INFLUENCE OF BORON AND MOLYBDENUM ON THE GROWTH AND YIELD OF MUNGBEAN *I Vigna radiata (L.)* Wilczek]

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*This is to certify that the thesis entitled, "**INFLUENCE OF BORON AND MOLYBDENUM ON THE GROWTH AND YIELD OF MUNGBEAN** [Vigna radiata (L.) Wilczek] " Submitted to the Department of Agronomy, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE in AGRONOMY** embodies the result of a piece of bonafide research work carried out by **Md. Golam Sumdanee, Registration No. 03-01081** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

Dated:
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Dedicated to

my

Beloved Parents

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ABSTRACT

The experiment was conducted at the Agronomy field laboratory of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from March to May 2009 to study the effect of Boron and Molybdenum on the growth and yield of mungbean. The variety BARI mung-6 was used as test crop. The experiment consists of two factors: Factor A: Boron (4 levels); 0 (B_0), 1.0 (B_1), 1.5 (B_2) and 2.0 (B_3) kg B ha $^{-1}$ and Factor B: Molybdenum (4 levels); 0 (Mo_0), 1.0 (Mo_1), 1.5 (Mo_2) and 60 (Mo_3) kg Mo ha^{-1}. The experiment was conducted following split plot design with three replications. The result revealed that treatment B_3 (2 kg B ha^{-1}) showed the highest plant height (47.22 cm), dry matter plant^{-1} (16.68 g), number of pods plant^{-1} (30.36), pod length (8.97cm), seed yield (1.53 t ha^{-1}) and stover yield (1.78 t ha^{-1}), but B_2 (2 kg B ha^{-1}) showed the highest 1000-seed weight (44.28 g). On the other hand, B_o (0 kg B ha^{-1}) showed the lowest plant height (44.10cm), dry matter plant^{-1}(13.44 g), number of pods plant^{-1} (22.07), pod length (7.02 cm.), seeds pod^{-1} (7.91), 1000 seed weight (41.62 g), seed yield (1.18 t ha^{-1}) and stover yield (1.53 t ha^{-1}). The result also revealed that Mo_3 (2 kg Mo ha^{-1}) showed the highest plant height (44.06 cm), dry matter plant^{-1} (16.59 g), number of pods plant^{-1} (29.51), pod length (8.92 cm), 1000-seed weight (44.69 g), seed yield (1.60 t ha^{-1}) and stover yield (1.85 t ha^{-1}) but Mo_2 (2 kg Mo ha^{-1}) showed the highest seeds plant^{-1} (10.89). On the other hand, Mo_0 (0 kg Mo ha^{-1}) showed the lowest plant height (44.67cm), dry matter plant^{-1} (14.17g), number of pods plant^{-1} (24.14), pod length (7.05cm), seeds per pod (8.29), 1000-seed weight (40.31 g), seed yield (1.17 t ha^{-1}) and stover yield (4.5 t ha^{-1}). The interaction of B_3Mo_3 (2 kg B ha^{-1} x 2 kg Mo ha^{-1}) showed the highest plant height (47.44 cm), dry matter plant^{-1} (17.75 g), number of pods plant^{-1} (33.07), pod length (9.35 cm), 1000-seed weight (45.49 g) , and stover yield (1.97 tha^{-1}) but B_3Mo_2 (2 kg B ha^{-1}x1.5 kg Mo ha^{-1}) showed the highest seeds per pod(12.32) and seed yield (1.74 t ha^{-1}). On the other hand, B_0Mo_o (0 kg B ha^{-1} x 0 kg Mo ha $^{-1}$) showed the lowest plant height (40.21 cm), dry matter plant^{-1} (12.58 g),number of pods plant^{-1} (18.40), pod length (5.77 cm), seeds per pod (7.43), 1000 seed weight (38.05 g), seed yield (0.99 t ha^{-1}) and stover yield (1.37t ha^{-1}). It may be concluded that boron and molybdenum had a significant influence on the growth and yield of mungbean and 1.5 kg B and 1.5 kg Mo per hectare can be the optimum dose for higher yield of mungbean.

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SOME COMMONLY USED ABBREVIATIONS AND SYMBOLS

Abbreviations	**Full words**
AEZ	Agro- Ecological Zone
Anon.	Anonymous
Atm.	Atmospheric
B	Boron
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
BRRI	Bangladesh Rice Research Institute
cm	Centimeter
CV %	Percent Coefficient of Variance
cv.	Cultivar (s)
DAS	Days After Sowing
et al.	And others
FAO	Food and Agriculture Organization
g	Gram (s)
HI	Harvest Index
hr	Hour(s)
Kg	Kilogram (s)
LSD	Least Significant Difference

m^2	Meter squares
mm	Millimeter
MP	Muriate of Potash
N	Nitrogen
No.	Number
NS	Non significant
SAU	Sher-e- Bangla Agricultural University
SRDI	Soil Resources and Development Institute
TDM/ TDW	Total Dry Matter/ Total Dry Weight
TSP	Triple Super Phosphate
var.	Variety
Wt.	Weight
t ha^{-1}	Ton per hectare
^{0} C	Degree Centigrade
%	Percentage

CHAPTER 1

INTRODUCTION

Mungbean (*Vigna radiata* L.) is one of the most important pulse crops of Bangladesh with good digestibility, flavor and high protein content. It belongs to the family Leguminosae and sub family Papilionaceae. Mungbean is grown almost all regions of Bangladesh. It ranks fifth in acreage and production. The area under pulse crops in Bangladesh is 0.406 million hectares with a production of the 0.258 million tons where mungbean is cultivated in the area of 0.054 million hectares with production of 0.017 million tons (BBS, 2010). It is considered as a poor man's meat. It contains almost double amount of protein as compared to cereals. Mungbean contains 51% carbohydrate, 26% protein, 4% minerals, 3% vitamins, 10% moisture etc. Hence, on the point of nutrition value, mungbean is perhaps the best of all other pulses (Khan, 1981; Kaul, 1982). But unfortunately there is an acurate shortage of grain legumes production in the country. According to FAO (1999) a minimum intact of pulse by a human should be 45 g/day/capita for a balance diet, whereas in Bangladesh per capita daily consumption of pulses is only 14.19g (BBS, 2005). This crop, like other pulses, also has a great contribution to 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 especially mungbean 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 rabi season but it can also be cultivated in kharif season. During kharif season the crop fit well into the existing cropping system of many areas in Bangladesh. It requires warm temperature regime. Summer mungbean can tolerate a high temperature but not exceeding 40^0 c and does well in the temperature range of $30\text{-}35^0$ c. In our country, mungbean gives the highest yield under summer planting (Satter and Ahmad, 1995). The successes of growing mungbean in summer have already been made suitability for early pulses is their suitability for early kharif period, particularly in the area where low yielding Aus is produced. Experiment conducted at BARI indicates that summer pulses are more economical than low yielding Aus rice.

The production of mungbean has been steadily decreasing due to reduce acreage, poor management and low yielding local cultivars. Therefore, to meet the requirement it is necessary to boost up the production through varietal selection and proper management practices as well as increasing summer mungbean cultivation. Fitting mungbean in our usual cropping system and use of seed inoculation with effective rate of B and M_0 application will produce better nodulation, nitrogen fixation, growth and higher yield.

The response of mungbean to added B in major pulse growing soils was observed by many researcher (Jahiruddin, 2006, Shil *et al.,* 2007, Bhuiyan *et al*, 1997 and Zaman *et al*, 1996). Boron is very important in cell division and in pod as well as seed formation. The critical level of boron with reference to crops in general was reported to range from 0.3 to 0.8 ppm depending on soil types (Shorrocks, 1984). Due to B deficiency plants manifest restricted growth of terminal buds with necrosis, shortened internodes and lateral branching which gives the plants a bushy appearance. Under severe stress, boron deficient plants may develop chlorosis, drop their flower buds and fail to develop seeds. The leaves become thickened, deformed and brittle; petiole and stem organs may crack, and root may exhibit discolouration and rot. The deficiency of boron retards sugar formation and translocation. Boron also plays an important role in flowering and fruit setting process, N metabolism and hormonal action.

Molybdenum is indispensable for a variety of species especially for legumes forming root nodules because it is directly involved in nitrogen fixing enzymes nitrogenase and nitrogen reduction enzyme, nitrate reductase. Molybdenum application can play a vital role in increasing mungbean yield through its effect on the plant itself and also on the nitrogen fixation process. On the contrary, deficiency of molybdenum resulted in decreased growth, yield and quality of mungbean as well as low nitrogen fixation. Lews (1980) observed that molybdenum was responsible for the formation of nodule tissue and increase in nitrogen fixation. He also reported that without adequate quantities of molybdenum, nitrogen fixation could not occur and microbial activity was depressed. Grewal *et al*., (1967) reported that molybdenum has a significant response to fix atmospheric nitrogen and yield of legume crops. Pulses could produce active nodule only when soils were properly supplied with molybdenum (Ahmed, 1982).

Field studies revealed that deficiency of B causes considerable reduction of growth and nodulation (Howeler *et al*., 1978) and Mo is required for increasing nodulation and yield in mungbean (Paricca *et al*., 1983, and Velu and Savithri, 1982). In Bangladesh, hardly any attempt has so far been made on the application of B and Mo in mungbean for bringing about the improvement of nodulation and yield in relation to economic return.

So it is necessary to examine the effects of different levels of those nutrients and assess their best combination in relation to enhanced growth and productivity of mungbean. In view of these points the present study was undertaken to fulfill the following objectives:

1. To find out the effect of B and M_0 on the performance of mungbean.
2. To determine the appropriate rate of B and M_o for higher yield of mungbean , and
3. To determine the combine effect of B and M_o on growth and yield of mungbean.

CHAPTER II
REVIEW AND LITERATURE

Mungbean is one of the important pulse crop in Bangladesh as well as many countries of the world. The crop has conventional less concentration by the researcher on various aspects because normally it grows with less care and management practices. For that a very few studies releted to growth, yield and development of mungbean have been carried out of our country as well as many other countries of the world. So, the research so far done in Bangladesh is not adequate and conclusive. Nevertheless, some of the important and informative works and research findings related to the Boron and Molybdenum so far been done at home and abroad on this crop have been reviewed in this chapter –

2.1 Effect of boron on the growth and yield of mungbean

Biswas *et al.* (2010) conducted a two-year field experiment during kharif season of 2005 and 2006 at the Pulses and Oilseeds Research Sub-station, Beldanga, Murshidabad, West Bengal, India to study the effect of molybdenum spray and seed inoculation on nodulation, growth and seed yield in mungbean. The results revealed that two rounds of foliar spray of 0.05% ammonium molybdate solution at 25 and 40 DAS increased seed yield by 9.02% (1269.50 kg ha^{-1}) over water spray (1164.50 kg ha^{-1}). Combined inoculation of seeds with Rhizobium + Azotobacter + PSB (1629 kg ha^{-1}) and Rhizobium + PSB remarkably increased the seed yield due to better nodulation along with improvement in growth and yield attributes. The effect of interaction between foliar spray and seed inoculation on seed yield was found significant.

Srivastava *et al*. (2005) observed that in absence of applied B, there was no yield as no pods were formed, in comparison to a yield of 300 kg ha^{-1} in the full nutrient treatment. There was yellowing of younger leaves and typical 'little leaf' symptoms when B was omitted. A critical concentration range of 15-20 ppm B was found for the shoot tips of chickpeas.

Ali *et al.* (2002) reported that yield losses of varying magnitude in chickpea, e.g., 22-50 % due to iron (Fe), up to 100% due to boron (B), and 16-30% due to sulphur (S). Genotypic differences in response to application of Fe, B and zinc (Zn) have also been found among chickpea genotypes.

Talashikar and Chavan (1996) reported a significant increase of pod yield and haulm of ground due to application of boron.

Bharti *et al.* (2002) carried out a field experiment in Bihar, India during the winter of 1997-98 to observe the effects of B (0, 1.5 and 2.5 kg ha^{-1}) application on the yield and nutrition of chickpea (cv. BG256). They reported that the mean seed yield, and seed and stover N and B content increased, whereas stover yield decreased with the increasing B rate.

Abdo (2001) conducted 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 significantly most of the growth parameters 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 under investigation in both seasons. The effect of spraying with low level of Zn, Mn, B and their mixture on the internal structure of the vegetative growth of mungbean cv. VC-1000 was investigated.

Rizk (2001) carried out two field experiments 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. The obtained results could be summarized in the following: Generally, cultivar VC-1000 surpassed cultivar V-2010 in yield and its components as well as in the chemical composition of seeds with exception in 100-seed weight and phosphorus percentage in seeds. All treatments increased significantly yield and its components especially Zn1 (0.2 g/l) which showed a highly significant increase in all characters under investigation compared to the control. All adopted treatments increased significantly protein percentage in seeds of the two mungbean cultivars in both seasons. Among all treatments of micronutrients, B gave the highest percentage of crude protein. 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 statistical effect on the percentages of total carbohydrates, phosphorus and potassium in seeds of the two investigated mungbean cultivars in both seasons.

Verma and Mishra (1999) carried out a pot experiment with cv. PDM 54; boron was applied by seed treatment, soil application or foliar spraying. Boron increased yield and growth parameters, with the best results in terms of seed yield $plant^{-1}$ when the equivalent of 5 kg borax ha^{-1} was applied at flowering.

Wang *et al.* (1999) reported that there is limited risk of B toxicity due to the use of borax fertilizer at up to 4 to 8 times recommended rates in rape-rice cropping rotations in southeast China. The low risk of B toxicity can be attributed to relatively high B removal in harvested seed, grain and stubble, the redistribution of fertilizer B by leaching in the 0 to 60 cm layer and to boron sorption.

Mishra (1998): In a field study at Kanpur, Uttar Pradesh, mungbeans (*Vigna radiata*) cv. K-851 were given 0, 25 or 50 kg P_2O_5 ha^{-1} and 0, 2, 4 or 6 g Mo kg^{-1} seed by seed pelleting. Seed yields were 422, 624 and 714 kg ha^{-1} with the P rates as listed, and 486, 583, 649 and 628 kg from seed pelleting with increasing Mo rates. Nodule numbers were not significantly affected by treatment. Yield component data are tabulated.

Verma (1999) In a pot experiment with mungbean cv. PDM 54, boron was applied by seed treatment, soil application (basally or at flowering) or foliar spraying. Boron increased yield and growth parameters, with the best results in terms of seed yield/plant given when the equivalent of 5 kg boraxha^{-1} was applied at flowering.

Chowdhury *et al.*(1998) observed that the tallest plant height of 64.9 cm was found in plant receiving inoculums alon with Mo and B (both 1 kg ha^{-1}) as compared to all other treatments. They also reported that plant height increased 123% higher in plants receiving inoculums along with Mo (1 kg ha^{-1}) and B (1 kg ha^{-1}) over control.

Mondal *et al.* (1998) noted that most of alluvial acidic soils in North Bengal, India may response to the application of B fertilizer thus increasing the yield of pulse crops in the area.

Patra (1998) observed significant yield increase if soybean by the application of B (5 kgha^{-1}).

Rahman and Alam (1998) observed that application of B (1.5 kgha^{-1}) produced significantly 10.17% higher branches $plant^{-1}$ over control in groundnut.

Rahman *et al.* (1998) observed that application of B (1.5 kg ha^{-1}) significantly increased 19.2% higher plant height of groundnut over control.

Yang Yong Hua and Zhang Hong Yan (1998) observed that the addition of B promoted elongation of epicotyle and hypocotyle of mungbean and increased seedling height and dry weight. High concentrations of B decreased soluble protein.
Bonilla *et al.* (1997) suggested that B is an obligatory requirement for normal determinate nodule development and functioning in case of bean (*Phaseouls vulgaris*). Boron deficiency in pea (*Pissum sativum* L.) caused a decrease in the number of nodules and an alteration of indeterminate nodule development. Moreover, B plays an important role in mediating cell surface interactions that lead to endocytosis of rhizobia by host cells and hence to the correct establishment of the symbiosis between pea and rhizobium (Bolanos *et al*, 1997).

Saha *et al.* (1996) conducted a field experiment 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^{-1} applied as soil, 66% soil + 33% foliar or foliar applications and the residual effects were studied on summer green gram (*Vigna radiate*). 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.

Srivastavaet *et al.* (1996) conducted a field experiment in Nepal with chickpea in Boron deficient soil and observed the highest flower abortion and no seed production in the treatment with any B addition.

Zaman *et al.* (1996) conducted an experiment on mungbean and observed that application of B (2 kg ha^{-1}) produced 23.37% higher 1000 seed weight over control.

Zaman *et al.* (1996) conducted an experiment on mungbean and observed that the application of Mo (1kg ha^{-1}) with B (2 kg ha^{-1}) produced maximum plant height (35.03cm) compared to control (21.53cm). They also reported that the application of Mo (1kg ha^{-1}) either alone or in combination with B (1 or 2 kg hg^{-1}) appreciably increased root length of mungbean over the control. They also reported that plant received 1kg Mo ha^{-1} with 2 kg B ha^{-1} produced 50.31 and 40.2 1% higher root length of mungbean over control.

Zaman *et al.* (1996) observed that application of B (2 kg ha^{-1}) significantly increased 23.59% higher plant height of mungbean over control. They also observed that application of B (2 kg ha^{-1}) produced 23.18% and 20.49% higher root length over control in 1989 and 1990 respectively.

Bolanos *et al.* (1994) suggested that B is required for normal development and function of nodules in case of pea (*Pisum sativum*). In the absence of B, the number, size and weight of nodules decreased and nodule development changed leading to an inhibition of nitrogenase activity.

Mahajan *et al.* (1994) found that soil application of B (0.5 kg ha^{-1}) increased pod yield and harvest index signicantly.

Wu *et al*. (1994) observed that plant dry weights of different organs in soybean were positively correlated with Mo concentration.

Gupta *et al.* (1993) reported that in a pot experiment in soil containing 0.4 mg kg^{-1} available B, chickpeas or lentils were grown following application of 0-6 mg B kg^{-1} soil and also reported that lentil was more susceptible to boron than chickpea. Boron concentration in both crops was lower in the seeds than in the straw, and was increased at higher B rates.

Islam and Sarker (1993) found higher number of seeds pod^{-1} due to application of B @ 1.5 kg ha^{-1} above and below which seed set was hampered.

Bell *et at.* (1990) observed that leaf elongation was inhibited by interruption of the B supply 5 days later than the appearance of B deficiency symptoms in the roots as observed in green gram (*Vigna radiata*).

Buzetti *et al.* (1990) found that plant boron concentration increased or decreased with increasing or decreasing rate of applied boron.

Dwivedi *et al.* (1990) observed that under acute B stress flowering and grain formation of pulse, oil seed and cereal crops were drastically reduced.

Marschner (1990) reported that the deficiency symptoms of some boron sensitive crops like legumes, Brassica, beets, celery, grapes and fruit trees showed chllorosis and browning of young leaves, killed growing points, distorted blossom development, lesions in pith and roots, and plants, burning of the tips of the leaves and restricted root growth are the boron toxicity symptoms in most crops.

Sakal *et al*. (1990) carried out field trials at 7 sites in North Bihar, India. They observed the seed yield of chickpea increased from 1 .4t with no B to 1.79 t/ha with 3kg B/ha. The yield response to B application was grater on low B soils. It was concluded that on soils <0.35 ppm B, 3 kg B ha^{-1} was optimum and on soils >0.35 ppm B, 2 kg B ha^{-1} was optimum.

Kulkarny *et al.* (1989) reported that the boron application increased nodule weight, nodule number and dry weight of groundnut.

Yang *et al.* (1989) reported that combmed application of N, K and B increased seed yield in rapeseed. Application of B along with N and K promoted CO_2 assimilation, nitrate reductase activity in leaves and dry matter accumulation. Seed glucosinolate and erucic acid content varies among cultivars and generally decrease with increasing K and B, while seed oil content increases.

Sakal *et al*. (1988) reported that on a coarse textured highly calcareous soil, application of 2.0 and 2.5 kg B ha^{-1} increased grain yields of blackgram and chickpea by 63 and 38%, respectively.

Sakal *et al.* (1988) obtained increased chickpea yields with increasing levels of B from 0 to 2.5 kg ha^{-1}. Similar results were also observed by Rerkasem *et al.*(1987) in black gram.

Rerkasem *et al.* (1987) observed that 10kg borax/ha increased the number of nodes $plant^{-1}$ in green gram.

Salins *et al.* (1985) reported that B application increased the weight of aerial parts and roots of peas.

Dutta *et al.* (1984) stated that application of B (1 kg ha^{-1}) in mungbean increased leaf area ratio (AR), leaf area index (LAI), crop growth rate (COR), number of branches $plant^{-1}$, no. of pod $plant^{-1}$, weight of seed pod^{-1} and a decrease in chlorophyll content and net assimilation rate (NAR), but the relative growth rate (RGR), total dry matter and seed yield and some of other growth attributes were unaffected.

Vinay-Singh and Singh (1984) observed that the toxicity symptoms of boron in lentil plants started appearing first in the 8 ppm level. Most important symptoms were the yellowing of the leaflets of lower leaf followed by browning and scorching.

Oliveira and Kato (1983) observed that foliar N, P and K contents of bean were unaffected by B fertilization.

Agarwala *et al.* (1981) found that direct effects of boron are reflected by the close relationship between boron supply and pollen producing capacity of the anthers as well as the viability of the pollen grains.

Franco and Munns (1981) found significantly higher shoot weight in bean due to Mo application.

Pandey and Singh (1981) reported that seed yields of greengram grown with NPK on a sandy loam calcareous soil (pH 8.3) were increased by applying 10 kg borax ha^{-1}.

Chakravarty *et al.* (1979) stated that boron concentration in all crops increased significantly with increasing level of applied boron.

Gupta (1979) reported that boron is a micronutrient requiring for plant growth relatively to a smaller amount. The total B content of soils lies between 20 and 200 ppm with the available (hot water soluble) B fraction ranging from 0.4 to 0.5 ppm.

Santos (1979) found a positive of legumes to Mo, which increases symbiotic N fixation and the effectiveness of nitrate reductase.

Howoler *et at.* (1978) observed that yield of beans was nearly doubled with the application of 1kg B ha^{-1}.

Novoselova and Ryabov (1977) observed that B slowed down the vegetative growth and increased the development of reproductive organs.

Gerath *et al.* (1975) reported an increase in yield of rape through application of boron fertilizer and recommended an application of 1 to 2 kg B ha^{-1} for increased yield.

4.2.2 Effect of Molybdenum on growth and yield of mungbean

Shil *et al.* (2007) found that boron played major role in augmenting yield. The highest mean yield (1.23 t ha^{-1}) was obtained with 2 kg ha^{-1} B and 1 kg ha^{-1} Mo, which was 52% higher over control. The optimum economic dose of boron was found to be 1.76 kg ha^{-1}.

Srinivasan *et al.* (2007) conducted two experiments on mungbean during two consecutive seasons (rabi and kharif-2005) in India on acid soil to study the response of mungbean variety VBN (Gg) 2 to different methods and levels of molybdenum (Mo) application on number of nodules, grain yield and protein content. Doses applied were: 0.5, 1.0 and 1.5 kg Mo/ha as sodium molybdate (Na< sub>2</ sub>MoO< sub>4</ sub>) for soil application, 1.75, 3.5 and 5.25 g sodium molybdate/kg seed for seed treatment and 5 mg Na< sub>2</ sub>MoO< sub>4</ sub>/L for foliar application. The physical and chemical characteristics of the soil were: pH-5.1, EC-0.07 ds/m and OC-0.15%. Available N, P and K were 76, 7 and 90 kg/ha, respectively. The Mo status of soil was 0.02 mg kg-1. The two season's pooled data revealed that foliar application of Mo significantly increased the grain yield by 12.2%. Soil application of 1.0 kg Mo/ha and seed treatment with 3.5 g Na< sub>2</ sub>MoO< sub>4</ sub>/kg seed also increased the grain yield by 8.2% and 9.3% over the yields at lower doses while it was at par with yields at higher doses of Mo. Protein content of grain, number of nodules per plant of mungbean also increased with increasing doses of Mo under all methods of application. Based on the present findings it can be concluded that Na< sub>2</ sub>MoO< sub>4</ sub> should be sprayed for obtaining higher seed yield of good quality mungbean under acid soil conditions.

Johansen *et al.* (2005) found that chickpea grown on residual soil moisture after rice harvet is a promising crop for the High Barind Tract (HBT), an uplifted, slightly undulating area in northwestern Bangladesh where the soils have an acid surface horizon (p^{H} 4.5-5.5 at 0-10 cm). to determine which elements could be limiting to chickpea. A subtractive design was used in which the absence of either sulfur (S), boron (B), zinc (Zn) or molybdenum (Mo) was compared to a complete nutrient control. Only Mo was found to be limiting, giving a grain yield response of 73%.

Niranjana (2005) conducted a field experiment to investigate the effect of B(1 g kg^{-1} seed), Zn (2 and 4 g kg^{-1} seed) and Mo (2 and 4 g kg^{-1} seed) as seed treatments on the growth and yield of groundnut cv. KRG-1 on Alfisol, which was deficient in Zn (0.46 mg kg^{-1}) and Mo (0.032 mg kg^{-1}). He observed that the micronutrients showed significant effect on yield, oil content and growth parameters. The Zn at 4g + Mo at 2g kg^{-1} seed treatment recorded the highest pod yield of 24.99 q kg^{-1} and growth parameters, total number of nodules (57.4) and their dry weight (100.2 mg $plant^{-1}$), number of effective nodules (27.80) and their dry weight (70mg $plant^{-1}$) as well as root length (13.66 cm) and its dry weight(887 mg), over the contril, The extent of increase was 24.11 % over the control.

Siag (2003) conducted a trial during kharif seasons of 1998, 1999 and 2000 under irrigated conditions to study the response of mungbean cv. MUM 2 to sulfur (applied as gypsum) with different application methods in sandy loam soil of Sriganganagar, Rajasthan, India. Treatments comprised: two sulfur rates (20 and 40 kg ha^{-1}) and three application methods (basal, sidedressing at 25 days after sowing (DAS) and half as basal + half as sidedressing at 25 DAS) along with a control (no sulfur). The number of pods per plant increased with increasing sulfur rates. Basal dose of 40 kg Sha^{-1} recorded the highest number of pods $plant^{-1}$ (34.2), which was at par with 40 kg S ha^{-1} (half applied as basal + half as sidedressing (32.5)) and 20 kg Sha^{-1} as basal (30.7). Plant height, number of seeds per pod and 1000-seed weight were not influenced by different treatments in any year. Grain yield obtained at basal dose of 20 kg S/ha (973 kg ha^{-1}) was 42.9% higher than that of the control treatment (681 kg ha^{-1}). Grain yield was highest with a basal dose of 40 kg S ha^{-1} (1095 kg ha^{-1}), but did not differ significantly from 20 kg S ha^{-1}. A sidedressing of 20 kg S ha^{-1} at 25 DAS did not increase grain yield over the control.

Hazra and Tripathi (1998) observed that Mo application at the rate of 1.5 kg ha^{-1} to Berseem increased forage and seed yield in calcareous soil.

Bhuiyan *et al*. (1997) conducted an experiment and observed that application of Mo and B both at the rate of 1 kg ha^{-1} along with 50 kg P_2O_5 ha^{-1} and 50 kg k_2O ha^{-1} produced significantly 347% and 440% higher nodule number and nodule weight in chickpea over uninoculated control treatment.

Mohan and Rao (1997) observed that seed yield and number of pods/plant generally increased with increased with increasing rate of Mo (0.50 kg $Moha^{-1)}$ and P (90 kg P_2O_5 ha^{-1}).

Saha (1996) : 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^{-1} applied as soil, 66% soil + 33% foliar or foliar applications and the residual effects were studied on summer green gram [*Vigna radiata*]. In both years green gram seed yield was highest with a combination of 5 kg borax + 2 kg sodium molybdate. Soil application gave higher yields than foliar or soil + foliar application.

Zaman *et al.* (1996) conducted an experiment on mungbean and observed that application of 2 kg B ha^{-1} /ha in combination with 2 kg ha^{-1} produced 176% and 229% higher nodules $plant^{-1}$ over control in 1989 and 1990, respectively. The significant effect of B and Mo each at the rate of 2 kg ha^{-1} in combination seems that Mo accelerated the Rhizobial multiplication and the biological N fixation activities (Grigg, 1953) and simultaneously B strengthened the attachment of nodules with root tissues (Peterburgskee, 1971) in consequence of increased nodulation .

Zaman *et al.* (1996) branches $plant^{-1}$ increased with increased level of Mo up to 2 kg ha^{-1}. They also reported that the highest branches $plant^{-1}$ of 11.60 in mungbean due to application of Mo (2 kg ha^{-1}), which was 89% higher over control.

Zaman *et al.* (1996) conducted an experiment on mungbean and found that the height of 30.29 cm in plants receiving 1kg ha^{-1} , which was 40.69% higher over control .They also observed that application of Mo (1 kg ha^{-1}) produced 44.6 higher root length over control .

Zaman *et al.* (1996) conducted an experiment on mungbean and observed that 1000 seed weight increased by 34.32% over control due to application of Mo (2 kg ha^{-1}) during 1990.

Zaman *et al.* (1996) conducted an experiment on mungbean and observered that application of B (1kg ha^{-1}) produced 53% and 30% higher nodule number and nodule weight, respectively over control.

Zaman *et al.* (1996) conducted an experiment on mungbeam and observed that application of Mo (1 kg ha^{-1}) produced 97% and 150% higher nodule number and nodule weight, respectively over control.

Li and Gupta (1995) conducted an experiment in USA and observed that application of Mo (2 mg kg^{-1} soil) increased leaf N and shoot , root, and nodule dry weight, but did not significantly change mean photosynthesis , nodule nitrogense activity and chlorophyll content in soybean.

Aghatise and Tayo (1994) reported that Mo application significantly increased soybean plant height compared with the control plants. At 10 weeks after emergence Mo application at the rate of 0.0, 0.2, 0.4, and 0.8kg ha^{-1} gave 23.1, 24 .2 25.1, and 24.4cm height respectively.

Gupta and Vyas (1994) observed that seed protein content of soybean was increased by Mo application.

Paulino *et al.* (1994) showed that application of Mo favorably affected total N accumulation in soybean and benefiting N fixation, increased dry matter production. Mo applications significantly increased the plant's content if micronutrient.

Gupta and Narayanan (1992) reported that the pod number, seed number and weight and shoot dry weight showed significant higher values on exposure to 2 kg Mo ha^{-1} soil.

Sharma (1992) observed that application of Mo (1.5 hg ammonium molybdate ha^{-1}) increased 26.2% higher seed yield of soybean than control.

Singh *et al.* (1992) showed that protein content of cowpea grain increased significantly with increasing levels of Mo. Application of Mo at the rate of 1 or 2 kg ha^{-1} increased the protein content by 0.31 and 0.83 % , respectively.

Sarkar and Banik (1991) conducted and experiment in Calcutta, India on green gram and observed that Mo application significantly increased pods per plant, seeds per pod, 100 seed weight and straw yield . They also reported that application of Mo at the rate of 0.10 and 0.25 kg ha^{-1} gave 11.45 and 11.76 kg ha^{-1} straw yield and 19.25 and 20.18 pods $plant^{-1}$, respectively.

Solaiman *et al.* (1991) carried out an experiment with two varieties of lentil, Utfala and Mymensingh local. They reported that 2 kg Mo ha^{-1} when applied with *rhizobium* inoculants was found stimulating in respect of nodulation and dry matter production of the crop.

Anwar (1989) conducted a field experiment at BARI farm, Faridpur in Calcarious Dark Floodplain Soil with mungbean (*Vigna radiate* L.). He observed that application of Mo had significant effect on grain yield, and Mo content in straw bulk and grain.

Tiwari *et al.* (1989) reported that Mo application improved 75% higher nodule number in chickpea. Pradhan and Sarkar (1985) found that Mo application increased weight of nodules in chickpea.

Kalia and Sharma (1989) observed that soybean yield was increased 46% higher than control due to application of 1 kg Mo ha^{-1}.

Nayak *et al.* (1989) reported that the treatment with Mo had a significant influence on growth, yield and yield attributes like $podsplant^{-1}$, seeds pod^{-1} and seed weight.
Tiwari *et al.* (1989) reported that Mo application improved 75% higher nodule number in chickpea.

Verma *et al.* (1988) observed that application of Mo and P increase the pod number and seed yield increased with Mo application up to the highest level. Similar trends were noted for seed protein content. Mo is potentially limiting factor for chickpea yields in similar alluvial soil.

Pradhan and Sarker (1985) observed that application of Mo increased nodule by dry weight.
Sherrell (1984) conducted an experiment in New Zealand and observed that application of Mo by seed soaking was greater 20 times as efficient as soil application in increasing yield and N fixation.

Molybdenum is required for increasing yield in mungbean (Velu and Savithri, 1982; Paricca *et al*., 1983).

Significant yield responses of pulses to applied Mo in different soils has been reported from home and abroad (Kliewer and Kennedy, 1960, Ahmed, 1982). Although pulses are usually grown in Bangladesh with minimum fertilization in the recent years. Inadequate soil fertility in many instances has appeared as serious limitation of their yields (Islam *et al*. 1993).

Paricca *et al. (*1983) conducted a field experiment with *Vigna radiata* L. and observed that Mo alone increased the yield by 26.4% and this effect was equivalent to 25 kg Nha^{-1}.

According to FAO (1982, 1983), application of Mo at the rate of 0.4 kg ha^{-1} is sufficient for the maximum nodulation in legumes on acid soils.

Molybdenum is required for increasing nodulation in Mungbean (Paricca *et al* .1983; Velu and Savithri, 1982).

Molybdenum is essential for symbiotic N fixation. Pulses and legumes can have active nodules only when soils are adequately supplied with this element (Ahmed, 1982).

Mortvedt (1981) observed that Mo (2ppm) application to the soil increased the growth and N and Mo uptake of legumes.

Barthakur (1980) conducted a field experiment in India on soybean and observed that seed yield of soybean was increased 27% higher than control treatment with 400g Mo ha^{-1} application.

Weeratna (1980) observed that Mo application increased dry weight and N content in soybean. The beneficial effect of Mo was due to an increase in N fixation. Kumar and Shing (1980) observed that Mo application produced an antagonistic effect and significantly depressed P concentration in leaves, stems, pod husks and grains of soybean.

Gerath *et al*. (1975) reported an increase in yield of winter rape through application of boron fertilizer and recommended an application of 1 to 2 kg B ha^{-1} for Increased yield.

Jakson and Chapman (1975) observed that boron stimulates germination, particularly pollen tube growth. Boron is also essential for sugar translocation, thus affecting carbon and nitrogen metabolism of plants.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at the Agronomy field laboratory of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from March to May 2009 to study the effect of Boron and Molybdenum on the growth and yield of Mungbean. This chapter includes materials and methods that were used in conducting the experiment. The details regarding materials and methods of the experiment are presented below under the following headings-

3.1. Climate and soil type of the experimental site

3.1.1. Geographical location

The location of the experimental area was situated at 23°77′N latitude and 90°33′E longitude at an altitude of 9 meter above the sea level. The site is around the central part of Bangladesh and situated at the Dhaka city, capital of Bangladesh.

3.1.2. Agro-ecological region

The experimental field belongs to the Agro-ecological zone of “The Modhupur Tract”, AEZ-28. This was a region of complex relief and soils developed over the Modhupur clay, where floodplain sediments buried the dissected edges of the Modhupur Tract leaving small hillocks of red soils as ‘islands’ surrounded by floodplain.

3.1.3. Climate

The climate of the experimental site was sub-tropical characterized by heavy rainfall, high humidity, high temperature and relatively long day during the Kharif season including the month of April to September and hardly rainfall, low temperature and short day period during the Rabi season including the month of October to March. Plenty of sunshine and moderately low temperature prevailed during rabi season, which were suitable for growing of winter vegetables like cauliflower, cabbage, radish etc. in Bangladesh. The detailed record of monthly total rainfall, temperature and humidity during the period of experiment were collected from the adjacent Meteorological Department of Bangladesh (Climate division), Agargaon, Dhaka-1207 and has been presented in Appendix II.

3.1.4. Soil

The soil of the experimental site belongs to the general soil type, Shallow Red Brown Terrace Soils under Tejgaon Series. Top soils were clay loam in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH ranged from 6.00-6.63 and had organic matter 1.10-1.99%. The experimental area was flat having available irrigation and drainage system and above flood level. Soil samples from 0-15 cm depths were collected from experimental field. The analyses were done by Soil Resource and Development Institute (SRDI), Dhaka.

3.2. Planting materials

The Mungbean variety "BARI mung-6" released by Bangladesh Agricultural Research Institute (BARI) 2003, Joydevpur, Gajipur, was used as planting materials. BARI mung-6 is a recommended variety of mungbean. It grows both in kharif and rabi season. The variety is resistant to diseases, insects and pest attack. The variety is resistant to *Cercospora* leaf spot and yellow mosaic virus. Average seed yield is 1.8 t ha^{-1}. Seed contains 21.20% protein and 46.80% carbohydrate.

3.3 Details of the experiment

3.3.1 Land preparation

The land was irrigated before ploughing. After having zoe condition the land was first opened with the tractor drawn disc plough. The land was first ploughed on 10 March, 2009 by disc plough. The land then was harrowed again on 12 and 14 March to bring the soil in a good tilth condition. Ploughed soil was then brought into desirable fine tilth by 4 operations of ploughing, harrowing and laddering. The stubble and weeds were removed. The final land preparation was done by disc harrow on 19 March, 2009. The land was prepared thoroughly and leveled by ladder. Weeds and stubbles were removed from the field. The experiment was laid out on 19 March, 2009 according to the design adopted. The basal dose of fertilizers was incorporated with the soil by spading.

3.3.2 Fertilization

Urea, Triple Super Phosphate (TSP) and Muriate of Potash (MP) were used as a source of nitrogen, phosphorous and potassium, respectively.
The recommended fertilizer dose of Mungbean which were applied as follows:

Cowdong	=	8 Kg ha^{-1}
Nitrogen	=	21 Kg ha^{-1}
P_2O_5	=	48 Kg ha^{-1}
K_2O	=	35 Kg ha^{-1}
Boron	=	As per recommended
Molybdenum	=	As per recommended

The land was uniformly fertilized with Urea, TSP, MP, Boron and Molybdenum at the time of final land preparation. Boron and molybdenum were applied as per treatment requirement.

3.3.3 Treatments

Sixteen treatment combinations included in the study were as follows:
Treatments:
Factor A. Boron (4 levels)

a. $B_{0} =$Control
b. $B_{1} =$1.0 kg ha^{-1}
c. $B_{2} =$1.5 kg ha^{-1}
d. $B_{3=}$2.0 kg ha^{-1}

Factor B. Molybdenum (4 levels)

a. $Mo_{0=}$ Control
b. $Mo_{1=}$ 1.0 $kgha^{-1}$
c. $Mo_{2=}$ 1.5 $kgha^{-1}$
d. $Mo_{3=}$ 2.0 $kgha^{-1}$

There were on the whole 16 treatment combinations such as $B_0M_{0,}$ B_0M_1, B_0 $M_{2,}$ B_0 $M_{3,}$ $B_1M_{0,}$ $B_1M_{1,}$ $B_1M_{2,}$ $B_1M_{3,}$ $B_2M_{0,}$ B_2 $M_{1,}$ $B_2M_{2,}$ $B_2M_{3,}$ $B_3M_{0,}$ $B_3M_{1,}$ $B_3M_{2,}$ $B_3M_{3.}$

3.3.4 Experimental design and lay out

The two factors experiment was laid out in Split plot Design (SPD) with three replications. An area of 27.25m × 31.00m was divided into three equal blocks. Each of the blocks was divided into 4 main plots. Each of the main plots was divided into four sub plots. Boron was used as main treatment in the main plots and molybdenum was the sub-treatment in the sub-plots. The treatment combinations were allocated at random with three replication. There were 48 unit plots altogether in the experiment. The size of the each unit plot was 4.0m × 2.5m. The distance maintained between two blocks and plots were 1.0 m and .75 m, respectively.

3.4.1 Sowing of seed in the field

The Seeds of mungbean were sown on 21 March 2009. The seeds were treated with Bavistin before sowing the seeds to control the seed born disease. The seeds were sown in rows in the furrows having a depth of 2-3 cm. Row to Row distance was 30 cm.

3.4 Intercultural operations

3.4.1 Thinning

Seeds were germinated four days after sowing (DAS). Thinning was done twice; first thinning was done at 8 days after sowing(DAS) and second was done at 15 DAS to maintain 30 cm × 10 cm distance between row to row and plant to plant for obtain proper plant population in each plot.

3.4.2 Weeding

The crop was infested with some weeds during the early stages of crop establishment. The crop was weeded thrice; first weeding was done at 15 DAS, second weeding was done at 25 DAS and third Second weeding was done at 35 DAS.

3.4. 3 Application of irrigation water

The crop was grown in early kharif season when rainfall is likely to be occurred . So , two irrigation was given to the field. First irrigation was done at 20 DAS and last irrigation was done at 35 DAS.

3.4.4 Drainage

There was rainfall during the experimental period. Drainage channels were properly prepared to easy and quick drained out of excess water.

3.4.5 Plant protection measures

The crops were infested by insects and diseases. These were effectively and timely controlled by applying recommended insecticides and fungicides. Insecticides were applied for three times in the plot. Aktara at @ 5g/l.was applied on 6th April, Admaire 15 ml/l was applied on 15th April and Ripcord 30ml/l was used on 10th may, 2009 consecutively to protect the crop from white fly and mungbean pod borer.

3.4.6 Plant Sampling

Plants were sampled 4 times commencing from 20, 35, 50 and 60 DAS (at harvest).
Ten plants from each treatment were randomly marked inside the plot with sample card. Sample plants were collected from second and third rows. The first rows were avoided from sampling for border effect. The plant were then dried to a constant weight in a electric oven at 70^{o}C for 72 hours and weighted.

3.4.3 Harvesting and post harvest operation

The crops were harvested plot wise according to the maturity of the crops. Maturity of crop was determined when 90% of the pod became brown to black in color. Harvesting was done in four times. The harvesting was done on 21th May, 2009; 1st June, 2009; 12th June, 2009 and 23th June, 2009. Before harvesting 10 sample plants from each plot was marked and harvested for recording yield contributing characters data. For taking yield data, an area of $3m^2$ The matured pods were collected by hand picking from a pre demarcated area of three linear at the inside of each plot and yield was converted into t ha^{-1}. Threshing was done by hand. The grains were cleaned and sun dried to maintain an approximate moisture level of 12% of seeds. Husk was also sun dried properly. Finally grain and husk yields plot^{-1} were determined and converted to ton ha^{-1}.

3.6 Recording of data

The following data were recorded from the experiment:

i. Plant height (cm)
ii. Dry weight plant^{-1} (g)
iii. Number of pods per plant
iv. Pod length (cm)
v. Seeds per pod
vi. 1000-seed weight (g)
vii. Seed yield (kg ha^{-1})
viii. Stover yield (kg ha^{-1})
ix. Biological yield (kg ha^{-1})
x. Harvest index (%)

3.7 Detailed procedures of recording data

A brief outline of the data recording procedure followed during the study have been presented below:

a. Plant height (cm)

The height of five plants were measured with a meter scale from the ground level to top of the plants and mean height was expressed in cm. The plants were selected at random from theinner rows of each plot and data were taken from 20 to 65 DAS at 15 days interval .

b. Dry weight plant^{-1} (g)

Five plants were collected at different days after sowing (20, 35, 50 and 60 DAS and at harvest) and dried at 70° C for 24 hours. The dried samples were then weighted and averaged.

d. Number of pods plant^{-1}

Number of total pods of selected plants from each plot was counted and the mean number was expressed on per plant basis.

e. Pod length (cm)

Twenty pods of the selected 5 plants from each plot were measured and the mean length number was expressed on per plant basis. The 5 plants selected at random from the inner rows of each plot.

f. Number of seeds pod^{-1}

The number of seeds in each pod was recorded from randomly selected 20 pods at the harvest. The average number of seeds from the 20 pods was expressed as number of seeds pod^{-1}.

g. Weight of 1000 seed (g)

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.

h. Seed yield (kg ha^{-1})

The seed collected from 6.0 m^2 area of each plot was sun dried properly. The weight of seeds was taken and converted the yield in kg ha^{-1}.

i. **Stover yield** (kg ha^{-1})

The Stover collected from 3.0 m^2 area of each plot was sun dried properly. The weight of stover was taken and converted the yield in kg ha^{-1}.

j. **Biological yield (kg ha^{-1})**

The sum of grain yield and stover yield is regarded as biological yield. Biologicla yied was determined by the using the following formula –
Biological yield (kg ha^{-1}) = Seed yield (kg ha^{-1}) + Stover yield (kg ha^{-1})

k. Harvest Index (%)

Harvest index (HI) was calculated by using the following formula:

$$HI = \frac{\text{Grain yield (kg ha}^{-1}\text{)}}{\text{Biological yield (kg ha}^{-1}\text{)}} \times 100$$

3.4.5 Data analysis

All the collected data were analyzed following the analysis of variance (ANOVA) technique using MSTAT-C package and the mean differences were adjudged by LSD technique.

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to evaluate the effect of boron and molybdenum on growth and yield of mungbean. The parameters studied were plant height, dry matter plant^{-1}, numbers of pods plant^{-1}, pod length, number of seeds pod^{-1}, thousand seed weight, seed yield, stover yield, biological yield and harvest index (%). The analysis of variance (ANOVA) of the data on different yield components and yield are given in Appendix III-VI. The findings have been presented and discussed, and possible interpretations have been given under the following headings:

4.1 Plant Height

4.1.1 Effect of boron

A statistically significant variation was observed for plant height of mungbean due to application of different level of boron at 20, 35, 50 and 60 DAS (Table 1). Plant height showed an increasing trend with the increases rate of boron for all the sampling dates. The maximum plant height was recorded with the opposition of the highest dose of boron comprised with 2 kg B ha^{-1} for all the sampling dates (18.98 cm, 37.79 cm, 46.13 cm and 47.22 cm, respectively for 20, 35, 50, and 60 DAS) and that of lowest for the control treatment comprised with (no boron application) (17.71 cm, 33.32 cm, 42.74 cm, respectively for 20, 35, 50 and 60 DAS).

4.1.2 Effect of molybdenum

Effect of different level of Mo on plant height was observed at 20, 35, 50 and 60 DAS. Among these, statistically significant variation was recorded at 35 DAS. The maximum plant height of 36.38 cm was found at Mo_1 and Mo_3 which was statistically similar with Mo_2. On the other hand, minimum plant height of 34.01 cm was obtained at Mo_0 level of molybdenum application. Plant height recorded for other sampling dates (20, 35, 50 and 60 DAS) showed non significant difference due to molybdenum level (Table 2).

4.1.3 Interaction effect of boron and molybdenum

Interaction effect of boron and molybdenum showed statistically significant differences for plant height at 20, 35, 50 and 60 DAS (Table 3). At 20 DAS, the tallest plant height (19.21 cm) was recorded from B_3Mo_3 (2 kg B ha^{-1} × 2 kg Mo ha^{-1}) and the shortest plant (16.47 cm) was recorded from $BoMo_0$ (0 kg B ha^{-1} × 0 kg Mo ha^{-1}) interaction. The tallest plant (39.89 cm) was recorded from B_3Mo_3 and the shortest plant (30.51 cm) was recorded from BoM_{Oo} at 35 DAS. At 50 DAS, the tallest plant (46.70 cm) was recorded from B_3Mo_3 interaction and the shortest plant (39.13 cm) was recorded from B_0M_{0o} interaction. The tallest plant (48.13 cm) was recorded from B_1Mo_3 and the shortest plant

(40.21cm) was found from B_oM_{0o} interaction at 60 DAS. The result corroborates with findings of Zaman *et al.* (1996) in that the interaction of Mo (1kg ha^{-1}) with B (2 kg ha^{-1}) produced maximum plant height (35.03cm) compared to control (2 1.53 cm) in mungbean.

4.2 Dry matter weight (plant^{-1})

4.2.1 Effect of boron

Different level of boron application in mungbean showed significant variation in plant height at all the sampling dates except 20 DAS (Table 4). The result showed that control treatment (without boron) produced the lowest dry matter per plant for all sampling dates. Dry matter per plant showed increasing trend with the increases of boron doses and the highest weights were found with the highest boron dose (2 kg B ha^{-1}) for all the sampling dates (20, 35, 50 and 60 DAS).

4.2.2 Eeffect of molybdenum

Dry matter per plant of mungbean varied significantly due to application of different levels of molybdenum at 20, 35, 50 and 60 DAS (Table 5), Data showed that the highest dose of molybdenum produced heaviest plant 0.83, 8.77, 10.79 and 16.59 g at 20, 35, 50 and 60 DAS, respectively. Dry weight per plant showed a decreasing trend with decreases of molybdenum dose and the lowest dry weight was recorded with control treatment (without molybdenum) for all the growth stages. The result was consistence with the findings with Gupta and Narayanan (1992) that shoot dry weight showed significant higher values on exposure to 2 kg Mo ha^{-1} in soil.

Table 1. Effect of boron on plant height of BARI mung -6 at different days after sowing (DAS)

Boron level (kg ha^{-1})	Plant height at different DAS			
	20	35	50	60
B_0(0)	17.71 b	33.32 c	42.74 c	44.10 b
B_1(1)	18.71 a	35.45 b	44.10 bc	46.90 a
B_2(1.5)	18.81 a	36.62 ab	45.10 ab	46.86 a
B_3(2)	18.98 a	37.79 a	46.13 a	47.22 a
LSD (0.05 %)	0.8488	1.471	1.757	2.606
CV (%)	5.70	5.31	6.02	6.59

Factor A. Boron (4 levels)

a. B_{0} =Control
b. B_{1} =1.0 kgha^{-1}
c. B_{2} =1.5 kgha^{-1}
d. B_{3}=2.0 kgha^{-1}

Factor B. Molybdenum (4 levels)

a. Mo_{0}= Control
b. Mo_{1}= 1.0 kgha^{-1}
c. Mo_{2}= 1.5 kgha^{-1}
d. Mo_{3}= 2.0 kgha^{-1}

Table 2. Effect of molybdenum on plant height of BARI mung -6 at different days after sowing(DAS)

Molybdenum level (kg ha^{-1})	Plant height at different DAS			
	20	35	50	60
Mo_0(0)	18.05	34.01 b	43.37	44.67
Mo_1(1)	18.63	36.38 a	44.68	46.56
Mo_2(1.5)	18.74	35.92 a	45.33	46.79
Mo_3(2)	18.79	36.38 a	44.70	47.06
LSD (0.05 %)	NS	1.601	NS	NS
CV (%)	5.70	5.31	6.02	6.59

Factor A. Boron (4 levels)

a. B_{0} =Control
b. B_{1} =1.0 kgha^{-1}
c. B_{2} =1.5 kgha^{-1}
d. B_{3}=2.0 kgha^{-1}

Factor B. Molybdenum (4 levels)

a. Mo_{0}= Control
b. Mo_{1}= 1.0 kgha^{-1}
c. Mo_{2}= 1.5 kgha^{-1}
d. Mo_{3}= 2.0 kgha^{-1}

Table 3. Interaction effect of boron and molybdenum on plant height of BARI mung-6 at different days after sowing (DAS)

Interaction (Boron × Molybdenum)	Plant height at different DAS			
	20	35	50	60
B_0 × Mo_0	16.47 b	30.51 d	39.13 b	40.21 b
B_0 × Mo_1	17.91 ab	33.57 cd	43.19 ab	44.88 ab
B_0 × M o_2	18.11 ab	34.09 c	44.11 ab	45.53 ab
B_0 × Mo_3	18.34 ab	35.11 bc	43.51 a	45.76 ab
B_1 × Mo_0	18.71 a	33.49 cd	43.14 ab	44.80 ab
B_1 × Mo_1	18.69 a	36.94 a-c	43.80 ab	46.87 a
B_1 × Mo_2	18.81 a	35.74 bc	44.55 a	47.79 a
B_1 × Mo_3	18.63 a	35.63 bc	44.91 a	48.13a
B_2 × Mo_0	18.41 ab	35.44 bc	45.34 a	46.51 a
B_2 × Mo_1	18.99a	36.99 a-c	45.53 a	47.20 a
B_2 × Mo_2	18.88a	37.17 a-c	45.96 a	46.40 a
B_2× Mo_3	18.97 a	36.87 a-c	43.58 ab	47.33 a
B_3 × Mo_0	18.61 a	36.60 a-c	45.85 a	47.14 a
B_3× Mo_1	18.93 a	38.01 ab	46.19 a	47.29 a
B_3× Mo_2	19.17 a	36.67 a-c	46.70 a	47.44 a
B_3× Mo_3	19.21 a	39.89 a	45.80 a	47.03 a
LSD (0.05 %)	1.783	3.202	4.514	5.141
CV (%)	5.70	5.31	6.02	6.59

Factor A. Boron (4 levels)

a. B_0 =Control
b. B_1 =1.0 kg ha^{-1}
c. B_2 =1.5 kg ha^{-1}
d. B_3=2.0 kg ha^{-1}

Factor B. Molybdenum (4 levels)

a. Mo_0= Control
b. Mo_1= 1.0 kg ha^{-1}
c. Mo_2= 1.5 kg ha^{-1}
d. Mo_3= 2.0 kg ha^{-1}

Table4. Effect of boron on dry matter per plant of BARI Mung -6 at different days after sowing(DAS)

Boron level (kg ha^{-1})	Dry Matter per plant at different DAS			
	20	35	50	60
B_0(0)	0.63	6.57b	8.71 b	13.44c
B_1(1)	0.74	7.86a	9.34ab	15.21b
B_2(1.5)	0.78	8.08a	10.16a	16.38a
B_3(2)	0.83	7.98a	10.32a	16.48a
LSD (0.05 %)	NS	0.471	1.053	0.7469
CV (%)	5.64	7.34	6.64	4.32

Factor A. Boron (4 levels)

a. $B_{0=}$Control
b. $B_{1=}$1.0 kgha^{-1}
c. $B_{2=}$1.5 kgha^{-1}
d. $B_{3=}$2.0 kgha^{-1}

Factor B. Molybdenum (4 levels)

a. $Mo_{0=}$ Control
b. $Mo_{1=}$ 1.0 kgha^{-1}
c. $Mo_{2=}$ 1.5 kgha^{-1}
d. $Mo_{3=}$ 2.0 kgha^{-1}

Table5. Effect of molybdenum on dry matter per plant of BARI Mung -6 at different days after sowing(DAS)

Molybdenum level (kg ha^{-1})	Dry Matter per plant at different DAS			
	20	35	50	60
Mo_0(0)	0.62d	6.360d	8.39d	14.17d
Mo_1(1)	0.71c	7.24c	9.18c	14.93c
Mo_2(1.5)	0.80b	8.08b	10.20b	15.82b
Mo_3 (2)	0.83a	8.77a	10.79a	16.59a
LSD (0.05 %)	0.0376	0.470	0.539	0.560
CV (%)	5.64	7.34	6.64	4.32

Factor A. Boron (4 levels)

a. $B_{0=}$Control
b. $B_{1=}$1.0 kgha^{-1}
c. $B_{2=}$1.5 kgha^{-1}
d. $B_{3=}$2.0 kgha^{-1}

Factor B. Molybdenum (4 levels)

a. $Mo_{0=}$ Control
b. $Mo_{1=}$ 1.0 kgha^{-1}
c. $Mo_{2=}$ 1.5 kgha^{-1}
d. $Mo_{3=}$ 2.0 kgha^{-1}

4.2.3 Interaction effect of Boron & molybdenum

Interaction effect of boron and molybdenum showed significant variation on total dry matter per plant at 20, 35, 50 and 60 DAS. At 20 DAS, the highest dry matter per plant (0.93 g) was recorded from the interaction of B_3Mo_3 (2 kg B ha^{-1}×2 kg Mo ha^{-1}) and the lowest dry matter per plant (0.49 g) was recorded from B_0Mo_0 (0 kg B ha^{-1}×0 kg Mo ha^{-1}) interaction. The interaction of B_3Mo_3 also showed highest dry weight of 9.76g, 11.35g and 17.75g for 35, 50 and 60 DAS respectively, and that of lowest was recorded with B_0Mo_0 interaction (5.15g, 7.45g and 12.58g for 35, 50 and 60 DAS respectively). Other interactions showed statistically different level of dry weight plant^{-1}.

4.3 Number of pods plant^{-1}

4.3.1 Effect of boron

Different doses of boron fertilization exerted sowed significant variation in respect of number of pods plant^{-1} (Table 7). Among the different doses, B_3 (2 kg B ha^{-1}) sowed the highest number of pods plant^{-1} (30.36), which was statistically similar with that of B_2 (1.5 kg B ha^{-1}) and the minimum number of pods per plant (22.07) was recorded from B_0 (0 kg B ha^{-1}).

4.3.2 Effect of molybdenum

Number of pods per plants of mungbean varied significantly due to application of different levels of molybdenum. The maximum number of pods plant^{-1} (29.51) was recorded from Mo_2 (1.5 kg Mo ha^{-1}), which was statistically at per (27.87) with that of Mo_1 (1 kg Mo ha^{-1}) and of Mo_3 (2 kg Mo ha^{-1}). While the minimum number of pods per plant (24.14) was recorded from Mo_0 (0 kg Mo ha^{-1}) (Table 8). Gupta and Narayanan (1992) observed similar result that the pod number showed higher values on exposure to 2 kg Mo ha^{-1} in soil.

4.3.3 Interaction effect of boron and molybdenum

Interaction effect of boron and molybdenum exerted statistically significant differences for number of pods per plant. The maximum number of seeds per plant (33.07) was recorded from B_3Mo_2 (2 kg B ha^{-1} × 1.5 kg Mo ha^{-1}) which was statistically similar with the interaction of B_3Mo_3, B_3Mo_1, B_2Mo_3, B_2Mo_2, B_2Mo_1 and B_1Mo_1. Significantly the lowest number of pods per plant (18.40) was observed in B_0Mo_0 (0 kg B ha^{-1} × 0 kg Mo ha^{-1}) (Table 9).

Table6. Interaction effect of boron and molybdenum on dry matter per plant of BARI Mung -6 at different days after sowing (DAS)

Interaction Boron × Molybdenum	Dry matter per plant at different DAS			
	20	35	50	60
$B_0 \times Mo_0$	0.49i	5.15f	7.45 f	12.58i
$B_0 \times Mo_1$	0.59h	6.30e	8.30ef	13.08hi
$B_0 \times M\ o_2$	0.68e-g	6.99de	9.04de	13.80gh
$B_0 \times Mo_3$	0.72d-f	7.77cd	10.02bd	14.29fh
$B_1 \times Mo_0$	0.62gh	6.75de	8.07ef	13.83gh
$B_1 \times Mo_1$	0.74de	7.74cd	8.85de	14.56eg
$B_1 \times Mo_2$	0.77cd	8.32bc	9.85cd	15.72ce
$B_1 \times Mo_3$	0.82bc	8.58bc	10.72ac	16.74ac
$B_2 \times Mo_0$	0.64fh	6.90de	9.00de	15.06df
$B_2 \times Mo_1$	0.72de	7.73cd	9.74cd	15.89bd
$B_2 \times Mo_2$	0.84bc	8.69bc	10.80ac	16.97ab
$B_2 \times Mo_3$	0.88ab	8.97ab	11.08ab	17.58a
$B_3 \times Mo_0$	0.70df	6.62e	9de.03	15.21df
$B_3 \times Mo_1$	0.77cd	7.17de	9.8cd1	16.19bd
$B_3 \times Mo_2$	0.88ab	8.30bc	11.09ab	16.79ac
$B_3 \times Mo_3$	0.93a	9.76a	11.35a	17.75a
LSD (0.05 %)	0.075	0.941	1.079	1.120
CV (%)	5.64	7.34	6.64	4.32

Factor A. Boron (4 levels)

a. $B_{0} =$ Control
b. $B_{1} =$ 1.0 $kgha^{-1}$
c. $B_{2} =$ 1.5 $kgha^{-1}$
d. $B_{3} =$ 2.0 $kgha^{-1}$

Factor B. Molybdenum (4 levels)

a. $Mo_{0} =$ Control
b. $Mo_{1} =$ 1.0 $kgha^{-1}$
c. $Mo_{2} =$ 1.5 $kgha^{-1}$
d. $Mo_{3} =$ 2.0 $kgha^{-1}$

Table7. Effect of boron on plant and yield contributing characters of BARI Mung -6.

Boron level (kg ha^{-1})	Pod $plant^{-1}$ (no.)	Pod length (cm)	Seeds pod^{-1} (no.)	Weight of 1000 seed (g)
B_0(0)	22.07 c	7.025 c	7.91 b	41.62 b
B_1(1)	27.61 b	8.503 b	10.18 a	44.25 a
B_2(1.5)	28.86 ab	8.637 ab	10.53 a	44.28 a
B_3(2)	30.36a	8.975 a	10.93 a	44.22 a
LSD (0.05 %)	**2.601**	**0.3869**	**1.187**	**0.8394**
CV (%)	**8.38**	**8.90**	**6.87**	**6.11**

Factor A. Boron (4 levels)

a. $B_{0=}$ Control
b. $B_{1=}$ 1.0 $kgha^{-1}$
c. $B_{2=}$ 1.5 $kgha^{-1}$
d. $B_{3=}$ 2.0 $kgha^{-1}$

Factor B. Molybdenum (4 levels)

a. $Mo_{0=}$ Control
b. $Mo_{1=}$ 1.0 $kgha^{-1}$
c. $Mo_{2=}$ 1.5 $kgha^{-1}$
d. $Mo_{3=}$ 2.0 $kgha^{-1}$

Table8. Effect of molybdenum on yield contributing characters of BARI Mung -6.

Molybdenum level ($kgha^{-1}$)	Pod $plant^{-1}$ (no.))	Pod length (cm	Seeds pod^{-1} (no.)	Weight of 1000 seed (g)
Mo $_0$(0)	24.14 c	7.050 b	8.29 c	40.31 b
Mo $_1$(1)	27.87 ab	8.465 a	9.85 b	44.54 a
Mo_2(1.5)	29.51 a	8.705 a	10.89 a	44.82 a
Mo_3 (2)	27.38 b	8.920 a	10.53 a	44.69 a
LSD (0.05 %)	**1.923**	**0.386**	**0.5727**	**2.405**
CV (%)	**8.38**	**8.90**	**6.87**	**6.11**

Factor A. Boron (4 levels)

a. $B_{0=}$ Control
b. $B_{1=}$ 1.0 $kgha^{-1}$
c. $B_{2=}$ 1.5 $kgha^{-1}$
d. $B_{3=}$ 2.0 $kgha^{-1}$

Factor B. Molybdenum (4 levels)

a. $Mo_{0=}$ Control
b. $Mo_{1=}$ 1.0 $kgha^{-1}$
c. $Mo_{2=}$ 1.5 $kgha^{-1}$
d. $Mo_{3=}$ $_S$2.0 $kgha^{-1}$

4.4 Pod length

4.4.1 Effect of boron

Statistically significant variation was observed on plant length due to the application of different levels of boron (Table 7). The maximum pod length (8.97 cm) was recorded from B_3 (2 kg B ha^{-1}), which was statistically similar with B_2 (1.5 kg B ha^{-1}), while the minimum pod length (7.02 cm) was recorded from B_0 (0 kg B ha^{-1}).

4.4.2 Effect of molybdenum

Pod length varied significantly due to application of different levels of molybdenum (Table 8). Among the molybdenum treatments plots, the highest dose (2 kg Mo ha^{-1}) showed the highest pod length, but it was interesting that all the molybdenum treated plots showed statistically similar pod length. The lowest result was recorded from Mo_o treatment.

4.4.3 Interaction effect of boron and molybdenum

Interaction effect of boron and molybdenum showed statistically significant differences for length (Table 9). The maximum pod length (9.58 cm) was observed from B_3Mo_3 (2 kg B ha^{-1} +2 kg Mo ha^{-1}) and the minimum pod length (5.77cm) was recorded from B_0M_{0o} (0 kg B ha^{-1} +0 kg Mo ha^{-1}).

Table9. Interaction Effect of boron and molybdenum on yield contributing characters of BARI Mung -6.

Interaction Boron xMolybdenum	Pod plant^{-1} (no.)	Pod length (cm)	Seeds pod^{-1} (no.)	Weight of 1000 seed (gm)
$B_0 \times Mo_0$	18.40 g	5.770 e	7.43 f	38.05 b
$B_0 \times Mo_1$	22.88 f	6.230 de	7.63 f	43.34 ab
$B_0 \times M\ o_2$	24.40ef	8.070 bc	8.44ef	42.76 ab
$B_0 \times Mo_3$	22.59 f	8.030 bc	8.14 ef	42.33 ab
$B_1 \times Mo_0$	25.16 d-f	7.010 c-e	8.31ef	41.05 ab
$B_1 \times Mo_1$	28.14b-e	8.870 ab	10.01 cd	44.72 a
$B_1 \times Mo_2$	29.60 a-c	8.840 ab	11.13 a-c	45.73 a
$B_1 \times Mo_3$	27.54 b-e	9.290 ab	11.29a-c	45.48 a
$B_2 \times Mo_0$	26.29 c-f	7.190 cd	8.45ef	41.03 ab
$B_2 \times Mo_1$	29.34a-d	9.570 a	10.59 bc	44.70a
$B_2 \times Mo_2$	30.97 ab	8.780 ab	11.67 ab	45.93a
$B_2 \times Mo_3$	28.84 a-d	9.010 ab	11.43ab	45.45 a
$B_3 \times Mo_0$	26.71b-f	8.230 a-c	8.97 de	41.11 ab
$B_3 \times Mo_1$	31.13 ab	9.190 ab	11.15a-c	45.39 a
$B_3 \times Mo_2$	33.07 a	9.130 ab	12.31a	44.87 a
$B_3 \times Mo_3$	30.54 a-c	9.35 ab	11.27a-c	45.49a
LSD (0.05 %)	**3.846**	**1.254**	**1.145**	**4.811**
CV (%)	**8.38**	**8.90**	**6.87**	**6.11**

Factor A. Boron (4 levels)

a. B_{0} =Control
b. B_{1} =1.0 kgha^{-1}
c. B_{2} =1.5 kgha^{-1}
d. B_{3} =2.0 kgha^{-1}

Factor B. Molybdenum (4 levels)

a. Mo_{0} = Control
b. Mo_{1} = 1.0 kgha^{-1}
c. Mo_{2} = 1.5 kgha^{-1}
d. Mo_{3} = 2.0 kgha^{-1}

4.5 Number of seeds pod^{-1}

4.5.1 Effect of boron

Significant variation was observed in number of seeds pod^{-1} of mungbean due to different doses of boron application (Table 7). The maximum seeds per pod (10.93 cm) was recorded from B_3 (2 kg B ha^{-1}), which was statistically similar with of B_2 (1.5 kg B ha^{-1}) and B_1 (1 kg B ha^{-1}) (10.53cm and 10.18cm, respectively) while the minimum mumber of seeds per pod (7.02 cm) was recorded from B_0 (0 kg B ha^{-1}).

4.5.2 Effect of molybdenum

Different doses of molybdenum had significant effect on number of seeds pod^{-1}(Table 8). Among the different doses, Mo_2 (1.5kg Mo ha^{-1}) showed the highest number of seeds pod^{-1} (10.89) which was statistically similar with Mo_3 (2 kg Mo ha^{-1}). On the contrary, lowest number of seeds pod^{-1}(8.29) was observed with M_o, where no molybdenum was applied. The result corroborates with the findings of Gupta and Narayanan (1992) who reported that seed number was higher values on exposure to 2 kg Mo ha^{-1} in soil.

4.5.3 Interaction effect of boron and molybdenum

The combined effect of different doses of boron and molybdenum on number of seeds pod^{-1} of mungbean was significant (Table 9). The highest number of seeds pod^{-1} (12.31) was recorded from B_3Mo_2 (2 kg B ha^{-1}×1.5 kg Mo ha^{-1}). On the other hand, the lowest number of seeds pod^{-1} (7.43) was found in B_oMo_o (0 kg B ha^{-1}×0 kg Mo ha^{-1}) treatment.

4.6. 1000-seed weight.

4.6.1 Effect of boron

Weight of 1000 seed differed significantly due to application of different levels of boron on mungbean (Table7). Boron treated plots showed statistically higher thousand seed weight than control plots (no boron). Among the boron treated plots there observed a statistically similar result, although the values are numerically different. Zaman *et al.* (1996) observed similar result that application of B (2 kg ha^{-1}) produced 23.37% higher 1000 seed weight over control.

4.6.2 Effect of molybdenum

Weight of 1000 seed differed significantly due to application of different levels of molybdenum on mungbean (Table 8). The highest weight of 1000 seed (44.82 g) was observed by applying molybdenum at Mo_2 (1.5 kg Mo ha^{-1}), which was statistically similar (44.64 g) to that 1000 seed weight obtained from Mo_3 (2 kg Mo ha^{-1}). Molybdenum treated plots showed statistically higher thousand seed weight than control plots (no molybdenum). Among the molybdenum treated plots there observed a statistically similar result, although the values are numerically different. The result was similar with Zaman *et al.* (1996) that 1000 seed weight increased by 34.32% over control due to application of Mo (2 kg ha^{-1}).

4.6.3 Interaction effect of boron and molybdenum.

Interaction effect of boron and molybdenum showed statistically significant difference for 1000 seed weight (Table 9). Data showed that all the interaction showed statistically similar 1000 seed weight except $BoMo_o$, where no boron and molybdenum was used. However, the maximum 1000 seed weight (45.93 g) was recorded from B_2Mo_2 (1.5 kg B ha^{-1}×1.5kg Mo ha^{-1}) and that of minimum from the interaction of B_oMo_o (0 kg B ha^{-1} × 0 kg Mo ha^{-1}) (Table 9).

4.7 Seed yield (kg ha^{-1})

4.7.1 Effect of boron

Seed yield showed significant variation due to different level of boron application in mungbean (Table 10). All the boron doses showed increase of seed yield over control. However, significantly highest increase was observed in highest two doses of boron (1531.09 and 1529.36 $kgha^{-1}$ respectively for 2 and 1.5 kg B ha^{-1}). One kg B ha^{-1}showed intermediate increase of seed yield than control and higher doses of boron.

4.7.2 Effect of molybdenum

Effect of different levels of molybdenum on seed yield per hectare of mungbean was significant (Table 11). The highest seed yield (1559.19 kg ha^{-1}) was recorded from Mo_3 (2 kg Mo ha^{-1}), which was statistically similar with Mo_2 (1.5 kg Mo ha^{-1}). The minimum seed yield (1165.09 kg ha^{-1}) was recorded from Mo_0 treatment. The result was consistence with the finding of Paricca *et al. (*1983) that Mo alone increased the yield by 26.4% and this was equivalent to 25 kg N ha^{-1}.

4.7.3 Interaction effect of boron & molybdenum.

Seed yield of mungbean varied significantly with the effect of interaction of varied level of boron and molybdenum. It appears that treatment combination of B_3Mo_2 (2 kg B ha^{-1}+1.5 kg Mo ha^{-1}) produce significantly the highest yield (1743.65 kg ha^{-1}) and the minimum seed yield (993.5 kg ha^{-1}) was observed from B_0Mo_0 (0 kg B ha^{-1}+0 kg Mo ha^{-1}) (Table 12).

4.8 Stover yield per hectare

4.8.1 Effects of boron

Application of different doses of boron showed significant variation in terms of stover yield of mungbean (Table 10).The highest stover yield (1785.25 kg ha^{-1}) was obtained from the highest dose of boron B_3 (2 kg B ha^{-1}) followed by B_2 (1.5 kg B ha^{-1}) and B_1(1 kg B ha^{-1}) treatments. The control treatment showed significantly the lowest stover yield (1534.64 kg ha^{-1}).

4.8.2 Eeffect of molybdenum

Stover yield of mungbean varied significantly due to application of different levels of molybdenum (Table 11). The maximum stover yield 1850.63 kg ha^{-1} was recorded from Mo_3 (2 kg Mo ha^{-1}), which was statistically identical with Mo_2 (1.5 kg Mo ha^{-1}) (1811.03 kg ha^{-1}). While the minimum stover yield (1491.54 kg ha^{-1}) was recorded from M_o (without molybdenum) treated plots.

4.8.3 Interaction effect of boron & molybdenum

It was observed that combined effect of boron and molybdenum showed significant differences to produce Stover yield (Table 12).The maximum stover yield (1964.63 kg ha^{-1}) was recorded from B_3Mo_3 (2 kg B ha^{-1} × 2 kg Mo ha^{-1}) and the minimum stover yield (1375.16 kg ha^{-1}) was observed from B_0Mo_0 (0 kg B ha^{-1} × 0 kg Mo ha^{-1}) (Table 12).

4.9 Biological yield (kg ha^{-1})

4.9.1 Effect of boron

A statistically significant difference was recorded for biological yield of mungbean due to the application of different level of boron (Table 10). The highest biological yield per hectare (3315.22 kg) was recorded from B_3 (2 kg B ha^{-1}) which was statistically similar with B_2 (1.5 kg B ha^{-1}). The minimum biological yield (2711.15 kg ha^{-1}) was recorded from B_o (0 kg B ha^{-1}).

4.9.2 Effect of molybdenum

Application on molybdenum fertilizer exerted significant influence on the biological yield of mungbean (Table 11). The maximum biological yield (3410.84 kg) was recorded from the highest dose of molybdenum (Mo_3 treatment) which was statistically similar with Mo_2 treatment (3298.41 kg). Application of 1 kg Mo ha^{-1} (Mo_1 treatment) gave the second highest biological yield (3000.09 kg ha^{-1}) and significantly the lowest biological yield was found with control treatment.

Table10. Effect of Boron on yield and harvest index of BARI Mung -6

Boron level (kg ha^{-1})	**Seed yield (kg ha^{-1})**	**Stover yield (kg ha^{-1})**	**Biological yield (kg ha^{-1})**	**Harvest Index (%)**
B_0(0)	1177.25 c	1534.64 b	2711.15 c	43.32 c
B_1(1)	1380.68 b	1713.16 a	3094.35 b	44.54 b
B_2(1.5)	1529.36 a	1769.06 a	3298.41 a	46.34 a
B_3(2)	1531.09 a	1785.25 a	3315.22 a	46.01 a
LSD (0.05 %)	68.28	70.28	117.8	1.205
CV (%)	5.77	4.91	4.50	4.42

Factor A. Boron (4 levels)

a. $B_{0=}$ Control
b. $B_{1=}$ 1.0 kgha^{-1}
c. $B_{2=}$ 1.5 kgha^{-1}
d. $B_{3=}$ 2.0 kgha^{-1}

Factor B. Molybdenum (4 levels)

a. $Mo_{0=}$ Control
b. $Mo_{1=}$ 1.0 kgha^{-1}
c. $Mo_{2=}$ 1.5 kgha^{-1}
d. $Mo_{3=}$ 2.0 kgha^{-1}

Table11. Effect of Molybdenum on yield and harvest index of BARI Mung -6

Molybdenum level (kgha^{-1})	**Seed yield** (kgha^{-1})	**Stover yield** (kgha^{-1})	**Biological yield** (kgha^{-1})	**Harvest Index (%)**
Mo $_0$(0)	1165.16 c	1491.54 c	2656.14 c	43.71 b
Mo $_1$(1)	1352.06 b	1648.25 b	3000.09 b	44.96 a
Mo_2(1.5)	1541.28 a	1811.03 a	3352.32 a	45.84 a
Mo_3 (2)	1559.19 a	1850.63 a	3410.84 a	45.70 a
LSD (0.05 %)	**68.28**	**74.15**	**117.8**	**1.205**
CV (%)	**7.64**	**6.46**	**5.36**	**5.08**

Factor A. Boron (4 levels)

a. $B_{0=}$ Control
b. $B_{1=}$ 1.0 kgha^{-1}
c. $B_{2=}$ 1.5 kgha^{-1}
d. $B_{3=}$ 2.0 kgha^{-1}

Factor B. Molybdenum (4 levels)

a. $Mo_{0=}$ Control
b. $Mo_{1=}$ 1.0 kgha^{-1}
c. $Mo_{2=}$ 1.5 kgha^{-1}
d. $Mo_{3=}$ 2.0 kgha^{-1}

Table12. Interaction Effect of boron and molybdenum on yield and harvest index contributing of BARI Mungbean -6.

Interaction Boron x Molybdenum	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest Index (%)
$B_0 \times Mo_0$	993.5 h	1375.16 h	2369.13 h	41.95 e
$B_0 \times Mo_1$	1109.31 gh	1489.31 f-h	2597.36 jh	42.73 ce
$B_0 \times Mo_2$	1226.85 eg	1578.08 e-g	2804.94 fg	43.72 be
$B_0 \times Mo_3$	1379.18 bd	1694.38 c-e	3073.00 de	44.87 ad
$B_1 \times Mo_0$	1166.85 fg	1589.68 e-g	2755.41 fg	42.32 de
$B_1 \times Mo_1$	1343.09 ce	1644.26 d-f	2987.65 ef	44.98 ad
$B_1 \times Mo_2$	1496.16 b	1792.08 b-d	3287.16 cd	45.50 ab
$B_1 \times Mo_3$	1516.42 b	1829.49 a-c	3345.76 bc	45.34 ac
$B_2 \times Mo_0$	1275.86 df	1515.02 f-h	2789.65 fg	45.70 ab
$B_2 \times Mo_1$	1479.14 bc	1727.45 c-d	3206.09 ce	46.12 ab
$B_2 \times Mo_2$	1697.05 a	1923.61 ab	3621.17 a	46.97a
$B_2 \times Mo_3$	1665.23 a	1910.14 ab	3576.43 ab	46.56 a
$B_3 \times Mo_0$	1225.42 eg	1486.16 gh	2711.16 g	44.86 ad
$B_3 \times Mo_1$	1476.36 bc	1732.48 c-e	3208.14 ce	46.00 ab
$B_3 \times Mo_2$	1743.65 a	1952.11 a	3696.07 a	47.16 a
$B_3 \times Mo_3$	1677.86 a	1968.63 a	3646.71 a	46.03 ab
LSD	**136.6**	**140.6**	**235.56**	**2.410**
CV (%)	**7.64**	**6.46**	**5.36**	**5.08**

Factor A. Boron (4 levels)

a. B_0 =Control
b. B_1 =1.0 $kgha^{-1}$
c. B_2 =1.5 $kgha^{-1}$
d. B_3=2.0 $kgha^{-1}$

Factor B. Molybdenum (4 levels)

a. Mo_0= Control
b. Mo_1= 1.0 $kgha^{-1}$
c. Mo_2= 1.5 $kgha^{-1}$
d. Mo_3= 2.0 $kgha^{-1}$

4.9.3 Interaction effect of boron and molybdenum

Biological yield of mungbean varied due significantly to interaction of boron and molybdenum (Table 12). The maximum Biological yield per hectare (3646.71 kg) was recorded from B_3Mo_3 (2 kg B ha^{-1}×2 kg Mo ha^{-1}) and the minimum biological yield per hectare (2369.13 kg) was recorded from B_0Mo_0 (0 kg B ha^{-1}×0 kg Mo ha^{-1}).

4.10 Harvest index (%)

4.10.1 Effect of boron

Boron had a significant effect on the harvest index of mungbean (Table 10). The maximum harvest index (46.34%) was observed by applying boron at 1.5 $kgha^{-1}$, was statistically similar to that of B_3 (2 kg B ha^{-1}), The lowest harvest index (43.32%) was recorded from B_o(0 kg B ha^{-1}).

4.10.2 Effect of molybdenum

Application of different doses of molybdenum showed significant variation in terms of harvest index of mungbean (Table 11). Application of molybdenum increased harvest index significantly over control. The highest value (45.84%) was found with M_2 treatment, which was statistically at per with M_3 and M_1 treatment (45.70% and 44.96%, respectively).

4.10.3 Interaction effect of boron & molybdenum

Biological yield in mungbean also significantly varied due to variation in the boron and molybdenum level combination (Table 12). The maximum harvest index per hectare (47.16%) was recorded from B_3Mo_2 (2 kg Bha^{-1}+1.5 kg Mo ha^{-1}) and the minimum biological yield per hectare (41.95%) was recorded from B_0Mo_0 (0 kg B ha^{-1}+0 kg Mo ha^{-1}) (Table 12).

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the Agronomy field laboratory of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from March to May 2009 to study the effect of boron and molybdenum on the growth and yield of nungbean. The variety BARI Mung 6 was used as the test crop. The experiment consists of two factors: Factor A: Boron (4 levels); 0 (B_0), 1.0 (B_1), 1.5 (B_2) and 2.0 (B_3) kg B ha $^{-1}$ and Factor B: Molybdenum (4 levels); 0 (Mo_0), 1.0 (Mo_1) 1.5 (Mo_2), and 2 (Mo_3) kg Mo ha^{-1}. There were 16 treatment combinations. The two factors experiment as laid out in Split plot design with three replications. Data on different yield contributing characters and yield were recorded to find out the influence of boron and molybdenum.

The tallest plant (47.22cm) was recorded from B_3, while the shortest plant (44.10 cm) was found from B_0 at 60 DAS. The highest dry matter plant^{-1} (16.48g) was recorded from B_3, while the lowest dry matter per plant (13.44 g) was found from Bo at 60 DAS. The maximum number of pods per plant (30.36) was recorded from B_3 while the minimum number of pods per plant (22.07) was recorded from B_0 (without B). The maximum pod length (8.97cm) was recorded from B_3 (2 kg B ha^{-1}) and the minimum pod length (7.02 cm) was recorded from B_0 (without B). The maximum number of seeds per pod (10.93) was recorded from B_3, while the minimum number of seeds per pod (7.91) was recorded from B_0 (without B). The maximum 1000-seed weight (44.22 g) was recorded from B_3 (2 kg B ha^{-1}), while the minimum 1000-seed weight (41.62 g) was recorded from $B_{0.}$ The maximum seed yield (1531.09 kg ha^{-1}) was recorded from B_3 (2 kg B ha^{-1}), while the minimum seed yield (1177.25 kg ha^{-1}) was recorded from B_0 (without B). The maximum stover yield (1785.25 kg ha^{-1}) was recorded from B_3 and the minimum stover yield (1785.25 kg ha^{-1}) was recorded from Bo. The highest biological yield (3312.67 kg ha^{-1}) was recorded from B_3, while the lowest biological yield (2659.15 kg ha^{-1}) was recorded from B_0. The highest harvest index (46.34%) was recorded from B_2, while the lowest harvest index (43.32%) was recorded from B_o.

The tallest plant (47.06 cm) was recorded from Mo_3 and the shortest plant (44.67 cm) was recorded from Mo_0 at 60 DAS. The highest dry matter per plant (16.59 g) was recorded from Mo_3, while the lowest dry matter per plant (14.17 g) was recorded from Mo_0 at 60 DAS. The maximum number of pods per plant (29.51) was recorded from $Mo_{3,}$ while the minimum number of pods per plant (24.14) was recorded from Mo_3. The maximum pod length (8.92) was recorded from Mo_3, while the minimum pod length (7.05cm) was recorded from Mo_0. The maximum number of seeds per pod (10.89) was recorded from Mo_3, while the minimum number of seeds per pod (8.29) was recorded from Mo_0 (0 kg Mo ha^{-1}). The maximum 1000-seed weight (44.82 g) was recorded from Mo_3 and the minimum 1000-seed weight (41.31 g) was recorded from Mo_3. The maximum seed yield per hectare (1559.19 kg) was recorded from Mo_3 (2 kg Mo

ha^{-1}), while the minimum seed yield (1165.19 kg ha^{-1}) was recorded from Mo_0. The maximum stover yield per hectare (1850.63 kg ha^{-1}) was recorded from Mo_3 and the minimum stover yield per hectare (1491.54 kg ha^{-1}) was recorded from Mo_0. The highest biological yield (3410.84 kg ha^{-1}) was recorded from Mo_3, while the lowest biological yield (2656.14 kg ha^{-1}) was recorded from Mo_0. The highest harvest index (45.84%) was recorded from Mo_2, while the lowest harvest index (43.71%) was recorded from Mo_0.

The tallest plant (47.44 cm) was recorded from B_3Mo_2 and the shortest plant (40.21 cm) was found from B_0Mo_0 at 60 DAS. The highest dry matter per plant (17.75 g) was recorded from B_3Mo_3 and the lowest dry matter per plant (12.58 g) was found from B_0Mo_0 at 60 DAS. The maximum number of pods per plant (33.07) was recorded from B_3Mo_2 and the minimum number of pods per plant (18.80) was observed from B_0Mo_0. The maximum pod length (9.57 cm) was observed from B_3Mo_3 and the minimum pod length (5.77 cm) was recorded from B_0Mo_0. The maximum number of seeds per pod (12.31) was recorded from B_3Mo_2 and the minimum number of seeds per pod (7.43) was observed from B_0Mo_0. The maximum 1000 seed weight (45.49 g) was recorded from B_3Mo_3 and the minimum 1000-seed weight (38.05 g) was observed from B_0Mo_0. The maximum seed yield per hectare (1743.65 kg ha^{-1}) was recorded from B_3Mo_2 and the minimum seed yield per hectare (993.50 kg ha^{-1}) was observed from B_0Mo_0. The maximum stover yield per hectare (1968.63 kg ha^{-1}) was recorded from B_3Mo_3 and the minimum stover yield per hectare (1375.16 kg ha^{-1}) was observed from B_0Mo_0. The highest Biological yield (3696.07 kg ha^{-1}) was recorded from B_3Mo_2, while the lowest Biological yield (2369.13 kg ha^{-1}) was recorded from B_0Mo_0. The highest harvest index (47.16%) was recorded from B_3Mo_2 and the lowest harvest index (41.95%) was observed from B_0Mo_0.

Conclusion:

From the study the following conclusion can be made-

Boron and Molybdenum had significant influence on growth and yield of mungbean.

As B 2.0 kg ha^{-1} and 1.5 kg ha^{-1} produced similar yield then 1.5 kg ha^{-1} can be said as the optimum dose.

* Out of 4 lvels of boron, 1.5 kg ha^{-1} boron to be optimum for higher yield of summer mungbean.
* Molybdenum dose 1.5 kg ha^{-1} found suitable in producing higher yield in summer mungbean
* The interaction of 2 kg B ha^{-1} and 1.5 kg Mo ha^{-1}performed best in producing higher yield of summer mungbean.

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APPENDICES

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

A. Morphological characteristics of the Experimental Field

Morphological feature	**Characteristics**
Location	Horticulture Garden, SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land Type	High land
Soil series	Tejgaon
Topography	Family leveled
Drainage	Well drained
Cropping pattern	Winter Vegetable-Summer Vegetable

B. Physical and chemical propertics of the initial soil

Characteristics	**Value**
Partical size analysis	
Sand	27%
Silt	43%
Clay	30%
Textural class	Silty-clay
p^H	5.6
Organic corbon	0.45%
Total N	0.03%
Available B	20.00ppm
Exchangeable	0.10me/100g soil
Available S	45 ppm

Source: Soil Resource Development Institute, Khamarbari, Dhaka.

Appendix II. Monthly average of air temperature, relative humidity, total rainfall and sunshine of the experimental site during the period from March, 2009 to May, 2009

Month	Air temperature(^{o} c)		Relative humidity (%)	Rainfall (mm)(total)	*Sunshine(hr)
	Maximum	Minimum			
March,2009	31.4	19.6	54	11	8.2
April,2009	34.6	23.6	69	163	6.4
May,2009	36.7	25.9	70	185	7.8

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

Appendix III. Analysis of variance(ANOVA) on the data of plant height of mungbean as influenced by boron, molybdenum and their interaction

Source of variation	Degree of freedom	Mean square			
		Plant height (cm) at			
		20DAS	35 DAS	50 DAS	60 DAS
Replication	2	2.204	5.131	8.891	7.339
Boron (A)	3	3.95*	43.663*	25.242*	25.542*
Molybdenum(B)	3	1.399	18.836*	8.196	14.224
Interaction(AxB)	9	0.402**	2.713**	5.244**	4.595**
Error	24	1.120	3.611	7.525	9.306

* Significant at 0.01 level of probability

* Significant at 0.05 level of probability

Appendix IV. Analysis of variance(ANOVA) on the data of dry matter per plant of mungbean as influenced by boron, molybdenum and their interaction

Source of variation	Degree of freedom	Mean square			
		Dry matter per plant (g) at			
		20DAS	35 DAS	50 DAS	60 DAS
Replication	2	0.010	1.424	2.956	1.648
Boron (A)	3	0.085	6.028*	6.675*	24.050**
Molybdenum(B)	3	0.120**	13.133**	13.642**	13.334**
Interaction(AxB)	9	0.001**	0.343*	0.086**	0.176**
Error	24	0.002	0.312	0.410	0.442

* Significant at 0.01 level of probability

* Significant at 0.05 level of probability

Appendix V. Analysis of variance(ANOVA) on yield contributing characters of mungbean as
influenced by boron, molybdenum and their interaction

Source of variation	**Degree of freedom**	**Mean square**			
		Number of pods per plant (No.)	**Pod length(cm)**	**Number of seeds per pod (no.)**	**1000 seed weight (g)**
Replication	2	9.543*	0.327	4.512*	5.697*
Boron (A)	3	157.09**2	8.941**	21.977**	21.900**
Molybdenum(B)	3	60.722**	8.549**	15.880**	56.981**
Interaction(AxB)	9	0.643	0.916	0.925	0.547
Error	24	5.210	0.544	0.462	8.801

* Significant at 0.01 level of probability

* Significant at 0.05 level of probability

Appendix VI. Analysis of variance(ANOVA) on yield of mungbean as influenced by boron,
and their interaction

Source of variation	**Degree of freedom**	**Mean Square**			
		Seed yield (kg\ha)	**Stover yield (kg\ha)**	**Biological yield (kg\ha)**	**Harvest Index (%)**
Replication	2	9345.175	14106.910	46165.345	0.109
Boron (A)	3	335397.065**	158463.774**	947514.151**	23.431**
Molybdenum(B)	3	410955.675**	325444.890**	1466455.635**	11.436**
Interaction(AxB)	9	8875.276**	11166.969**	36304.772**	1.199*
Error	24	6566.596	6956.976	19533.311	2.045

* Significant at 0.01 level of probability

* Significant at 0.05 level of probability