surpassed Giza 1 in oil yield (35.78 kg/feddan), the latter cultivar recorded higher values of protein percentage and yield (28.22% and 264.6 kg/feddan. The seed yield of both cultivars was positively and highly significantly correlated with all involved characters, except for 100-seed weight of Giza 1 and branch number per plant of Kawny 1.

2.2 Effects of boron application on plant characters of mungbean

Two field experiments were carried out by Rizk and Abdo (2001) at Giza Experimental Station, ARC, Egypt during 1998 and 1999 seasons to investigate the response of mungbean (*Vigna radiata*) to treatments with some micronutrients. Two cultivars of mungbean (V-2010 and VC-1000) were used in this investigation. Zn (0.2 or 0.4 g/l), Mn (1.5 or 2.0 g/l), B (3.0 or 5.0 g/l) and a mixture of Zn, Mn, and B (0.2, 1.5 and 3.0 g/l, respectively), in addition to distilled water as control were sprayed once at 35 days after sowing (DAS). The obtained results could be summarized in the following: Generally, cultivar VC-1000 surpassed cultivar V-2010 in yield and its components as well as in the chemical composition of seeds with exception in 100-seed weight and phosphorus percentage in seeds. All treatments significantly increased the yield and its components especially Zn1 (0.2 g/l) which showed a highly significant increase in all characters under investigation compared to the control. All the treatments showed significant protein percentage in seeds of the two mungbean cultivars in both seasons. Among all treatments of micronutrients, B gave the highest percentage of crude protein. Seeds of mungbean cv. VC-1000 exceeded those of mungbean cv. V-2010 in crude protein percentage with significant difference in both seasons. In contrast, all sprayed treatments with micronutrients showed no significant effect on the percentages of total carbohydrates, phosphorus and potassium in seeds of the two mungbean cultivars in both seasons.

Abdo (2001) carried out two field experiments at Giza Experimental Station, ARC, Egypt, during the 1998 and 1999 seasons to study the effect of foliar spray with micronutrients (Zn, Mn, or B) on morphological, physiological and anatomical parameters of two mungbean (*Vigna radiata*) cultivars V-2010 (Giza-1) and VC-1000. Zn (0.2 or 0.4 g/L), Mn (1.5 or 2.0 g/L), B (3.0 or 5.0 g/L) and a mixture of Zn, Mn and B (0.2, 1.5 and 3.0 g/L, respectively) in addition to distilled water as control were sprayed once at 35 days after sowing (DAS). The results showed that foliar spray with the adopted concentrations of Zn, Mn or B alone or in a mixture, increased most of the growth parameters significantly over the control in both seasons. Application of Zn (0.2 g/L) alone followed by a mixture of micronutrients resulted in better morphological and physiological parameters (stem length (cm), number of branches, number of leaves, leaf area (LA) (cm^2), leaf area index (LAI) and shoot dry weight (g) per plant. It was observed that mungbean cv. VC-1000 surpassed cv. V-2010 in all parameters in both seasons.

In a pot experiment carried out by Verma and Mishra (1999) to find out the effect of doses and methods of boron application on growth and yield of mungbean. Boron was applied during seed treatment, soil application (basally or at flowering) or foliar spraying. Boron increased the yield and growth parameters, with the best results in terms of seed yield/plant when the equivalent of 5 kg borax/ha was applied at flowering.

Boron (B) amelioration of aluminum (Al) toxicity was studied by Yang and Zhang (1998) with mungbean cv. Minglu seedlings and cuttings (without roots) in a growth chamber. mungbean seedlings and cuttings were grown in a solution culture with 0, 5 or 50 micro M B and 0, 2 or 5 mM Al for 16 days. The addition of B promoted elongation of epicotyls and hypocotyls, and increased seedling height and dry weight in the Al treated plants. High concentrations of B decreased soluble protein and increased chlorophyll content in seedlings treated with 2 mM Al. B had no ameliorative effect on cuttings grown with Al, although Al increased soluble protein content. It is concluded that B alleviation of Al toxicity was related to root function and Al toxicity may possibly be due, in part, to B deficiency.

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

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted during the period from March to July 2010 to study the effect of boron on the growth and yield of mungbean. This chapter includes materials and methods that were used in conducting the experiment. The details materials and methods of this experiment are presented below under the following headings:

3.1 Experimental site

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

3.2 Soil

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

3.3 Climate

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

3.4 Planting materials

The variety BARI mung-1 and BARI mung-5 was used as the test crops. The seeds were collected from the Pulse Seed Division of Bangladesh Agricultural Research Institute, Joydevpur, Gajipur. BARI mung-1 and BARI mung-5 are the released varieties of mungbean, which was recommended by the national seed board. They grow both in *Kharif*- I, II and late *Rabi* season. Life cycle of this variety ranges from 55-60 days. Maximum seed yield is 1.1-1.5 t/ha (Anon., 1999).

3.5 Land preparation

The land was irrigated before ploughing. After having 'zoe' condition the land was first opened with the tractor drawn disc plough. Ploughed soil was brought into desirable fine tilth by 4 ploughing and cross-ploughing, harrowing and laddering. The stubble and weeds were removed. The first ploughing and the final land preparation were done on 10 and 15 March 2010, respectively. Experimental land was divided into unit plots following the design of experiment.

3.6 Fertilizer application

Urea, Triple super phosphate (TSP), Muriate of potash (MOP) and Boric acid was used as a source of nitrogen, phosphorous, potassium and boron, respectively. Following the BARI recommendation, urea, TSP and MP were applied @ of 40, 40 and 50 kg per hectare respectively (Anon., 1999). Boric acids were applied as per treatment. All of the fertilizers except urea were applied during final land preparation and urea was applied in two equal installments at 25 and 35 DAS.

3.7 Treatments of the experiment

The experiment consisted of two factors:

Factor A: Mungbean variety: 2

i. V_1: BARI mung-1
ii. V_2: BARI mung-5

Factor B: Level of boron: 4 levels

i. B_0: Control (0 kg H_3BO_3 ha^{-1})
ii. B_1: 1.0 kg H_3BO_3 ha^{-1}
iii. B_2: 1.5 kg H_3BO_3 ha^{-1}
iv. B_3: 2.0 kg H_3BO_3 ha^{-1}

In total there were 8 (2 × 4) treatment combinations such as V_1B_0, V_1B_1, V_1B_2, V_1B_3, V_2B_0, V_2B_1, V_2B_2 and V_2B_3.

3.8 Experimental design and layout

The two-factor experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. An area of 29.5 m × 10.0 m was divided into three equal blocks. Each block was divided into 8 plots where 8 treatment combinations were allotted at random. There were 24 unit plots altogether in the experiment. The size of the each unit plot was 3.0 m × 2.0 m. The space between two blocks and two plots were 1.0 m and 0.5 m, respectively. The layout of the experiment is shown in Figure 1.

3.9 Sowing of seeds in the field

The seeds of mungbean were sown on March 16, 2010. Before sowing seeds were treated with Bavistin to control the seed borne diseases. The seeds were sown in rows in the furrows having a depth of 3-4 cm. Row to row distance was 30 cm.

3.10 Intercultural operations

3.10.1 Irrigation and weeding

Irrigation was done as per requirements. The crop field was weeded as per requirements.

3.10.2 Protection against insect and pest

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

3.11 Crop sampling and data collection

Ten plants from each treatment were randomly selected and marked with sample card. Plant height, number of branches per plant was recorded from selected plants at an interval of 10 days which was started from 20 DAS.

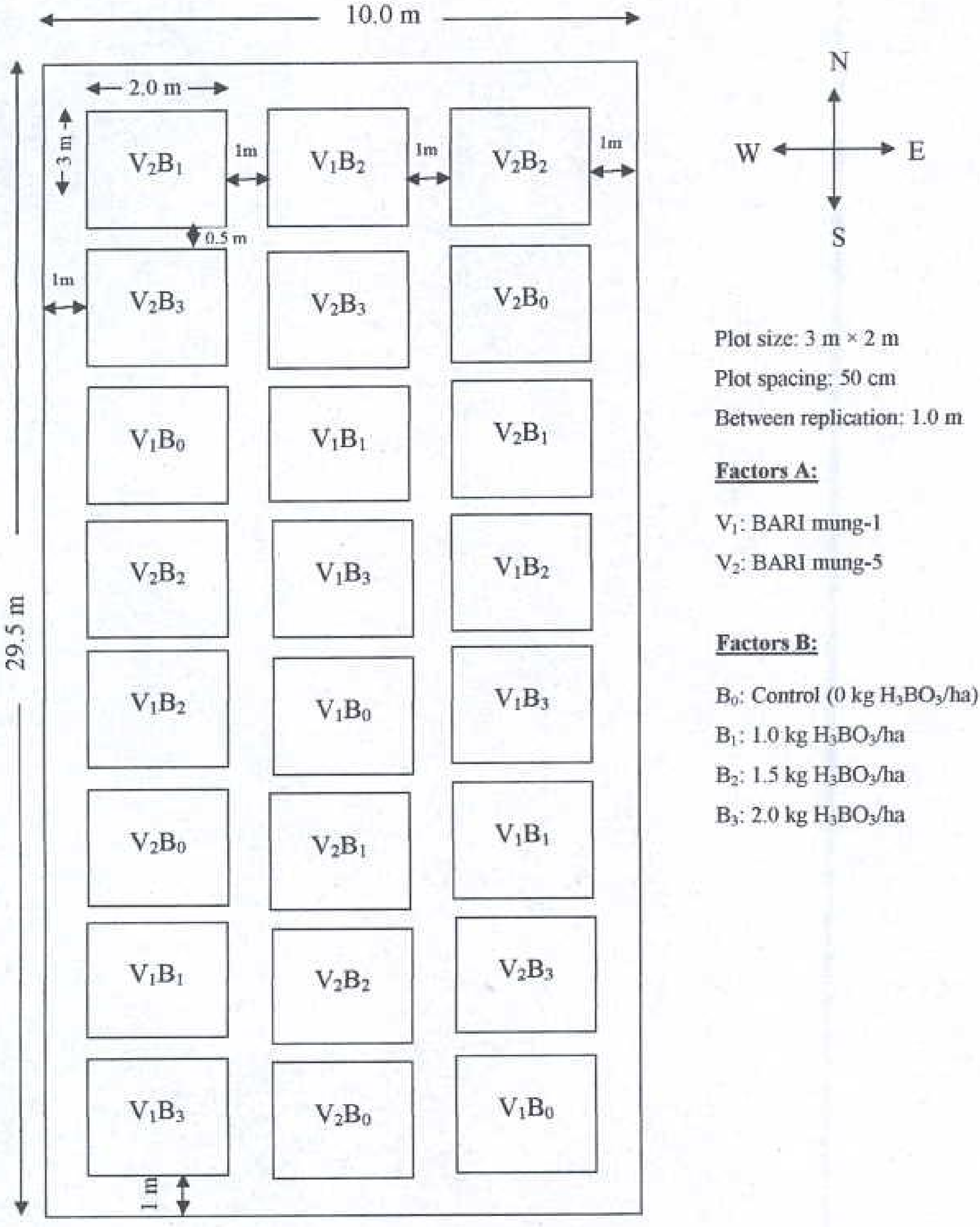


Figure 1. Layout of the experimental plot

3.12 Harvest and post harvest operations

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

3.13 Data collection

The following data were recorded

i. Plant height (cm)

ii. Number of branches plant^{-1}

iii. Number of leaves plant^{-1}

iv. Dry matter plant^{-1} (g)

v. Days to 1st flowering

vi. Days to 80% pod maturity

vii. Pods plant^{-1} (No.)

viii. Pod length (cm)

ix. Seeds pod^{-1} (No.)

x. Weight of 1000 seeds (g)

xi. Seed yield (t ha^{-1})

xii. Stover yield (t ha^{-1})

xiii. Boron content in plant sample (μg gm^{-1})

3.14 Procedure of data collection

3.14.1 Plant height

The height(cm) of plants were measured with a meter scale from the ground level to the top of the plants and the mean height was expressed in cm. Data were recorded as the average of 10 plants selected at random from the inner rows of each plot starting from 20 to 60 DAS at 10 days interval and at harvest.

3.14.2 Number of branches plant^{-1}

The number of branches plant^{-1} was counted from selected plants. The average number of branches per plant was determined. Data were recorded as the average of 10 plants selected at random from the inner rows of each plot starting from 20 to 60 DAS at 10 days interval and at harvest.

3.14.3 Number of leaves plant^{-1}

The number of leaves plant^{-1} was counted from selected plants. The average number of leaves per plant was determined. Data were recorded as the average of 10 plants selected at random from the inner rows of each plot starting from 20 to 60 DAS at 10 days interval and at harvest.

3.14.4 Dry matter plant^{-1}

Ten plants were collected randomly, from each plot at 10 day interval started from 20 to 60 days after sowing (DAS) and harvest. The entire plant including roots, stem (with pods) and leaves was oven dried at 70^0C for 72 hours and then transferred into desiceator and allowed to cool down to the room temperature and final weight was taken and converted into dry matter content plant^{-1}(g)

3.14.5 Days to 1st flowering

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

3.14.6 Days to 80% pod maturity

Days to 80% pod maturity were measured by counting the number of days required to attain maturity of 80% pods. Maturity was measured on the basis of brown colour of leaves and stem and dark grey colour of pods.

3.14.7 Pods plant^{-1}

Numbers of total pods (no.) of selected plants from each plot were counted and the mean numbers were expressed as per plant basis. Data were recorded as the average of 10 plants selected at random from the inner rows of each plot.

3.14.8 Seeds pod^{-1}

The number of seeds (no.) per pod was recorded randomly from selected pods at the time of harvest. Data were recorded as the average of 10 pods selected at random from the inner rows of each plot.

3.14.9 Pod length

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

3.14.10 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 weight was expressed in gram (g).

3.14.11 Seed yield per hectare

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

3.14.12 Stover yield per hectare

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

3.14.13 Available boron in seed sample

Available boron (B) content in the seed sample was determined. The extracting agent monocalcium phosphate [$Ca(H_2PO_4)_2$. H_2O] solution was used and colour was developed by curcumin solution. The absorbance was read on spectrophotometer at 555 nm wavelengths.

3.15 Statistical analysis

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

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to study the growth and yield performance of mungbean by using different doses of boron fertilizer. Data on different yield contributing characters and yield were recorded. The analyses of variance (ANOVA) of the data on different parameters are presented in Appendix III-VII. The results have been presented with the help of table and graphs and possible interpretations given under the following headings:

4.1 Plant height

Plant height varied significantly at 20, 30, 40, 50, 60 DAS and at harvest for BARI mung-1 and BARI mung-5 under the present study (Table 1; Appendix III). At 20, 30, 40, 50, 60 DAS and at harvest showed higher plant height (10.60, 21.65, 33.28, 41.41, 51.64 and 57.83 cm, respectively) of V_2 (BARI mung-5) over V_1(BARI mung-1). (9.01 cm, 19.63, 29.56, 36.88, 48.96 and 54.80 cm, respectively) .Different variety produced different plant height on the basis of their varietal characters. Raj and Tripathi (2005) reported that cultivar K-851 gave significantly longest plant compared to RMG-62.

Significant difference was recorded for different levels of boron on plant height at 20, 30, 40, 50, 60 DAS and at harvest (Table 2; Appendix III). At 20, 30, 40, 50, 60 DAS and at harvest, the tallest plant (11.06, 23.37, 35.04, 41.86, 53.64 and 59.52 cm, respectively) was observed from B_3 (2.0 kg H_3BO_3 ha^{-1}), which was

Table 1. Effects of varieties on plant height of mungbean

Variety	Plant height (cm) at					
	20 DAS	30 DAS	40 DAS	50 DAS	60 DAS	At harvest
V_1	9.01 b	19.63 b	29.56 b	36.88 b	48.96 b	54.80 b
V_2	10.60 a	21.65 a	33.28 a	41.41 a	51.64 a	57.83 a
Level of Significance	**	**	**	**	**	**
$LSD_{(0.05)}$	0.865	0.851	2.120	2.572	1.527	1.504
CV(%)	10.07	5.71	7.70	7.50	9.47	6.05

V_1: BARI mung-1 V_2: BARI mung-5

Table 2. Effects of boron on plant height of mungbean

Levels of boron	Plant height (cm) at					
	20 DAS	30 DAS	40 DAS	50 DAS	60 DAS	At harvest
B_0	8.33 b	17.50 d	26.56 c	35.00 b	45.25 c	51.67 c
B_1	9.25 b	19.52 c	30.32 b	38.75 a	49.29 b	55.11 b
B_2	10.57 a	22.17 b	33.76 a	40.97 a	53.02 a	58.94 a
B_3	11.06 a	23.37 a	35.04 a	41.86 a	53.64 a	59.52 a
Level of Significant	**	**	**	**	**	**
$LSD_{(0.05)}$	1.223	1.203	2.998	3.638	2.160	2.126
CV(%)	10.07	5.71	7.70	7.50	9.47	6.05

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

B_0: 0 kg H_3BO_3 ha^{-1} (Control) B_1: 1.0 kg H_3BO_3 ha^{-1}
B_2: 1.5 kg H_3BO_3 ha^{-1} B_3: 2.0 kg H_3BO_3 ha^{-1}

** Significant at 1% level of probability

Statistically identical (10.57, 22.17, 33.76, 40.97, 53.02 and 58.94 cm, respectively) to B_2 (1.5 kg H_3BO_3 ha^{-1}), while the shortest plant (8.33, 17.50, 26.56, 35.00, 45.25 and 51.67 cm, respectively) from B_0 (control) followed by B_1 (1.0 kg H_3BO_3 ha^{-1}) (9.25, 19.52, 30.32, 38.75, 49.29 and 55.11 cm, respectively).

Comparison effect of mungbean varieties and levels of boron showed significant differences on plant height at 20, 30, 40, 50, 60 DAS and at harvest (Table 3; Appendix III). At 20, 30, 40, 50, 60 DAS and at harvest the tallest plant (11.51, 24.01, 37.28, 44.46, 54.33, 60.96 cm, respectively) was found from V_2B_3 (BARI mung-5 + 2.0 kg H_3BO_3 ha^{-1}), while the shortest (6.63, 15.43, 22.90, 31.85, 41.51 and 48.53 cm, respectively) from V_1B_0 (BARI mung-1 + 0 kg H_3BO_3 ha^{-1}).

4.2 Number of branches plant^{-1}

Significant variation was recorded for number of branches plant^{-1} at 20, 30, 40, 50, 60 DAS and at harvest for BARI mung-1 and BARI mung-5 under the present trial (Table 4; Appendix IV). At 20, 30, 40, 50, 60 DAS and at harvest the maximum number of branches plant^{-1} (1.65, 3.87, 8.48, 16.23, 19.89 and 22.94, respectively) was found from V_2 (BARI mung-5) and the minimum (1.42, 3.45, 7.85, 13.98, 16.68 and 19.85, respectively) from V_1 (BARI mung-1). Previous findings suggested that management practices influenced the number of branches plant^{-1} but varieties itself manipulated the number of branches hill^{-1}. Aghaalikhani *et al.* (2006) working on two cultivars (Partow and Gohar) and a line of mungbean (VC-1973A) found that the line was superior to the other cultivars due to its increased number of branches per plant.

Table 3. A Comparison effect of varieties and levels of boron on plant height of two cultivars of mungbean

Variety	Levels of boron	Plant height (cm) at					
		20 DAS	30 DAS	40 DAS	50 DAS	60 DAS	At harvest
V_1	B_0	6.63 b	15.43 f	22.90 e	31.85 d	41.51 d	48.53 e
	B_1	8.06 b	18.46 e	26.85 de	34.13 cd	47.85 c	53.53 d
	B_2	10.73 a	21.87 bc	35.68 ab	42.28 ab	53.53 ab	59.03 ab
	B_3	10.61 a	22.74 ab	32.80 abc	39.26 abc	52.95 ab	58.09 ab
V_2	B_0	10.04 a	19.56 de	30.23 cd	38.16 bc	49.00 c	54.81 cd
	B_1	10.45 a	20.57 cd	33.78 abc	43.37 ab	50.73 bc	56.70 bc
	B_2	10.40 a	22.47 ab	31.84 bc	39.66 abc	52.51 ab	58.85 ab
	B_3	11.51 a	24.01 a	37.28 a	44.46 a	54.33 a	60.96 a
Level of Significance		*	*	**	*	**	*
$LSD_{(0.05)}$		1.729	1.701	4.239	5.145	3.054	3.007
CV(%)		10.07	5.71	7.70	7.50	9.47	6.05

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

V_1: BARI mung-1 V_2: BARI mung-5

B_0: 0 kg H_3BO_3 ha^{-1} (Control) B_1: 1.0 kg H_3BO_3 ha^{-1}

B_2: 1.5 kg H_3BO_3 ha^{-1} B_3: 2.0 kg H_3BO_3 ha^{-1}

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

Number of branches plant^{-1} showed significant variation for different levels of boron at 20, 30, 40, 50, 60 DAS and at harvest (Table 5; Appendix IV). At 20, 30, 40, 50, 60 DAS and at harvest, the maximum number of branches plant^{-1} (1.68, 4.28, 8.67, 16.60, 20.33 and 23.42, respectively) was recorded from B_3 (2.0 kg H_3BO_3 ha^{-1}), which was statistically identical (1.65, 4.00, 8.47, 15.73, 19.70 and 22.83, respectively) to B_2 (1.5 kg H_3BO_3 ha^{-1}), while the minimum number of branches plant^{-1} (1.23, 2.82, 7.38, 13.52, 15.55 and 18.33, respectively) from B_0 (0 kg H_3BO_3 ha^{-1}) followed (1.58, 3.53, 8.13, 14.57, 17.57 and 21.00, respectively) by B_1 (1 kg H_3BO_3 ha^{-1}). Number of branches plant^{-1} varied for different levels of boron. Rizk and Abdo (2001) also reported similar findings earlier from their experiment.

Statically significant difference was recorded due to the comparison effect of mungbean varieties and different levels of boron on number of branches plant^{-1} at 20, 30, 40, 50, 60 DAS and at harvest (Table 6; Appendix IV). At 20, 30, 40, 50, 60 DAS and at harvest the maximum number of branches plant^{-1} (1.87, 4.43, 9.27, 17.64, 22.26 and 25.51, respectively) was recorded from V_2B_3 (BARI mung-5 + 2.0 kg H_3BO_3 ha^{-1}). On the other hand the minimum number of branches plant^{-1} (1.07, 2.33, 6.47, 11.10, 13.17 and 15.40, respectively) was found from V_1B_0 (BARI mung-1 + 0 kg H_3BO_3 ha^{-1}).

Table 4. Effects of varieties on number of branches plant^{-1} of mungbean

Variety	Number of branches plant^{-1} at					
	20 DAS	30 DAS	40 DAS	50 DAS	60 DAS	At harvest
V_1	1.42 b	3.45 b	7.85 b	13.98 b	16.68 b	19.85 b
V_2	1.65 a	3.87 a	8.48 a	16.23 a	19.89 a	22.94 a
Level of Significance	**	**	*	**	**	**
$LSD_{(0.05)}$	0.068	0.251	0.512	1.038	0.517	0.912
CV(%)	5.02	7.84	7.16	8.85	10.23	8.87

V_1: BARI mung-1 V_2: BARI mung-5

Table 5. Effects of levels of boron on number of branches plant^{-1} of mungbean

Levels of boron	Number of branches plant^{-1} at					
	20 DAS	30 DAS	40 DAS	50 DAS	60 DAS	At harvest
B_0	1.23 b	2.82 c	7.38 b	13.52 c	15.55 c	18.33 c
B_1	1.58 a	3.53 b	8.13 a	14.57 bc	17.57 b	21.00 b
B_2	1.65 a	4.00 a	8.47 a	15.73 ab	19.70 a	22.83 a
B_3	1.68 a	4.28 a	8.67 a	16.60 a	20.33 a	23.42 a
Level of Significance	**	**	**	**	**	**
$LSD_{(0.05)}$	0.096	0.355	0.724	1.467	0.731	1.290
CV(%)	5.02	7.84	7.16	8.85	10.23	8.87

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

B_0: 0 kg H_3BO_3 ha^{-1} (Control) B_1: 1.0 kg H_3BO_3 ha^{-1}

B_2: 1.5 kg H_3BO_3 ha^{-1} B_3: 2.0 kg H_3BO_3 ha^{-1}

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

Table 6. A Comparison effect of varieties and levels of boron on number of branches $plant^{-1}$ of two cultivars of mungbean

Variety	Levels of boron	Number of branches $plant^{-1}$ at					
		20 DAS	30 DAS	40 DAS	50 DAS	60 DAS	At harvest
V_1	B_0	1.07 e	2.33 de	6.47 d	11.10 c	13.17 e	15.40 d
	B_1	1.50 cd	3.23 c	7.83 c	13.63 b	15.43 d	19.50 c
	B_2	1.63 bc	4.10 ab	9.03 ab	15.63 ab	19.70 b	23.20 b
	B_3	1.50 cd	4.13 ab	8.07 bc	15.53 ab	18.43 c	21.30 bc
V_2	B_0	1.40 d	3.30 c	8.30 abc	15.93 ab	17.93 c	21.27 bc
	B_1	1.67 b	3.83 b	8.43 abc	15.50 ab	19.70 b	22.50 b
	B_2	1.67 b	3.90 ab	7.90 c	15.83 ab	19.70 b	22.47 b
	B_3	1.87 a	4.43 a	9.27 a	17.64 a	22.26 a	25.51 a
Level of Significance		**	*	**	*	**	**
$LSD_{(0.05)}$		0.136	0.502	1.024	2.075	1.033	1.824
CV(%)		5.02	7.84	7.16	8.85	10.23	8.87

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

V_1: BARI mung-1 V_2: BARI mung-5

B_0: 0 kg H_3BO_3 ha^{-1} (Control) B_1: 1.0 kg H_3BO_3 ha^{-1}

B_2: 1.5 kg H_3BO_3 ha^{-1} B_3: 2.0 kg H_3BO_3 ha^{-1}

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

4.3 Number of leaves $plant^{-1}$

Significant variation was recorded for number of leaves $plant^{-1}$ at 20, 30, 40, 50, 60 DAS and at harvest for BARI mung-1 and BARI mung-5 under the present trial (Table 7; Appendix V). At 20, 30, 40, 50, 60 DAS and at harvest the maximum number of leaves $plant^{-1}$ (10.03, 31.40, 37.97, 50.36, 58.59 and 64.48, respectively) was found from V_2 (BARI mung-5) and the minimum (8.48, 27.50, 34.19, 43.94, 51.41 and 57.64, respectively) from V_1 (BARI mung-1).

Number of leaves $plant^{-1}$ showed significant variation for different levels of boron at 20, 30, 40, 50, 60 DAS and at harvest (Table 8; Appendix V). At 20, 30, 40, 50, 60 DAS and at harvest, the maximum number of leaves $plant^{-1}$ (10.25, 35.15, 39.12, 54.18, 62.83 and 69.37, respectively) was recorded from B_3 (2.0 kg H_3BO_3 ha^{-1}), which was statistically identical (9.95, 32.55, 37.72, 50.43, 60.37 and 66.77, respectively) to those shown by B_2 (1.5 kg $H_3BO_3ha^{-1}$), while the minimum number of leaves $plant^{-1}$ (7.13, 21.75, 31.47, 39.42, 44.63 and 48.82, respectively) from B_0 (0 kg H_3BO_3 ha^{-1}) followed by B_1 (0 kg H_3BO_3 ha^{-1}) (9.67, 28.35, 36.02, 44.57, 52.17 and 59.30, respectively).

Statistically significant difference was recorded due to the Comparison effect of mungbean variety and different levels of boron on number of leaves $plant^{-1}$ at 20, 30, 40, 50, 60 DAS and at harvest (Table 9; Appendix V). At 20, 30, 40, 50, 60 DAS and at harvest the maximum number of leaves $plant^{-1}$ (11.40, 36.50, 42.80, 56.97, 67.67 and 74.83, respectively) was recorded from V_2B_3 (BARI mung-5 + 2.0 kg H_3BO_3 ha^{-1}) and identical to V_2B_2. On the other hand the minimum number of leaves $plant^{-1}$ (5.87, 17.00, 25.83, 29.57, 37.80 and 39.43, respectively) from V_1B_0 (BARI mung-1 + 0 kg H_3BO_3 ha^{-1}).

Table 7. Effects of varieties on number of leaves plant^{-1} of mungbean

Variety	Number of leaves plant^{-1} at					
	20 DAS	30 DAS	40 DAS	50 DAS	60 DAS	At harvest
V_1	8.48 b	27.50 b	34.19 b	43.94 b	51.41 b	57.64 b
V_2	10.03 a	31.40 a	37.97 a	50.36 a	58.59 a	64.48 a
Level of Significance	**	**	**	**	**	**
$LSD_{(0.05)}$	0.544	2.089	3.028	4.986	2.542	3.474
CV(%)	6.72	8.10	9.58	12.08	5.28	6.50

V_1: BARI mung-1 V_2: BARI mung-5

Table 8. Effects of levels of boron on number of leaves plant^{-1} of mungbean

Levels of boron	Number of leaves plant^{-1} at					
	20 DAS	30 DAS	40 DAS	50 DAS	60 DAS	At harvest
B_0	7.13 b	21.75 c	31.47 b	39.42 c	44.63 c	48.82 c
B_1	9.67 a	28.35 b	36.02 a	44.57 bc	52.17 b	59.30 b
B_2	9.95 a	32.55 a	37.72 a	50.43 ab	60.37 a	66.77 a
B_3	10.25 a	35.15 a	39.12 a	54.18 a	62.83 a	69.37 a
Level of Significance	**	**	**	**	**	**
$LSD_{(0.05)}$	0.769	2.955	4.282	7.051	3.595	4.913
CV(%)	6.72	8.10	9.58	12.08	5.28	6.50

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

B_0: 0 kg H_3BO_3 ha^{-1} (Control) B_1: 1.0 kg H_3BO_3 ha^{-1}

B_2: 1.5 kg H_3BO_3 ha^{-1} B_3: 2.0 kg H_3BO_3 ha^{-1}

** Significant at 1% level of probability

Table 9. A Comparison effect of variety and levels of boron on number of leaves plant^{-1} of two cultivars of mungbean

Variety	Levels of boron	Number of leaves plant^{-1} at					
		20 DAS	30 DAS	40 DAS	50 DAS	60 DAS	At harvest
V_1	B_0	5.87 d	17.00 d	25.83 d	29.57 c	37.80 d	39.43 d
	B_1	9.23 bc	25.70 c	34.27 c	42.23 b	46.63 c	56.03 c
	B_2	9.70 b	33.50 ab	41.23 ab	52.57 ab	63.20 a	71.20 a
	B_3	9.10 bc	33.80 ab	35.43 bc	51.40 ab	58.00 b	63.90 b
V_2	B_0	8.40 c	26.50 c	37.10 abc	49.27 ab	51.47 c	58.20 bc
	B_1	10.10 b	31.00 b	37.77 abc	46.90 ab	57.70 b	65.57 bc
	B_2	10.20 b	34.60 a	40.20a	52.30 ab	63.53 a	69.33 abc
	B_3	11.40 a	36.50 a	42.80 a	56.97 a	67.67 a	74.83a
Level of Significance		*	**	**	*	**	**
$LSD_{(0.05)}$		1.088	4.179	6.055	9.972	5.084	6.948
CV(%)		6.72	8.10	9.58	12.08	5.28	6.50

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

V_1: BARI mung-1 V_2: BARI mung-5

B_0: 0 kg H_3BO_3 ha^{-1} (Control) B_1: 1.0 kg H_3BO_3 ha^{-1}

B_2: 1.5 kg H_3BO_3 ha^{-1} B_3: 2.0 kg H_3BO_3 ha^{-1}

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

4.4 Dry matter content plant^{-1}

Dry matter content in plant showed non-significant variation at 20, 30, 40, 50, 60 DAS and at harvest for BARI mung-1 and BARI mung-5 (Table 10; Appendix VI). At 20, 30, 40, 50, 60 DAS and at harvest the higher dry matter content in plant (7.23, 9.95, 11.73, 13.98, 14.84 and 16.81 g plant^{-1}, respectively) was obtained from V_2 (BARI mung-5), while the lower dry matter content (6.72, 8.82, 10.78, 12.69, 13.89 and 15.64 g plant^{-1}, respectively) was recorded from V_1 (BARI mung-1). Rahman *et al.* (2005) reported that the highest dry matter production ability was found in 4 modern mungbean cultivars, and dry matter partitioning was found highest in seeds of Binamung 2 and lowest in Local.

Statistically significant variation was obtained from dry matter content of plant at 20, 30, 40, 50, 60 DAS and at harvest due to different levels of boron (Table 11; Appendix VI). At 20, 30, 40, 50, 60 DAS and at harvest the highest dry matter content in plant (7.62, 10.01, 12.34, 14.43, 15.06 and 17.86 g plant^{-1}, respectively) was found from B_3 (2.0 kg H_3BO_3 ha^{-1}), which was statistically identical (7.50, 9.88, 11.93, 14.11, 14.96 and 17.15 g plant^{-1}, respectively) to B_2 (1.5 kg H_3BO_3 ha^{-1}), again the lowest dry matter content in plant (6.24, 8.82, 10.13, 12.36, 13.34 and 14.49 g plant^{-1}, respectively) from B_0 (0 kg H_3BO_3 ha^{-1}) which was statistically identical (6.53, 8.82, 10.62, 12.45, 14.10 and 15.15 g plant^{-1}, respectively) to B_1 (1.0 kg H_3BO_3 ha^{-1}) at 20, 30, 40, 50, 60 DAS and at harvest. Verma and Mishra (1999) reported that boron increased yield and growth parameters and dry matter content of mungbean.

Table 10. Effects of varieties on dry matter content in plant of mungbean

Variety	Dry matter content (g $plant^{-1}$)					
	20 DAS	30 DAS	40 DAS	50 DAS	60 DAS	At harvest
V_1	6.72 b	8.82 b	10.78 b	12.69 b	13.89 b	15.64 b
V_2	7.23 a	9.95 a	11.73 a	13.98 a	14.84 a	16.81 a
Level of Significance	**	**	**	**	*	*
$LSD_{(0.05)}$	0.363	0.601	0.741	0.863	0.800	0.994
CV(%)	5.94	7.31	7.51	7.38	6.36	7.00

V_1: BARI mung-1 V_2: BARI mung-5

Table 11. Effects of levels of boron on dry matter content in plant of mungbean

Levels of boron	Dry matter content (g $plant^{-1}$)					
	20 DAS	30 DAS	40 DAS	50 DAS	60 DAS	At harvest
B_0	6.24 b	8.82 b	10.13 b	12.36 b	13.34 b	14.49 b
B_1	6.53 b	8.82 b	10.62 b	12.45 b	14.10 ab	15.41 b
B_2	7.50 a	9.88 a	11.93 a	14.11 a	14.96 a	17.15 a
B_3	7.62 a	10.01 a	12.34 a	14.43 a	15.06 a	17.86 a
Level of Significance	**	**	**	**	**	**
$LSD_{(0.05)}$	0.514	0.850	1.047	1.220	1.131	1.406
CV(%)	5.94	7.31	7.51	7.38	6.36	7.00

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

B_0: 0 kg H_3BO_3 ha^{-1} (Control) B_1: 1.0 kg H_3BO_3 ha^{-1}

B_2: 1.5 kg H_3BO_3 ha^{-1} B_3: 2.0 kg H_3BO_3 ha^{-1}

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

Dry matter content in plant at 20, 30, 40, 50, 60 DAS and at harvest showed significant differences due to the Comparison effect of mungbean variety and different levels of boron (Table 12; Appendix VI). At 20, 30, 40, 50, 60 DAS and at harvest the highest dry matter content in plant (7.89, 10.13, 12.53, 14.87, 15.61 and 18.76 g $plant^{-1}$, respectively) was attained from V_2B_3 (BARI mung-5 + 2.0 kg H_3BO_3 ha^{-1}), while the lowest dry matter content in plant (5.69, 7.50, 8.75, 11.03, 12.44 and 13.13 g $plant^{-1}$, respectively) from V_1B_0 (BARI mung-1 + 0 kg H_3BO_3 ha^{-1}).

4.5 Days to 1st flowering

BARI mung-1 and BARI mung-5 showed significant differences for days to 1st flowering under the present trial (Table 13; Appendix VII). The maximum days to 1st flowering (36.67) was found from V_1 (BARI mung-1), again the minimum days to 1st flowering (34.56) from V_2 (BARI mung-5). Days to 1st flowering varied for different varieties might be due to genetical and environmental influences as well as management practices. Shamsuzzaman *et al.* (2004) reported Binamung-2 performed slightly better than Binamung-5 for synchronous in flowering.

Days to 1st flowering differed significantly for different levels of boron under the present experiment (Table 14; Appendix VII). The maximum days to 1st flowering (36.50) was recorded from B_0 (0 kg H_3BO_3 ha^{-1}), which was statistically similar (36.33 and 35.50) to B_1 (1.0 kg H_3BO_3 ha^{-1}) and B_3 (2.0 kg H_3BO_3 ha^{-1}). On the other hand, the minimum (34.17) was recorded from B_2 (1.5 kg H_3BO_3 ha^{-1}).

Table 12. A comparison effect of varieties and levels of boron on dry matter content of two cultivars of mungbean

Variety	Levels of boron	Dry matter content (g plant^{-1})					
		20 DAS	30 DAS	40 DAS	50 DAS	60 DAS	At harvest
V_1	B_0	5.69 d	7.50 b	8.75 c	11.03 c	12.44 c	13.13 d
	B_1	6.02 d	8.12 b	10.08 bc	11.63 bc	12.82 bc	14.21 cd
	B_2	7.80 ab	9.78 a	12.15 a	14.13 a	15.80 a	18.27 a
	B_3	7.35 abc	9.89 a	12.15 a	13.99 a	14.50 ab	16.95 ab
V_2	B_0	6.79 c	10.15 a	11.52 ab	13.69 a	14.23 ab	15.85 bc
	B_1	7.03 bc	9.53 a	11.16 ab	13.27 ab	15.38 a	16.62 ab
	B_2	7.20 abc	9.97 a	11.72 a	14.09 a	14.13 ab	16.03 bc
	B_3	7.89a	10.13 a	12.53 a	14.87 a	15.61 a	18.76 a
Level of Significance		**	*	*	*	**	**
$LSD_{(0.05)}$		0.726	1.202	1.481	1.725	1.599	1.988
CV(%)		5.94	7.31	7.51	7.38	6.36	7.00

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

V_1: BARI mung-1 V_2: BARI mung-5

B_0: 0 kg H_3BO_3 ha^{-1} (Control) B_1: 1.0 kg H_3BO_3 ha^{-1}

B_2: 1.5 kg H_3BO_3 ha^{-1} B_3: 2.0 kg H_3BO_3 ha^{-1}

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

Table 13. Effects of variety on days to flowering and days to 80% pod maturity of mungbean

Variety	Days to 1st flowering	Days to 80% pod maturity
V_1	36.67 a	73.58 a
V_2	34.56 b	70.42 b
Level of Significance	**	**
$LSD_{(0.05)}$	0.718	1.576
CV(%)	12.30	9.50

V_1: BARI mung-1 V_2: BARI mung-5

Table 14. Effects of levels of boron on days to flowering and days to 80% pod maturity of mungbean

Levels of nitrogen	Days to 1st flowering	Days to 80% pod maturity
B_0	36.50 a	74.67 a
B_1	36.33 a	73.50 a
B_2	34.17 b	70.50 b
B_3	35.50 a	69.33 b
Level of Significance	**	**
$LSD_{(0.05)}$	1.016	2.228
CV(%)	12.30	9.50

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

B_0: 0 kg H_3BO_3 ha^{-1} (Control) B_1: 1.0 kg H_3BO_3 ha^{-1}
B_2: 1.5 kg H_3BO_3 ha^{-1} B_3: 2.0 kg H_3BO_3 ha^{-1}

** Significant at 1% level of probability

Variety and different levels of boron showed significant variation on days to 1st flowering due to the interaction effect (Table 15; Appendix VII). The maximum days to 1st flowering (40.33) was observed from V_1B_0 (BARI mung-1 + 0 kg H_3BO_3 ha^{-1}), again the minimum days (32.67) from V_2B_0 (BARI mung-5 + 0 kg H_3BO_3 ha^{-1}).

4.6 Days to 80% pod maturity

Days to 80% pod maturity showed statistically significant variation for BARI mung-1 and BARI mung-5 under the present trial (Table13; Appendix VII). The maximum days to 80% pod maturity (73.58) was found from V_1 (BARI mung-1), while the minimum days to 80% pod maturity (70.42) from V_2 (BARI mung-5). Aghaalikhani *et al.* (2006) reported that VC-1973A was superior to cultivars Partow and Gohar due to its early and uniform seed maturity

Different levels of boron showed significant differences on days to 80% pod maturity (Table 14; Appendix VII). The maximum days to 80% pod maturity (74.67) was observed from B_0 (0 kg H_3BO_3 ha^{-1}), which was identical (73.50) to B_1 (1.0 kg H_3BO_3 ha^{-1}), while the minimum days (69.33) from B_3 (2.0 kg H_3BO_3 ha^{-1}) which was statistically similar (70.50) to B_2 (1.5 kg H_3BO_3 ha^{-1}).

comparison effect of mungbean variety and different levels of boron showed significant variation for days to 80% pod maturity (Table 15; Appendix VII). The maximum days to 80% pod maturity (78.33) was recorded from V_1B_0 (BARI mung-1 + 0 kg H_3BO_3 ha^{-1}) and the minimum (69.33) from V_2B_3 (BARI mung-5 + 2.0 kg H_3BO_3 ha^{-1}) that was statistically similar to V_2B_2 (1.5kg H_3BO_3 ha^{-1})

Table 15. A comparison effect of varieties and levels of boron on days to1st flowering and days to 80% pod maturity of mungbean

Variety	Levels of boron	Days to 1st flowering	Days to 80% pod maturity
V_1	B_0	40.33 a	78.33 a
	B_1	37.00 b	74.67 b
	B_2	33.33 d	70.00 cd
	B_3	36.00 bc	71.33 c
V_2	B_0	32.67 d	71.00 c
	B_1	35.67 bc	72.33 bc
	B_2	35.00 c	71.00 c
	B_3	35.00 c	69.33 c
Level of Significance		**	**
$LSD_{(0.05)}$		1.437	3.151
CV(%)		12.30	9.50

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

V_1: BARI mung-1 V_2: BARI mung-5

B_0: 0 kg H_3BO_3 ha^{-1} (Control) B_1: 1.0 kg H_3BO_3 ha^{-1}

B_2: 1.5 kg H_3BO_3 ha^{-1} B_3: 2.0 kg H_3BO_3 ha^{-1}

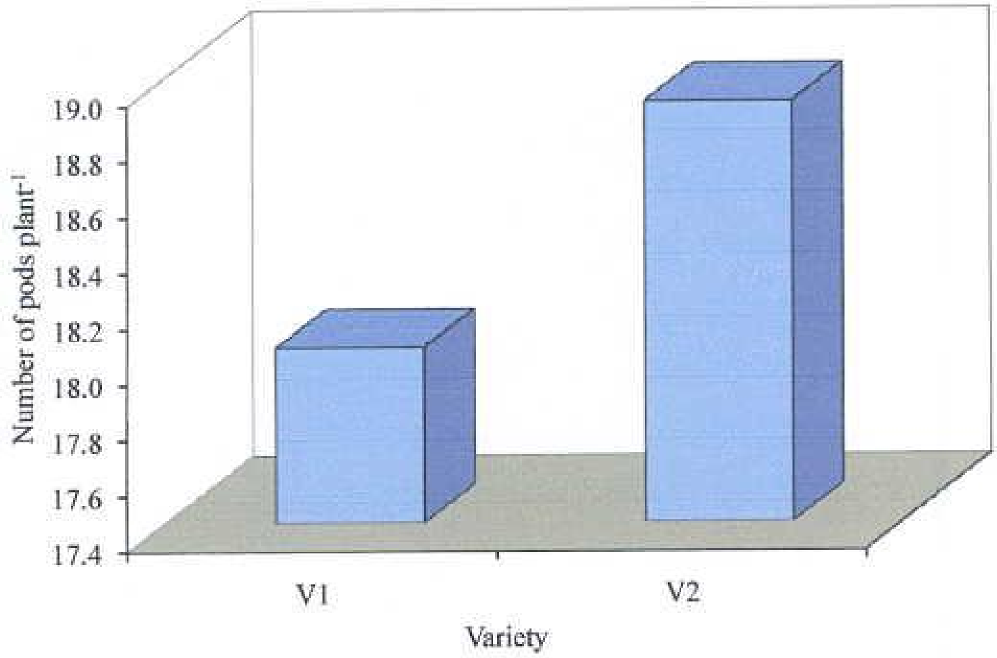
** Significant at 1% level of probability

4.7 Pods plant^{-1}

In the context of number of pods plant^{-1} significant variation was recorded for BARI mung-1 and BARI mung-5 (Figure 2; Appendix VII). The higher number of pods plant^{-1} (18.91) was recorded from V_2 (BARI mung-5), whereas the lower number of pods plant^{-1} (18.03) from V_1 (BARI mung-1). Different varieties responded differently to input supply, method of cultivation and the prevailing environment during the growing season. Raj and Tripathi (2005) reported that cultivar K-851 gave significantly higher values for pods per plant compared to RMG-62.

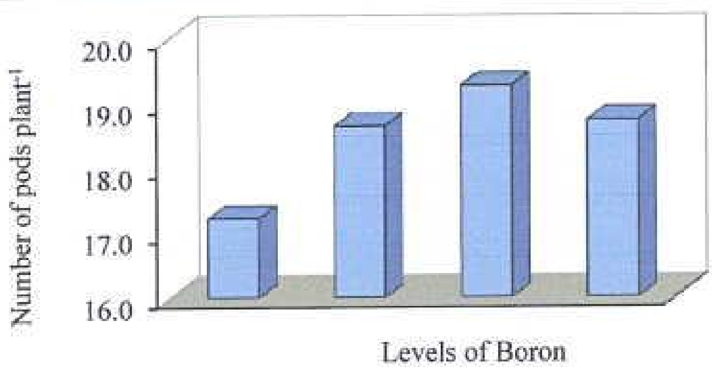
Number of pods plant^{-1} varied significantly for different levels of boron (Figure 3; Appendix VII). The highest number of pods plant^{-1} (19.28) was found from B_2 (1.5 kg H_3BO_3 ha^{-1}), which was statistically similar (18.74 and 18.65) to B_3 (2.0 kg H_3BO_3 ha^{-1}), and B_1 (1.0 kg H_3BO_3 ha^{-1}). On the other hand, the lowest number of pods plant^{-1} (17.22) was recorded from B_0 (0 kg H_3BO_3 ha^{-1}).

Statistically significant variation was recorded due to the comparison effect of mungbean variety and different levels of boron on number of pods plant^{-1} (Figure 4; Appendix VII). The highest number of pods plant^{-1} (19.75) was recorded from V_2B_2 (BARI mung-5 + 1.5 kg H_3BO_3 ha^{-1}) and the lowest number of pods plant^{-1} (16.91) from V_1B_0 (BARI mung-1 + 0 kg H_3BO_3 ha^{-1}).



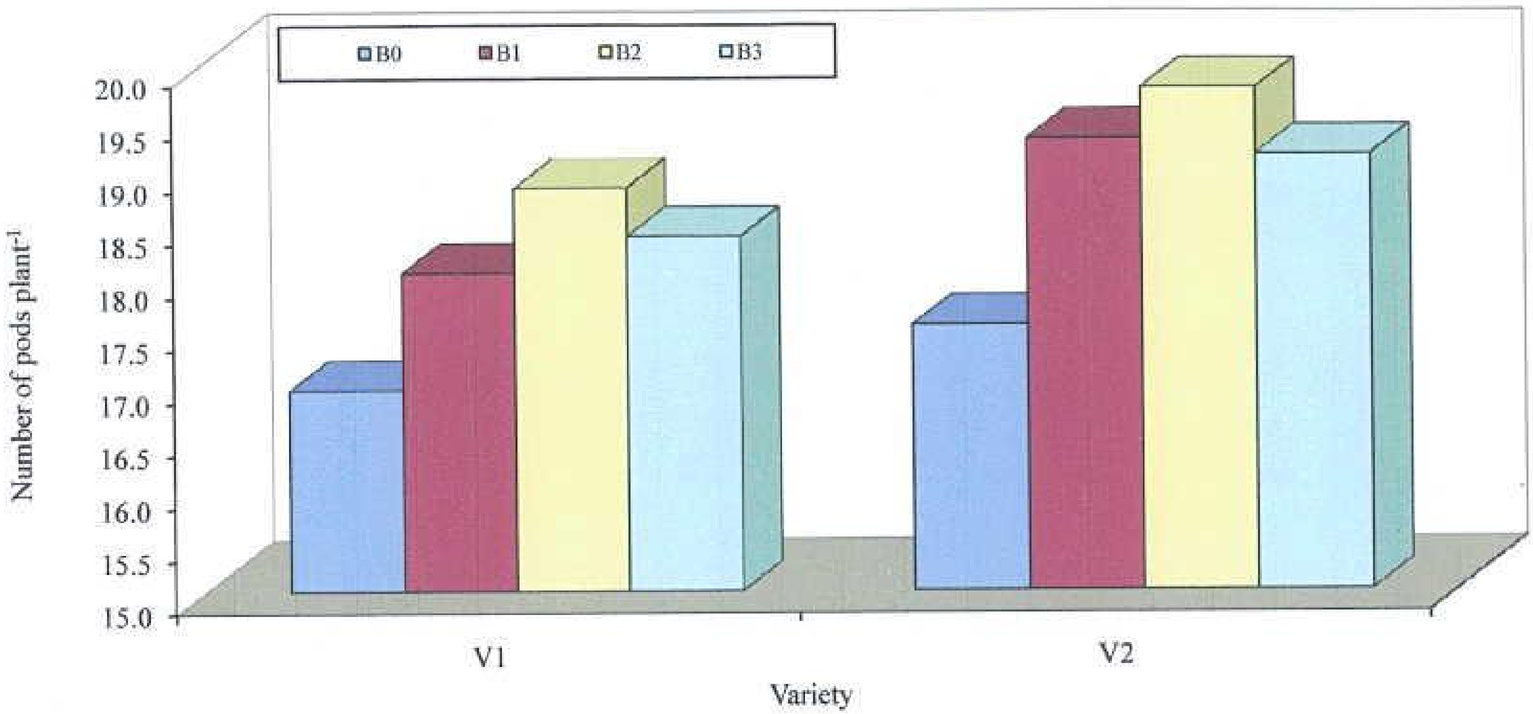
V_1: BARI mung-1 V_2: BARI mung-5

Figure 2. Effects of varieties on number of pods plant^{-1} of mungbean



B_0: Control (0 kg H_3BO_3 ha^{-1}) B_1: 1.0 kg H_3BO_3 ha^{-1}
B_2: 1.5 kg H_3BO_3 ha^{-1} B_3: 2.0 kg H_3BO_3 ha^{-1}

Figure 3. Effects of levels of boron on number of pods plant^{-1} of mungbean



V_1: BARI mung-1
V_2: BARI mung-5

B_0: Control (0 kg H_3BO_3 ha^{-1})
B_2: 1.5 kg H_3BO_3 ha^{-1}

B_1: 1.0 kg H_3BO_3 ha^{-1}
B_3: 2.0 kg H_3BO_3 ha^{-1}

Figure 4. Comparison effect of varieties and level of boron on number of pods $plant^{-1}$ of mungbean

4.8 Pod length

Statistically significant variation was recorded for pod length in BARI mung-1 and BARI mung-5 in this present study (Table 16; Appendix VII). The longest pod (8.10 cm) was recorded from V_2 (BARI mung-5), whereas the shortest pod (7.30 cm) from V_1 (BARI mung-1).

Different levels of boron showed significant variation on pod length (Table 17; Appendix VII). The longest pod length (8.43 cm) was found from B_2 (1.5 kg H_3BO_3 ha^{-1}), which was statistically similar (8.31 cm) to B_3 (2.0 kg H_3BO_3 ha^{-1}) and the shortest pod (6.78 cm) from B_0 (0 kg H_3BO_3 ha^{-1}) which was statistically identical (7.29 cm) to B_1 (1.0 kg H_3BO_3 ha^{-1}).

Varieties and different levels of boron showed significant differences on pod length due to comparison effect (Table 18; Appendix VII). The longest pod (8.84 cm) was attained from V_2B_2 (BARI mung-5 + 1.5 kg H_3BO_3 ha^{-1}) which was statistically identical with V_1B_3 and all other levels of boron of V_2, while the shortest pod (5.80 cm) from V_1B_0 (BARI mung-1 + 0 kg H_3BO_3 ha^{-1}).

4.9 Seeds pod^{-1}

Number of seeds pod^{-1} varied significantly for BARI mung-1 and BARI mung-5 under the present experiment (Figure 5; Appendix VII). The higher number of seeds pod^{-1} (10.12) was found from V_2 (BARI mung-5), again the lower number of seeds pod^{-1} (8.75) from V_1 (BARI mung-1).

Table 16. Effects of variety on pod length, weight of 1000-seeds, seed yield and stover yield of mungbean

Variety	Pod length (cm)	Weight of 1000-seed (g)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})
V_1	7.30 b	40.64 a	1.29b	2.04 b
V_2	8.10 a	42.34 a	1.54 a	2.32 a
Level of Significance	**	NS	**	**
$LSD_{(0.05)}$	0.519	--	0.09	0.124
CV(%)	7.70	6.35	7.59	6.52

V_1: BARI mung-1 V_2: BARI mung-5

Table 17. Effects of levels of boron on pod length, weight of 1000-seeds, seed yield and straw yield of mungbean

Levels of nitrogen	Pod length (cm)	Weight of 1000-seed (g)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})
B_0	6.78 b	36.14 c	1.18 b	1.88 c
B_1	7.29 b	39.46 b	1.43 a	2.13 b
B_2	8.43 a	45.27 a	1.52 a	2.31 a
B_3	8.31 a	45.08 a	1.53 a	2.40 a
Level of Significance	**	**	**	**
$LSD_{(0.05)}$	0.734	3.263	0.130	0.175
CV(%)	7.70	6.35	7.59	6.52

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

B_0: 0 kg H_3BO_3 ha^{-1} (Control) B_1: 1.0 kg H_3BO_3 ha^{-1}

B_2: 1.5 kg H_3BO_3 ha^{-1} B_3: 2.0 kg H_3BO_3 ha^{-1}

** Significant at 1% level of probability

Table 18. A. Comparison effect of variety and levels of boron on pod length, weight of 1000-seeds, seed yield and Stover yield of mungbean

Variety	Levels of boron	Pod length (cm)	Weight of 1000 seeds (g)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})
V_1	B_0	5.80 b	34.33 d	1.04 d	1.56 e
	B_1	6.64 b	38.45 cd	1.32 c	1.82 d
	B_2	8.77 a	44.33 ab	1.51 b	2.48 a
	B_3	8.01 a	45.44 ab	1.27 c	2.31 abc
V_2	B_0	7.77 a	37.96 cd	1.31 c	2.20 bc
	B_1	7.95 a	40.47 bc	1.53 b	2.44 ab
	B_2	8.84 a	46.21 a	1.79 a	2.14 c
	B_3	7.85 a	44.72 ab	1.53 b	2.49 a
Level of Significance		**	**	**	**
$LSD_{(0.05)}$		1.038	4.615	0.184	0.248
CV(%)		7.70	6.35	7.59	6.52

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

V_1: BARI mung-1

V_2: BARI mung-5

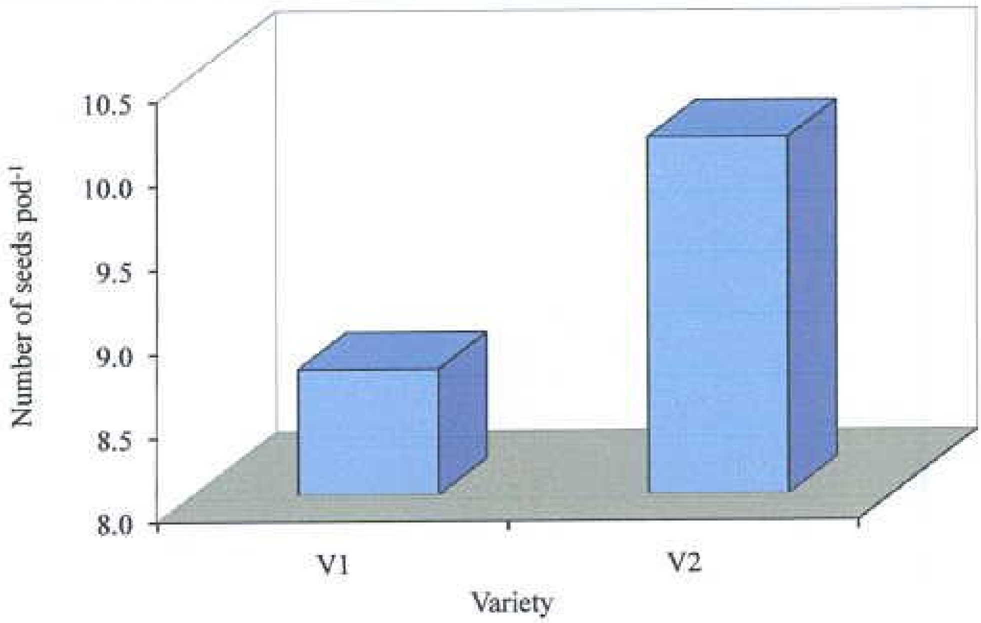
B_0: 0 kg H_3BO_3 ha^{-1} (Control)

B_1: 1.0 kg H_3BO_3 ha^{-1}

B_2: 1.5 kg H_3BO_3 ha^{-1}

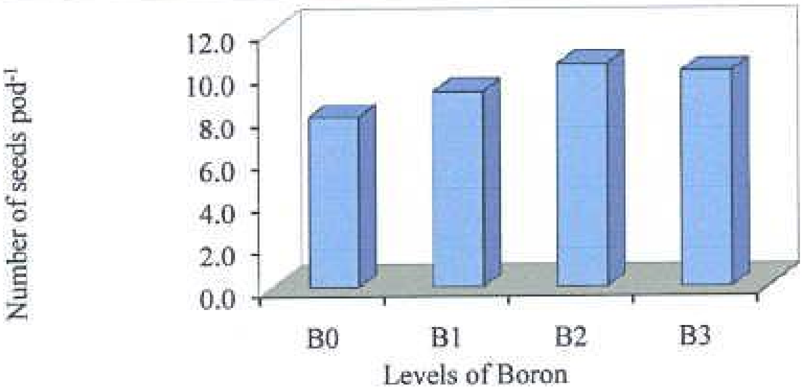
B_3: 2.0 kg H_3BO_3 ha^{-1}

** Significant at 1% level of probability



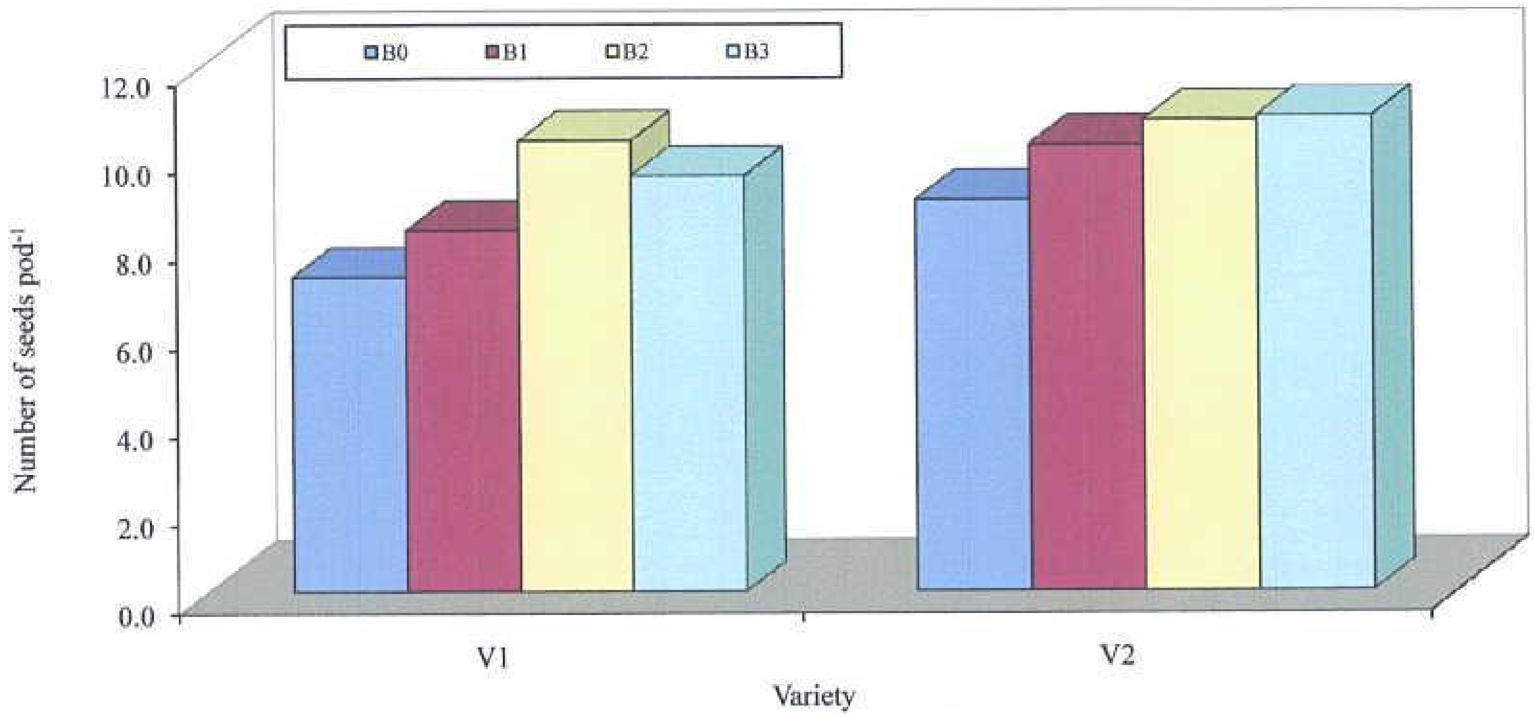
V_1: BARI mung-1 V_2: BARI mung-5

Figure 5. Effects of variety on number of seeds pod^{-1} of mungbean



B_0: Control (0 kg H_3BO_3 ha^{-1})
B_1: 1.0 kg H_3BO_3 ha^{-1}
B_2: 1.5 kg H_3BO_3 ha^{-1}
B_3: 2.0 kg H_3BO_3 ha^{-1}

Figure 6. Effects of levels of boron on number of seeds pod^{-1} of mungbean



V_1: BARI mung-1
V_2: BARI mung-5

B_0: Control (0 kg H_3BO_3 ha^{-1})
B_2: 1.5 kg H_3BO_3 ha^{-1}

B_1: 1.0 kg H_3BO_3 ha^{-1}
B_3: 2.0 kg H_3BO_3 ha^{-1}

Figure 7.A Comparison on the effect of boron on mungbean of seeds pod^{-1} of the two cultivars of mungbean

Significant variation was recorded for different levels of boron on number of seeds pod^{-1} (Figure 6; Appendix VII). The highest number of seeds pod^{-1} (10.45) was obtained from B_2 (1.5 kg H_3BO_3 ha^{-1}), which was statistically identical (10.11) to B_3 (2.0 kg H_3BO_3 ha^{-1}). On the other hand, the lowest number of seeds pod^{-1} (8.01) from B_0 (0 kg H_3BO_3 ha^{-1}) which was closely followed (9.17) by B_1 (1.0 kg H_3BO_3 ha^{-1}).

Comparison effect of mungbean variety and different levels of boron varied significantly on number of seeds pod^{-1} (Figure 7; Appendix VII). The highest number of seeds pod^{-1} (10.78) was recorded from V_2B_3 (BARI mung-5 + 2.0 kg H_3BO_3 ha^{-1}), while the lowest number of seeds pod^{-1} (7.15) from V_1B_0 (BARI mung-1 + 0 kg H_3BO_3 ha^{-1}).

4.10 Weight of 1000-seeds

Weight of 1000-seed showed non-significant differences for BARI mung-1 and BARI mung-5 under the present experiment (Table 16; Appendix VII). The maximum weight of 1000-seed (42.34 g) was observed from V_2 (BARI mung-5) and the minimum weight (40.64 g) from V_1 (BARI mung-1). Raj and Tripathi (2005) reported that cultivar K-851 gave significantly higher values for 1000-seeds weight compared to RMG-62.

Statistically significant variation was observed on weight of 1000-seed due to different levels of boron (Table 17; Appendix VII). The maximum weight of 1000-seed (45.27 g) was recorded from B_2 (1.5 kg H_3BO_3 ha^{-1}), which was statistically identical (45.08 g) to B_3 (2.0 kg H_3BO_3 ha^{-1}). Again the minimum weight of 1000-seeds (36.14 g) was obtained from B_0 (0 kg H_3BO_3 ha^{-1}) which was closely followed (39.46 g) to B_1 (1.0 kg H_3BO_3 ha^{-1}).

Weight of 1000-seed showed significant differences due to comparison effect of mungbean variety and different levels of boron (Table 18; Appendix VII). The maximum weight of 1000-seeds (46.21 g) was observed from V_2B_2 (BARI mung-5 + 1.5 kg H_3BO_3 ha^{-1}), while the minimum weight of 1000-seed (34.33 g) from V_1B_0 (BARI mung-1 + 0 kg H_3BO_3 ha^{-1}).

4.11 Seed yield

Significant variation was recorded for seed yield of mungbean in BARI mung-1 and BARI mung-5 under the present trial (Table 16; Appendix VII). The higher seed yield (1.54 t ha^{-1}) was observed from V_2 (BARI mung-5), whereas the lower seed yield (1.29 t ha^{-1}) from V_1 (BARI mung-1). Seed yield varied for different varieties might be due to genetical and environmental influences as well as management practices. Quaderi *et al.* (2006) reported that mungbean varieties, Binamoog-5 performed better than that of BINA moog-4 in context of yield. Tickoo *et al.* (2006) recorded that the cultivar Pusa Vishal recorded higher grain yield (1.63 t/ha) compared to cv. Pusa 105.

Different levels of boron showed significant variation on seed yield of mungbean (Table 17; Appendix VII). The higher seed yield (1.53 t ha^{-1}) was obtained from B_3 (2.0 kg H_3BO_3 ha^{-1}), which was statistically similar (1.52 t ha^{-1} and 1.43 t ha^{-1}) to B_2 (1.5 kg H_3BO_3 ha^{-1}) and B_1 (1.0 kg H_3BO_3 ha^{-1}), again the lower seed yield (1.18 t ha^{-1}) from B_0 (0 kg H_3BO_3 ha^{-1}). Verma and Mishra (1999) reported that boron increased yield and growth parameters, to the best results in terms of seed yield/plant.

Comparison effect of mungbean variety and different levels of boron showed significant differences on seed yield of mungbean (Table 18; Appendix VII). The highest seed yield (1.79 t ha^{-1}) was found from V_2B_2 (BARI mung-5 + 1.5 kg H_3BO_3 ha^{-1}) and the lowest yield (1.04 t ha^{-1}) from V_1B_0 (BARI mung-1 + 0 kg H_3BO_3 ha^{-1}).

4.12 Stover yield

Statistically significant variation was recorded for stover yield of BARI mung-1 and BARI mung-5 under the present experiment (Table 16; Appendix VII). The highest stover yield (2.32 t ha^{-1}) was recorded from V_2 (BARI mung-5), again the lowest stover yield (2.04 t ha^{-1}) from V_1 (BARI mung-1). Bhati *et al.* (2005) mungbean cv. PDM-54 showed 13.7% higher fodder yield than the local cultivar.

Stover yield of mungbean varied significantly for different levels of boron (Table 17; Appendix VII). The highest stover yield (2.40 t ha^{-1}) was observed from B_3 (2.0 kg H_3BO_3 ha^{-1}), which was statistically identical (2.31 t ha^{-1}) to B_2 (1.5 kg H_3BO_3 ha^{-1}), while the lowest stover yield (1.88 t ha^{-1}) from B_0 (0 kg H_3BO_3 ha^{-1}).

Variety and different levels of boron showed significant differences on stover yield of mungbean due to comparison effect (Table 18; Appendix VII). The highest stover yield (2.49 t ha^{-1}) was observed from V_2B_3 (BARI mung-5 + 2.0 kg

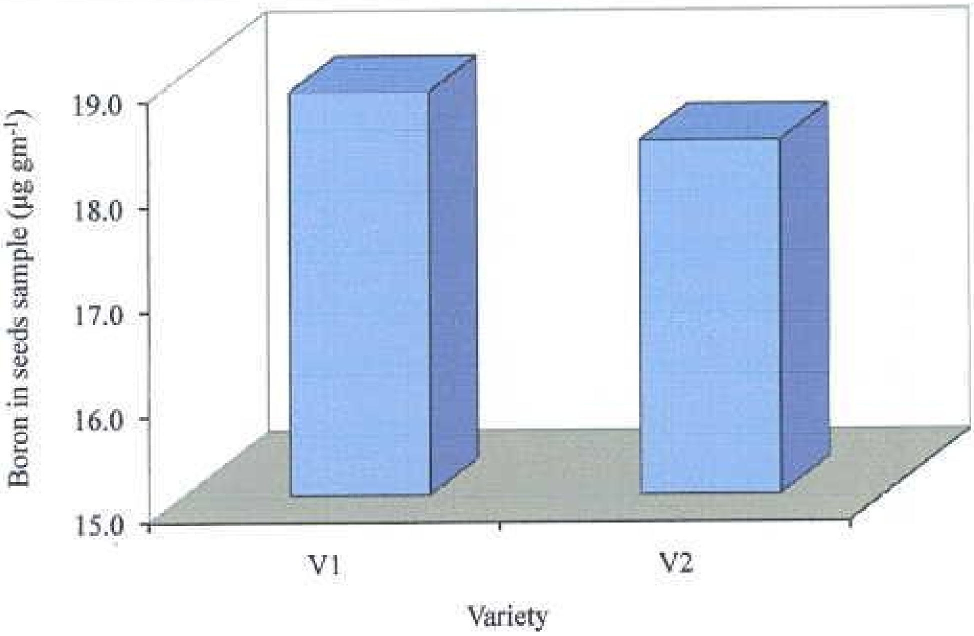
H_3BO_3 ha^{-1}), whereas the lowest stover yield (1.56 t ha^{-1}) from V_1B_0 (BARI mung-1 + 0 kg H_3BO_3 ha^{-1}).

4.13 Available boron in seeds

Statistically non-significant variation was recorded for available boron in seeds of BARI mung-1 and BARI mung-5 under the present experiment (Figure 8; Appendix VII). The highest available boron in seeds (18.83 μg gm^{-1}) was recorded from V_1 (BARI mung-1), again the lowest available boron in seeds (18.36 μg gm^{-1}) from V_2 (BARI mung-5).

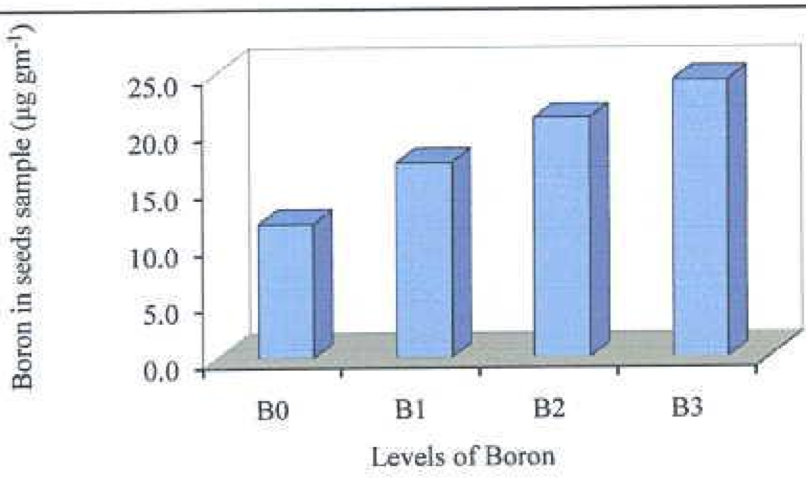
Available boron in seeds of mungbean varied significantly for different levels of boron (Figure 9; Appendix VII). The highest available boron in seeds (24.33 μg gm^{-1}) was observed from B_3 (2.0 kg H_3BO_3 ha^{-1}), which was closely followed (21.05 μg gm^{-1}) to B_2 (1.5 kg H_3BO_3 ha^{-1}), while the lowest available boron in seeds (11.83 μg gm^{-1}) from B_0 (0 kg H_3BO_3 ha^{-1}) which was followed (17.17 μg gm^{-1}) by B_1 (1.0 kg H_3BO_3 ha^{-1}).

Variety and different levels of boron showed significant differences on available boron in seeds of mungbean due to interaction effect (Figure 10; Appendix VII). The highest available boron in seeds (24.33 μg gm^{-1}) was observed from V_2B_3 (BARI mung-5 + 2.0 kg H_3BO_3 ha^{-1}), whereas the lowest available boron in seeds (13.33 μg gm^{-1}) from V_1B_0 (BARI mung-1 + 0 kg H_3BO_3 ha^{-1}).



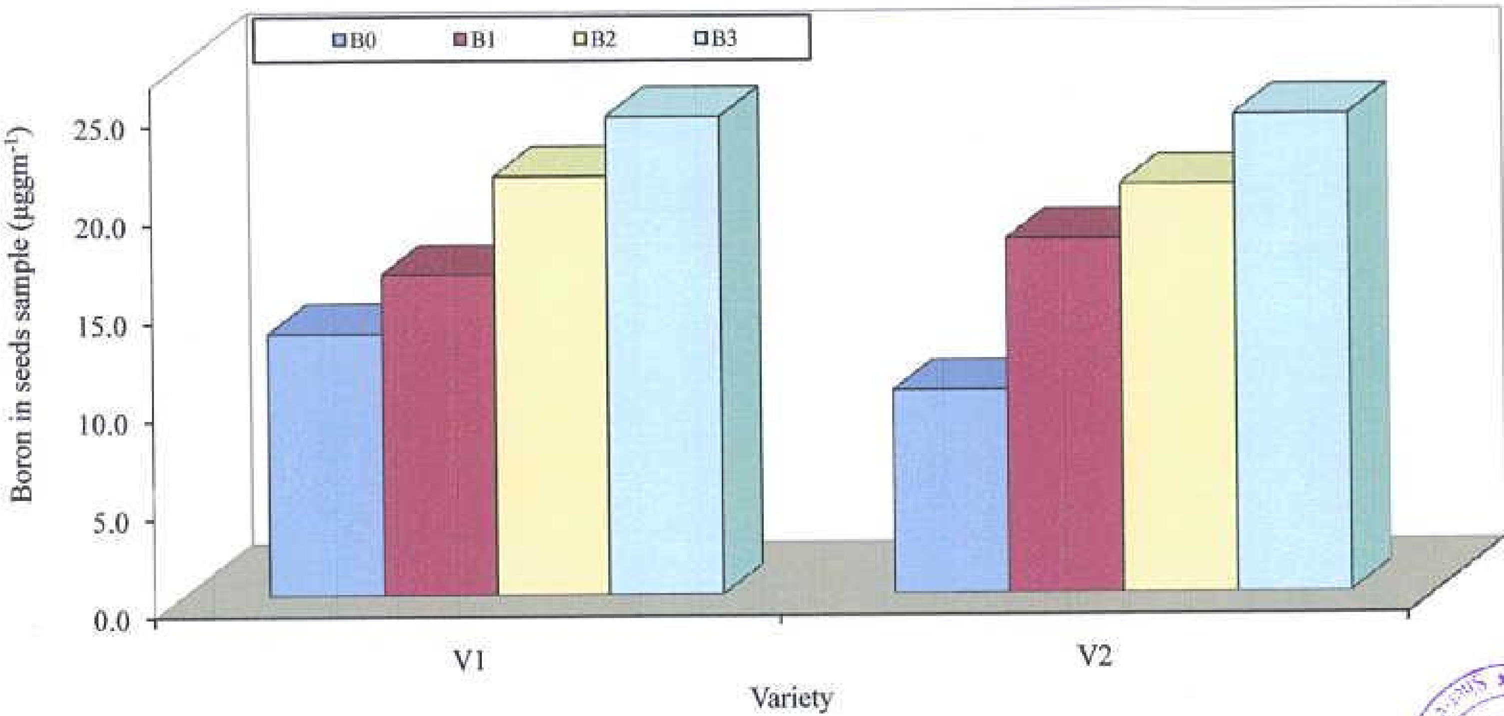
V_1: BARI mung-1 V_2: BARI mung-5

Figure 8. Effects of varieties on boron in seeds sample of mungbean



B_0: Control (0 kg H_3BO_3 ha^{-1}) B_1: 1.0 kg H_3BO_3 ha^{-1}
B_2: 1.5 kg H_3BO_3 ha^{-1} B_3: 2.0 kg H_3BO_3 ha^{-1}

Figure 9. Effects of levels of boron on boron in seeds sample of mungbean



V_1: BARI mung-1
V_2: BARI mung-5

B_0: Control (0 kg H_3BO_3 ha^{-1})
B_1: 1.0 kg H_3BO_3 ha^{-1}
B_2: 1.5 kg H_3BO_3 ha^{-1}
B_3: 2.0 kg H_3BO_3 ha^{-1}

Figure 10. A.Comparison effect of varieties and levels of boron on boron in seeds sample of two cultivars of mungbean

CHAPTER V

SUMMARY AND CONCLUSION

An experiment was carried out at the farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh during the period from March to July 2010 to study the effect of boron on the growth and yield of mungbean. The experiment consisted of two factors, viz., Factor A: Mungbean variety (2 levels) V_1: BARI mung-1 and V_2: BARI mung-5; Factor B: Levels of boron (4 levels); B_0: Control (0 kg H_3BO_3 ha^{-1}); B_1: 1.0 kg H_3BO_3 ha^{-1}; B_2: 1.5 kg H_3BO_3 ha^{-1} and B_3: 2.0 kg H_3BO_3 ha^{-1}. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data on different growth parameters, yield attributes and yield were recorded.

At 20, 30, 40, 50, 60 DAS and at harvest the height of plant (10.60, 21.65, 33.28, 41.41, 51.64 and 57.83 cm, respectively), the maximum number of branches $plant^{-1}$ (1.65, 3.87, 8.48, 16.23, 19.89 and 22.94, respectively), the maximum number of leaves $plant^{-1}$ (10.03, 31.40, 37.97, 50.36, 58.59 and 64.48, respectively) and the higher dry matter content in plant (7.23, 9.95, 11.73, 13.98, 14.84 and 16.81 g $plant^{-1}$, respectively) was recorded from V_2 and plant height (9.01, 19.63, 29.56, 36.88, 48.96 and 54.80 cm, respectively), the minimum number of branches $plant^{-1}$ (1.42, 3.45, 7.85, 13.98, 16.68 and 19.85, respectively), the minimum number of leaves $plant^{-1}$ (8.48, 27.50, 34.19, 43.94, 51.41 and 57.64, respectively) and the lower dry matter content (6.72, 8.82, 10.78, 12.69, 13.89 and 15.64 g $plant^{-1}$, respectively) from V_1. The maximum days to 1^{st} flowering (36.67) was found from V_1, again the minimum days to 1^{st} flowering

(34.56) from V_2 (BARI mung-5). The maximum days to 80% pod maturity (73.58) was observed from V_1, while the minimum days to 80% pod maturity (70.42) from V_2. The higher number of pods plant^{-1} (18.91) was recorded from V_2, whereas the lower number of pods plant^{-1} (18.03) from V_1. The highest number of seeds pod^{-1} (10.12) was found from V_2, again the lowest number of seeds pod^{-1} (8.75) from V_1. The longer pod (8.10 cm) was recorded from V_2, whereas the shorter pod (7.30 cm) from V_1. The maximum weight of 1000 seeds (42.34 g) was observed from V_2 and the minimum weight (40.64 g) from V_1. The higher seed yield (1.54 t ha^{-1}) was observed from V_2, whereas the lower (1.29 t ha^{-1}) from V_1. The higher Stover yield (2.32 t ha^{-1}) was recorded from V_2, again the lower (2.04 t ha^{-1}) from V_1. The higher available boron in seeds (18.83 μg gm^{-1}) was recorded from V_1, again the lower (18.36 μg gm^{-1}) from V_2.

At 20, 30, 40, 50, 60 DAS and at harvest, the tallest plant (11.06, 23.37, 35.04, 41.86, 53.64 and 59.52 cm, respectively), the maximum number of branches plant^{-1} (1.68, 4.28, 8.67, 16.60, 20.33 and 23.42, respectively), the maximum number of leaves plant^{-1} (10.25, 35.15, 39.12, 54.18, 62.83 and 69.37, respectively) and the highest dry matter content in plant (7.62, 10.01, 12.34, 14.43, 15.06 and 17.86 g plant^{-1}, respectively) was observed from B_3, again the shortest plant (8.33, 17.50, 26.56, 35.00, 45.25 and 51.67 cm, respectively), the minimum number of branches plant^{-1} (1.23, 2.82, 7.38, 13.52, 15.55 and 18.33, respectively), the minimum number of leaves plant^{-1} (7.13, 21.75, 31.47, 39.42, 44.63 and 48.82, respectively) and the lowest dry matter content in plant (6.24, 8.82, 10.13, 12.36, 13.34 and 14.49 g plant^{-1}, respectively) from B_0. The maximum days to 1st flowering (36.50) was recorded from B_0 and the minimum (34.17) was recorded from B_2. The maximum days to 80% pod maturity (74.67) was observed from B_0, while the minimum days to 80% pod maturity (69.33) from B_3. The highest number of pods plant^{-1} (19.28) was found from B_2 and the lowest number of pods plant^{-1} (17.22) was recorded from B_0. The highest number of seeds pod^{-1} (10.45) was obtained from B_2 and the lowest number of seeds pod^{-1} (8.01) from B_0. The longest pod (8.43 cm) was found from B_2, and the shortest pod (6.78 cm) from B_0. The maximum weight of 1000 seeds (45.27 g) was recorded from B_2, again the minimum weight (36.14 g) from B_0. The highest seed yield (1.53 t ha^{-1}) was obtained from B_3, again the lowest seed yield (1.18 t ha^{-1}) from B_0. The highest Stover yield (2.40 t ha^{-1}) was observed from B_3, while the lowest (1.88 t ha^{-1}) from B_0. The highest available boron in seeds (24.33 µg gm^{-1}) was observed from B_3, while the lowest (11.83 µg gm^{-1}) from B_0.

At 20, 30, 40, 50, 60 DAS and at harvest the tallest plant (11.51, 24.01, 37.28, 44.46, 54.33, 60.96 cm, respectively), the maximum number of branches plant^{-1} (1.87, 4.43, 9.27, 17.64, 22.26 and 25.51, respectively), the maximum number of leaves plant^{-1} (11.40, 36.50, 42.80, 56.97, 67.67 and 74.83, respectively) and the highest dry matter content in plant (7.89, 10.13, 12.53, 14.87, 15.61 and 18.76 g plant^{-1}, respectively) was observed from V_2B_3, while the shortest plant (6.63, 15.43, 22.90, 31.85, 41.51 and 48.53, respectively), the minimum number of branches plant^{-1} (1.07, 2.33, 6.47, 11.10, 13.17 and 15.40, respectively), the minimum number of leaves plant^{-1} (5.87, 17.00, 25.83, 29.57, 37.80 and 39.43, respectively) and the lowest dry matter content in plant (5.69, 7.50, 8.75, 11.03, 12.44 and 13.13 g plant^{-1}, respectively) from V_1B_0. The maximum days to 1st flowering (40.33) was observed from V_1B_0, again the minimum days (32.67) from V_2B_0. The maximum days to 80% pod maturity (78.33) was found from V_1B_0 and the minimum (69.33) from V_2B_3. The highest number of pods plant^{-1} (19.75) was recorded from V_2B_2 and the lowest number (16.91) from V_1B_0. The highest number of seeds pod^{-1} (10.78) was recorded from V_2B_3, while the lowest number (7.15) from V_1B_0. The longest pod (8.84 cm) was attained from V_2B_2, while the shortest pod (5.80 cm) from V_1B_0. The maximum weight of 1000 seeds (46.21 g) was found from V_2B_2, while the minimum (34.33 g) from V_1B_0. The highest seed yield (1.79 t ha^{-1}) was found from V_2B_2 and the lowest (1.04 t ha^{-1}) from V_1B_0. The highest Stover yield (2.49 t ha^{-1}) was observed from V_2B_3, whereas the lowest (1.56 t ha^{-1}) from V_1B_0. The highest available boron in seeds (24.33 μg gm^{-1}) was observed from V_2B_3, whereas the lowest (13.33 μg gm^{-1}) from V_1B_0. Based on the results of the experiment, the following conclusion may be drawn-

1. The cultivar BARI mung-5 was superior to BARI mung-1 in respect of seed yield ha^{-1}.
2. Boron played a vital role in the growth and yield of mungbean and 1.5 kg H_3BO_3 ha^{-1} was identified as proper in achieving potential growth and yield of mungbean as well as expenditure consideration for farmers use.

However, these findings need to be further studied and evaluated in different agro-climatic regions of the mungbean growing area before giving final recommendation(s) to the farmer.

REFERENCES

Abdo, F. A. (2001). The response of two mungbean cultivars to zinc, manganese and boron I. Morphological, physiological and anatomical aspects. *Bull. Faculty of Agric.*, **52**(3): 445-466.

Abid, H., Khalil, S. K., Sartaj, K. and Haroon, K. (2004). Effect of sowing time and variety on grain yield of mungbean. *Sarhad J. Agric.*, **20**(4): 481-484.

Aghaalikhani, M., Ghalavand, A. and Ala, A. (2006). Effect of plant density on yield and yield components of two cultivars and a line of mungbean [*Vigna radiata* (L.) Wilczek] in Karaj Region. *J. Sci. and Tech. Agric. Natural Resources.*, **9**(4): 111-121.

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

Anonymous. (1999). Lentil Cultivation in Bangladesh. Lentil Blackgram, Mungbean Development Pilot Project. Bangladesh Agricultural Research Institute. Joydebpur, Gazipur. Pub., 18.

Apurv, P. and Tewari, S. K. (2004). Yield dynamics of mungbean (*Vigna radiata* L. Wilczek) varieties in poplar based agroforestry system. *Indian J. Agroforestry.*, **6**(2): 89-91.

BBS. (1994). Agricultural Year Book of Bangladesh. Statistics Div., Ministry of planning .Government of the People's Republic of Bangladesh, Dhaka. p. 219 .

BBS. (2005). Statistical year book of Bangladesh.26th Edit. Bangladesh bureau of Statistics. Planning division, Ministry of Planning, Govt. of the People's Republic of Bangladesh, p., 131.

BBS. (2006). Statistical year book of Bangladesh.26th Edit. Bangladesh bureau of Statistics. Planning division, Ministry of Planning, Govt. of the People's Republic of Bangladesh, p. 143.

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

Bhati, T. K., Rathore, S. S. and Gaur, N. K. (2005). Effect of improved varieties and nutrient management in kharif legumes under arid ecosystem in Institution Village Linkage Programme. *J. Arid Leg.*, **2**(2): 227-229.

Bhuiyan, M. A. H., Khanam D. and Ali, M. Y. (1999). Chickpea root nodulation and yield as affected by micronutrient application and *Rhizobium,* inoculation. *Inter. Chickpea* and *Pigeonpea Newsl.*, 6: 28- 29.

Bhuiyan, M. A. H., Rhaman, M. H. H., Khanam, D. and Khatun, M. R. (1997). Effect of micronutrients (Mo and B) and rhizobial inoculums on nodulation yield of groundnut. *Legume Res.,* **20**(3/4):155-159.

Bhuiyan, M. A. H.., Khanam, D., Kadeir, M. M. and Hossain, A. K. M. (1999). Response of chickpea *(Cicer artitinum* L.) to molybdenum, boron and *Rhizobium* inoculation in Himalayan piedmpont soils. *Prog. Agric.*, **10**(1&2): 103-106.

Chaisri, P., Kaveeta, L., Chaisri, S. and Kaveeta, R. (2005). Mungbean yield trial for cropping system in Lopburi area. *Proceedings of 43rd Kasetsart University Annual Conference*, Thailand, 1-4 February., 2005: 214-222.

Daisy, K. E. (1979). Food legume, Crop and Product Digest No. 3, Trop. Product Inst. London. Pp., 273-279.

Durga, K. K., Rao, M. M., Reddy, M. V. and Rao, Y. K. (2003). Effect of early drought stress on morpho-physiological characters and yield of mungbean and urdbean cultivars. *Indian J. Pulses Res.*, **16**(2): 133-135.

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

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

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

Gowda, C. L. L. and Kaul, A. K. (1982). Pulse in Bangladesh. Bangladesh agricultural Research Institute, Joydebpur, Gazipur and food and Agricultural Organization of the United Nations.p.13

Hamed, M. F. (1998). Response of two mungbean varieties under irrigation intervals and certain fertilization treatments. *Ann. Agril. Sci.*, **36**(1): 31-42.

Hossain, D. and Solaiman, A. R. M. (2004). Performances of mungbean varieties as affected by *Rhizobium* inoculants. *Bull. Insti. Trop. Agric.*, **27**: 35-43

Infante, N., Madriz, P. and Gonzalez, T. (2003). Phases of development and yield components of three mungbean cultivars (*Vigna radiata* (L) Wilczek) in Maracay, Aragua state, Venezuela. *Revista Faculty Agron.*, **20**(4): 417-429.

Islam, M. K., Islam, S. M. A., Harun-or-Rashid, M., Hossain, A. F. M. G. F. and Alom, M. M. (2006). Effect of biofertilizer and plant growth regulators on growth of summer mungbean. *Int. J. Bot.*, **2**(1): 36-41.

Khanam, D., Rahman, M. H. H., Begum, D., Haque, M. A. and Hossain, A. K. M. (1994). Inoculation and varietal interactions of Chickpea (*Cicer arietinum* L.) in Bangladesh. *Thai J. Agric. Sci.*, 27: 123-130.

Kumar, L. S. S., Agarwala, A. C., Arakeri, H. R. and Kamath, M. O. (1963). Pulses Agriculture in India. Asian Publishing House, New Delhi. Vol. 2, Crop., 38.

Madriz-Isturiz, P. M. and Luciani-Marcano, J. F. (2004). Agronomic characterization of 20 cultivars of mungbean, *Vigna radiata* (L.) Wilczek during three seasons, in Maracay, Aragua state, Venezuela. *Revista Faculty Agron.*, **21**(1): 19-35.

Mohammad, D. and Hossain, I. (2003). Seed treatment with biofertilizer in controlling foot and root rot of mungbean. *Pakistan J. Pl. Path.*, **2**(2): 91-96.

Muhammad, A., Abdul, R., Muhammad, A. and Zafar, M. I., (2006). Association among Rhizobium phaseoli strains and mungbean genotypes under rainfed conditions. *Sarhad J. Agric.*, **22**(3): 453-457.

Navgire, K. D., Datar, V. V., Asewar, B. V. and Dahiwal, A. L. (2001). Response of mungbean cultivars to different Rhizobium strains under rainfed conditions. *Ann. Pl. Physiol.*, **15**(2): 134-137

Quaderi, R. S., Islam, S. M. A., Hossain, A. F. M. G. F., Hoque, M. M. and Haque, M. S. (2006). Influence of seed treatment with indole acetic acid on mungbean cultivation. *Int. J. Bot.*, **2**(1): 42-47.

Rahman, M. S., Eunus, M. and Awal, M. A. (2002). Dry matter production and partitioning of mungbean (*Vigna radiata* I.) varieties as influenced by sowing date and planting method in summer. *Bangladesh J. Train. Devel.*, **15**(1/2): 193-199.

Raj, S. and Tripathi, K. P. (2005). Productivity and economics of mungbean (Vigna radiata L.) as influenced by varieties and nutrient management. *J. Arid Legumes.*, **2**(2): 223-226.

Rerkasem, B., Netsangtip, R., Lonerangan, J. F. and Bell, R. W. (1987). Boron deficiency in grain legumes *In: Proc. Inter. Workshop* on *Food Legumes*. Improvement in Asian Farming System. Khon Kaen, *Thailand. ACIAR*. No.18. p., 267.

Riaz, A., Imran, M., Javed, K. and Bukhari, S. A. H. (2004). Growth and yield response of three mungbean (*Vigna radiata* L.) cultivars to varying seeding rates. *Int. J. Agric.Biol.*, **6**(3): 538-540.

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

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

Shaikh, M. A. Q. (1997). Grain legumes in Bangladesh. Induced nutrition for improvement of grain legume production in South East Asia. IAEA-TDCDOC- 203.Inter. Atomic energy, Viena. pp.66-77.

Shamsuzzaman, A. M. M., Alam, M. S., Mondal, G. and Ahamed, K. U. (2004). Growth and yield response of summer mungbean to irrigation frequency. *J. Agric. Rural Dev.*, **2**(1): 95-100.

Taj, F. H., Muhammad, A. and Kakar, K. M. (2003). Effect of seed rates on mungbean varieties under dryland conditions. *Int. J. Agric. Bio.*, **5**(2): 160-161.

Tickoo, J. L., Naresh, C., Gangaiah, B. and Dikshit, H. K. (2006). Performance of mungbean (*Vigna radiata*) varieties at different row spacings and nitrogen-phosphorus fertilizer levels. *Indian J. Agril. Sci.,* **76**(9): 564-565.

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

Yang, Y. H. and Zhang, H. Y. (1998). Boron amelioration of aluminum toxicity in mungbean seedlings. *J. Plant Nutri.*, **21**(5): 1045-1054.

APPENDICES

Appendix I. Characteristics of experimental field soil is analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Central Farm, SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained

B. Physical and chemical properties of the initial soil

Characteristics	Value
% Sand	27
% Silt	43
% clay	30
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

Source: SRDI

Appendix II. Monthly record of air temperature, relative humidity and rainfall of the experimental site during the period from March to July 2010

Month	*Air temperature (°C)		*Relative humidity (%)	*Rainfall (mm) (total)
	Maximum	Minimum		
March, 2010	31.4	19.6	54	11
April, 2010	33.2	21.1	61	88
May, 2010	34.1	20.2	78	102
June, 2010	35.3	24.6	79	134
July, 2010	36.4	25.2	82	165

* Monthly average,

* Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka - 1212

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

Source of variation	Degrees of freedom	Mean square					
		Plant height (cm) at					
		20 DAS	30 DAS	40 DAS	50 DAS	60 DAS	Harvest
Replication	2	0.053	0.014	1.127	6.824	2.648	0.805
Factor A (Variety)	1	15.221**	24.573**	83.366**	123.075**	43.139**	55.156**
Factor B (Levels of boron)	3	9.246**	41.932**	86.723**	56.050**	90.066**	80.336**
Interaction (A×B)	3	4.075*	3.514*	40.508**	38.473*	19.323**	10.451*
Error	14	0.975	0.944	5.860	8.631	3.042	2.949

**: Significant at 0.01 level of significance; *: Significant at 0.05 level of significance

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

Source of variation	Degrees of freedom	Mean square					
		Number of branches plant^{-1}					
		20 DAS	30 DAS	40 DAS	50 DAS	60 DAS	Harvest
Replication	2	0.015	0.010	0.008	1.322	0.241	1.393
Factor A (Variety)	1	0.304**	1.042**	2.350*	30.600**	61.760**	57.350**
Factor B (Levels of boron)	3	0.257**	2.463**	1.910**	10.885**	28.388**	31.372**
Interaction (A×B)	3	0.036**	0.365*	2.441**	5.518*	7.096**	11.822**
Error	14	0.006	0.082	0.342	1.404	0.348	1.085

**: Significant at 0.01 level of significance; *: Significant at 0.05 level of significance

Appendix V. Analysis of variance of the data on number of leaves plant^{-1} of mungbean plant as influenced by variety and levels of boron

Source of variation	Degrees of freedom	Mean square					
		Number of leaves plant^{-1} at					
		20 DAS	30 DAS	40 DAS	50 DAS	60 DAS	Harvest
Replication	2	0.354	0.521	0.200	28.080	5.735	0.145
Factor A (Variety)	1	14.415**	91.260**	85.504**	247.042**	309.602**	1.354**
Factor B (Levels of boron)	3	12.288**	205.200**	66.374**	253.452**	411.316**	173.432**
Interaction (A×B)	3	1.549*	34.200**	92.960**	147.183*	114.202**	5.598**
Error	14	0.386	5.694	11.957	32.424	8.48	2.145

**: Significant at 0.01 level of significance; *: Significant at 0.05 level of significance

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

Source of variation	Degrees of freedom	Mean square					
		Dry matter content in plant (%) at					
		20 DAS	30 DAS	40 DAS	50 DAS	60 DAS	Harvest
Replication	2	0.455	0.797	1.016	0.231	0.016	0.038
Factor A (Variety)	1	1.576**	7.584**	5.383**	9.899**	5.406*	8.265*
Factor B (Levels of boron)	3	2.863**	2.517**	6.599**	7.073**	3.929**	14.348**
Interaction (A×B)	3	0.913**	2.027*	2.777*	1.956*	5.102**	8.022**
Error	14	0.172	0.471	0.715	0.970	0.834	1.289

**: Significant at 0.01 level of significance; *: Significant at 0.05 level of significance

Appendix VII. Analysis of variance of the data on yield contributing characters and yield of mungbean as influenced by variety and levels of boron

Source of variation	Degrees of freedom	Mean square								
		Days to 1st flowering	Days to 80% pod maturity	Number of pods $plant^{-1}$	Pod length (cm)	Number of seeds $plant^{-1}$	Weight of 1000 seeds (g)	Seed yield ($t\ ha^{-1}$)	Stover yield ($t\ ha^{-1}$)	Available boron in seeds
Replication	2	1.625	8.000	0.364	0.169	0.516	0.455	0.004	0.048	0.213
Factor A (Variety)	1	26.042**	60.167**	4.726**	3.826**	11.138**	17.337	0.388**	0.449**	2.342**
Factor B (Levels of boron)	3	6.819**	37.444**	4.670**	3.799**	7.168**	119.73**	0.161**	0.316**	4.981**
Interaction (A×B)	3	23.486**	18.056**	2.109*	2.299**	3.651*	4.880**	0.065**	0.313**	1.231*
Error	14	0.673	3.238	0.615	0.351	0.577	6.945	0.011	0.020	0.1231

**: Significant at 0.01 level of significance; *: Significant at 0.05 level of significance