RESPONSE OF MUNGBEAN TO ZINC, BORON AND MOLYBDENUM APPLICATION

NAZMUN NAHAR

DEPARTMENT OF SOIL SCIENCE

SHER-E –BANGLA AGRICULTURALUNIVERSITY

DHAKA-1207

DECEMBER, 2017

RESPONSE OF MUNGBEAN TO ZINC, BORON AND MOLYBDENUM APPLICATION

BY

NAZMUN NAHAR

Reg. No.: 16-07563

A Thesis

Submitted to the Department of Soil Science, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE (MS) IN

SOIL SCIENCE

SEMESTER: JULY-DECEMBER, 2017

Approved by:

....

(Dr. Alok Kumar Paul)
Supervisor
&
Professor
Department of Soil Science
Sher-e-Bangla Agricultural University

....

(Dr. Md Ashraf Hossain)
Co-supervisor
Chief Scientific Officer
Head of Soil Science Division
BARI
Joydebpur, Gazipur

....

(Dr. Saikat Chowdhury)

Professor
&
Chairman

Examination Committee

Department of Soil Science

Sher-e-Bangla Agricultural University Dhaka

DEPARTMENT OF SOIL SCIENCE

Sher-e-Bangla Agricultural University

Sher-e--Bangla Nagar, Dhaka-1207

MemoNo:SAU/SOIL/…… Date: ……….………

CERTIFICATE

This is to certify that the thesis entitled, **“Response Of Mungbean To Zinc, Boron And Molybdenum Application”** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in the partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (M.S.) IN SOIL SCIENCE,** embodies the result of a piece of bonafide research work carried out by **NAZMUN NAHAR,** Registration No.**16-07563** 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 during the course of this investigation has been duly acknowledged and style of this thesis have been approved and recommended for submission.

…..……………………………….

Signature of the supervisor

(Dr. Alok KumarPaul)

Professor

Department of Soil Science

Date-

Dhaka, Bangladesh

DEDICATED

TO MY BELOVED PARENTS

ACKNOWLEDGEMENT

At first the author would like to express all her devotion and reverence to the omnipotent, Almighty Allah, the supreme ruler of the universe who enabled the author to complete the research work successfully.

The author is proud to express her deepest gratitude, deep sense of respect and immense indebtedness to her research supervisor Dr. Alok Kumar Paul, Professor, Department of Soil Science, Sher-e-Bangla Agricultural University, Dhaka-1207, for his cordial inspiration, worthy guidance, valuable suggestions, generous help, constructive criticism, constant supervision and encouragement during her research work and guidance in preparation of manuscript of the thesis.

The author sincerely express her heartiest respect and profound appreciation to her co-supervisor Dr. Md. Ashraf Hossain, Chief Scientific Officer, Head, Soil Science Division, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur, for his constant encouragement, cordial suggestions, constructive criticisms and valuable advice during the research period and preparing the thesis.

The author would like to express her deepest respect and boundless gratitude to all the respected teachers of the Department of Soil Science, Sher-e-Bangla Agricultural University, Dhaka, for their valuable advice, generosity and faith guidance.

The author expresses her sincere respect to Chairman, Department of Soil Science, Sher-e-Bangla Agricultural University, Dhaka for valuable suggestions and cooperation during the study period. The author is also grateful to the authority of Sher-e-Bangla Agricultural University for giving him permission for this study and field facilities in which the present work was carried out.

Lastly the author cannot but express her heartiest gratitude and indebtedness to her parents and all other members of her family for their encouragement, blessings, moral support, prayer and sacrifices which enabled him to complete the research work with patience and perseverance.

The Author

RESPONSE OF MUNGBEAN TO ZINC, BORON AND MOLYBDENUM APPLICATION

ABSTRACT

A field experiment was conducted at Sher-e-Bangla Agricultural University Farm, Dhaka during the period from April 2017 to July 2017 to study the response of mungbean (BARIMung-6) to zinc, boron and molybdenum application.The single factor experiment was consisted with eight treatments viz., T_1= Control, T_2= Zn 2.0 kg ha^{-1}, T_3= B 1.5 kg ha^{-1}, T_4= Mo 1.0 kg ha^{-1}, T_5= Zn+B, T_6= Zn+Mo, T_7= B+Mo and T_8= Zn+B+Mo.The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Results showed that plant height, number of branches plant^{-1}, pod length, number of pods plant^{-1}, number of seeds pod^{-1}, grain yield, stover yield, biological yield, harvest index and available phosphorous and exchangeable potassium content of post-harvest soil was significantly influenced by zinc, boron and molybdenum application.Among the different treatments T_8 (2kg Zn+1.5 kg B+1 kg Mo) treatment produced tallest plant (44.40 cm), highest number of branches plant^{-1} (9.5), maximum number of pods plant^{-1} (13.0), maximum length of pod (9.60 cm), maximum number of seeds pod^{-1} (10.00), highest 1000 grain weight (50.80g), highest grain yield (1.40 t ha^{-1}) and maximum harvest index (52.84%).This combination also exhibited highest pH (6.05), organic matter (1.39 %), total nitrogen (0.092%), available phosphorous (23.45 ppm) and exchangeable potassium content (0.24 meq/ 100 gm soil) of post-harvest soil. On the other hand, T_1 (Control) treatment produced lower values in all cases except stover yield and harvest index. From the growth, yield and post-harvest soil analytical reports, it is apparent that the combination of 2kg Zn+1.5 kg B+1 kg Mo (T_8) was suitable for mungbean cultivation.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURE

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

Pulses are the important source of dietary protein with a protein content nearly twice as high as that of in cereals. The food value of pulse grain is high and contain 18-28 per cent protein and 1-5 per cent fat and considered rich in calcium as compared to cereals and contain about 100-120 mg of calcium per 100 g seeds. They are also rich in iron, thiamine, riboflavin and niacin. Each plant of pulse crop is virtually a nature's mini nitrogen fertilizer that enable to meet its own requirements and benefit the succeeding crop. Pulses are also excellent feed and fodder for livestock. Besides their dietary value and nitrogen fixing ability, pulses also play an important role in sustaining intensive agriculture by improving physical, chemical and biological properties of soil and are considered excellent crops for diversification of cereals based cropping systems.Pulses constitute the main source of protein for the poor people. Besides, the crops have the capability to enrich soils through nitrogen fixation (Bolanos, 1994). Pulse protein is rich in lysine that is deficient in rice. According to FAO (2013) recommendation, a minimum per capita intake of pulse should be 80 g day^{-1}, whereas it is 7.92 g day^{-1} in Bangladesh (BBS, 2011).

Mungbean (*Vignaradiata* L.) is an important traditional legume crop of Bangladesh characterized by a relative high content of protein (Mensah and Ihenyen, 2009) and excellent nutritional attributes in terms of methionine and cysteine in adequate quantities otherwise lacking in other food crops (Tsou and Hsu, 2000).It 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.It 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). 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 accurate shortage of grain legumes production in the country. According to FAO (1988) 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 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.

The pulse crop status in Bangladesh is generally low.In Bangladesh, total production of pulses is only 0.65 million ton against 2.7 million tons requirement. This means the shortage is almost 80% of the total requirement (Rahman and Ali, 2007). This is mostly due to low yield (MoA, 2013). At present, the area under pulse crop is 0.406 million hectare with a production of 0.322 million tons (BBS, 2013), where mungbean is cultivated in the area of 0.108 million ha with production of 0.03 million tons (BBS, 2014).There are so many reasons for low yield. Nutrients deficiency is an important factor, especially micronutrients like Zn, B and Mo.The soils of different parts of southern belt of Bangladesh are more or less deficient in boron and molybdenum as well as nitrogen fixing bacteria (*Rhizobium sp*.) which causes poor yield of mungbean. However, there is a great possibility to increase its production by cultivating HYV with balanced fertilization including micronutrients.

Micronutrients play an important role in increasing yield of pulses and oilseed legumes through their effects on the plant itself and on the nitrogen fixing symbiotic process. Deficiencies of these nutrients have been very pronounced under multiple cropping systems due to excess removal by HYV of crops and hence their exogenous supplies are urgently required.

Zinc is involved in auxin formation; activation of dehydrogenase enzymes; stabilization of ribosomal fractions (Obata *et al*., 1999). Boron is very important in cell division and in pod and seed formation (Vitosh*et al*., 1997). Rate of water absorption and carbohydrate translocation restricted due to boron deficiency. 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*, 1996b). 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. Lewis (1980) observed that molybdenum was responsible for the formation of nodule tissue and increase in nitrogen fixation. So, applications of micronutrients including essential macro elements have significantly important for mungbean production.

The present study was therefore, undertaken with the following objectives:

- To evaluate the response of Zn, B and Mo on the yield and yield component of mungbean.
- To observe the combine effect of Zn, B and Mo on growth and yield of mungbean.
- To find out an effective doses of Zn, B and Mo for the mungbean yield maximization.

CHAPTER II

REVIEW OF 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. In Bangladesh, little attention has so far been given for the improvement of mungbean variety or its cultural management. In this section a brief review of the important and informative works and research findings related to the zinc, boron and molybdenum has been presented.

2.1 Effect of Zinc on the growth and yield of mungbean

Vallee and Auld (1990) revealed that the metabolic function of zinc is based on its strong tendency to form tetrahedral complex with N-, O-, and particularly S- ligands and thereby it plays both functional (catalytic) and structural role in enzyme reactions .

The enzymes in which Zn has catalytic functions are carbonic anhydrase and carboxypeptidase. It performs structural function in alcohol dehydrogenase and proteins involved in DNA replication and gene expression (Coleman, 1992).

Alam and Islam (2016) observed that, highest seed yield (1.418 ton/ha) was obtained from 1.0 kg Zn/ha which was statistically similar (1.358 t/ha) with dose 1.0 kg Zn/ha and but significantly higher (1.034 t/ha) than the control.

Biswas *et al*. (2010) revealed that two rounds of foliar spray of 0.05% $ZnSO_4$ solution at 25 and 40 days after sowing (DAS) increased seed yield by 9.02% (1236.50 kg ha^{-1}) over water spray (1164.50 kg ha^{-1}). Combined inoculation of seed with Rhizobium + Azotobacter + PSB (1629.00 kg ha-1) and Rhizobium + PSB remarkably increased the seed yield due to better nodulation along with improvement in growth and yield. The effect of interaction between foliar spray and inoculation on seed yield was found significant.

Zinc is involved in N metabolism of plants. In Zn deficient plants, protein synthesis is markedly reduced, besides amino acids and amides are accumulated. Zinc is the structural component of ribosomes and is essential for their structural integrity. Price *et al*. (1972)

showed that early stage of zinc deficiency is indicated by sharp decrease in the level of RNA and ribosome content of cell.

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

Praveena*et al*. (2018) revealed that, the highest number of seeds per pod (6.90) was however recorded under basal application of zinc @ 5.5 kg ha^{-1}. Seeds per pod were also increased with zinc application over control which might be due to the role of zinc in seed setting.

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

Howeler*et al*. (1978) observed that yield of mungbeans was nearly doubled with the application of 1 kg Zn ha^{-1}.

Mishra and Masood (1998) in a field study at Kanpur, Uttar Pradesh, mungbean (*Vignaradiata*) cv. K-851 were given 0, 25 or 50 kg P_2O_5 ha^{-1} and 0, 2, 4 or 6 g Znha^{-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 Zn rates. Nodule numbers were not significantly affected by treatment.

Chowdhury and Narayanan (1992) observed that the tallest plant height of mungbean (64.9 cm) was found in plant receiving inoculums alone with Zn 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 Zn (1 kg ha^{-1}) and B (1 kg ha^{-1}) over control.

Patra (1998) observed significant yield increase in soybean by the application of 5 kg Zn ha^{-1}.

Zaman*et al*. (1996) observed that the application of Zn (1 kg ha^{-1}) with B (2 kg ha^{-1}) produced maximum plant height (35.03 cm) compared to control (21.53 cm). They also reported that the application of Zn (1 kg ha^{-1}) either alone or in combination with B (1 or 2 kg ha^{-1}) appreciable increased root length of mungbean over the control. They also reported that plant received 1 kg Mo ha^{-1} with 2 kg B ha^{-1} produced 50.31 and 40.21% higher root length of mungbean over control.

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

2.2 Effect of Boronon the growth and yield of mungbean

Alam and Islam (2016) observed that,the highest seed yield (1.550 t/ha) was found from the treatment 1.50 kg B/ha which was statistically identical with 3.0 kg B/ha and the lowest (0.927 t/ha) for control.

Singh *et al*. (2014) found that, addition of boron improved the seedling height.Plant height, significantly was recorded maximum in treatment boron @ 3.75 kg/ha through soil application (43.05 cm) followed by treatment boron @ 2.50 kg/ha through soil application (41.29 cm) and Mo @ 0.75 kg/ha through soil application (41.04 cm). Control recorded lowest value over all treatment.

Dutta*et al*. (1984) reported that number of pods per plant increase with the application of boron.

It was reported that number of Boron application increased 1000-seeds weight was recorded by Zaman*et al*., (1996).

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

Boron spray improved the sex ratio and early production of fruit and gave high fruit yields reported by El-Yazied*et al*. (2007).

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.

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.

Praveena*et al*. (2018) revealed that, Foliar application of boron (0.2% through borax) increased the vegetative growth in terms of plant height, Crop growth rate and also increased the no. of nodules per plant Foliar application 0.2% of borax increased the total dry matter production and nodules weight in greengram.

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.

Boron plays important roles in some of the metabolic processes such as nucleic acid metabolism, carbohydrate biosynthesis, photosynthesis, protein metabolism and has a role in cell wall synthesis and plasma membrane integrity (Pilbeam and Kirkby, 1983).

Boron affects fertilisation by increasing the pollen producing capacity of anthers and pollen viability and also help in pollen tube growth (Agarwal *et al*., 1981).

Mandal *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.

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.

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

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

Bonilla *et al*. (1997) suggested that B is an obligatory requirement for normal determinate nodule development and functioning in case of bean. Boron deficiency in pea caused a decrease in the number of nodules and an alteration of indeterminate nodule development.

Boron plays an important role in mediating cell surface interactions that lead to endocytosis of rhizobia by hoist cells and hence to the correct establishment of the symbiosis between pea and rhizobium (Bolanos*et al*., 1994).

Sohidul Islam *et al*. (2017) found that, the maximum plant height (39.63 cm), root length (8.55 cm), total pods per plant (8.22), pod length (6.83 cm), number grains per pod (6.66), grain yield (1.60 t ha^{-1}), biological yield (2.21t ha^{-1}) and harvest index (72.25%) were recorded from the combined application of 22.22 kg ha^{-1}sulphur and 2.0 kg ha^{-1} boron.

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.

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

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

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.

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.

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.

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 black gram and chickpea by 63 and 38%, respectively.

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

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

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.

Salinas *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.

Ganie*et al*. (2014) observed that the increase in boron from 0 kg/ha (control) to 1.0 kg/ha increased N, P, K, S and B by 3.35, 6.89, 23.07, 13.51 and 37.98 and 45.14, 54.54, 25.64, 30.0 and 30.40%, respectively in pods and stover at pod picking stage. Similarly at harvesting stage, N, P, K, S and B were observed to increase by 9.90, 2.61, 3.0, 18.51 and 46.60 and 42.10, 5.0, 1.08, 42.85 and 36.46 percent respectively in seeds and stover. They also found that,uptake of potassium increased significantly at pod picking and harvesting stage up to 1.0 kg B ha^{-1}.

Singh *et al*. (2006) found that, Seed yield of soybean was significantly influenced by boron level. Seed yield was significantly higher (18.82 q ha^{-1}) with 1.0 kg B ha^{-1} followed by 1.5 kg B ha^{-1} (18.71 q ha^{-1}) and 0.5 kg B ha^{-1} (18.23 q ha^{-1}) whereas the lowest seed yield (16.02 q ha^{-1}) was obtained from 0 kg B ha^{-1}.

Vimalan*et al*. (2017) noted that 1.5 kg of B ha^{-1} significantly increased plant height, number of branches $plant^{-1}$, number of pods $plant^{-1}$, number of seeds pod^{-1}, 1000 seed weight, seed yield and protein content (%).

2.3 Effect of Molybdenum on growth and yield of mungbean

Niranjana (2005) 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 control, The extent of increase was 24.11 % over the control.

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}.

Singh *et al*. (2014) found that, Molybdenum @ 0.75 significantly given good response in the dry weight of pod/plant.

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.

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}).

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

Zaman*et al*. (1996a) found that, 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.

Molybdenum is required for increasing nodulation in mungbean (Paricca*et al*. 1983, Velu and Savithri, 1982). It is essential for symbiotic N fixation. Pulses and legumes can have active nodules only when soils arc adequately supplied with this element.

The transition element molybdenum (Mo) is an essential micronutrient for plants where it is needed as a catalytically active metal during enzyme catalysis. Four plant enzymes depend on molybdenum: nitrate reductase, sulphite oxidase, xanthine dehydrogenase and aldehyde oxidase. However, in order to gain biological activity and fulfil its function in enzymes, molybdenum has to be complexed by a protein compound thus forming the molybdenum cofactor. (Mendel *et al*., 2007).

Zaman*et al*. (1996a) 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 .

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.

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.

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 yield in mungbean (Velu and Savithri, 1982; Paricca*et al*., 1983).

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

Awomi*et al*. (2011) stated that Increase in application of Mo (from 0.75 to 1.50 kg ha^{-1}) and Co (from 0.5 to 1.00 kg ha^{-1}) at a particular level of P could improve growth and yield performance of mungbean.Mungbean showed maximum growth and yield with application of 1.5 kg Mo/ha; the yield was 31.9 and 5.4% higher than the control (272 kg/ha) and 0.75 kg Mo/ha (378 kg/ha) treatments, respectively.

Amadi (1994) conducted a field experiment in Baghdad to investigate the influence of five levels of molybdenum (0, 0.16, 0.36, 0.48 and 0.64 k/ha as ammonium molybdate) on the growth of soybean in the alkaline soil of Iraq (pH range 7.6 to 7.9). The results indicated a significant increase in weight of seeds/plant and total crop yield, the plant height, protein and oil percentage but not significantly.

Srinivasan *et al*. (2007) 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_2MoO_4/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.

2.4 Combined effect of zinc, Boron and Molybdenumon the growth and yield of mungbean

It was observed that 1.5 kg Zn ha^{-1} + 1.0 kg B ha^{-1} of was achieved the optimum yield andyield components of mungbean (Islam *et al*., 2017).

Howeler*et al*. (1978), Dwivedi*et al*. (1990) and Gupta (1993) reported that, Grain yield was significantly maximum with boron @ 3.75 kg/ha followed by molybdenum @ 0.75 kg/ha and boron @ 2.50 kg/ha applied through soil application. Harvest index was significantly maximum in molybdenum @ 0.75 kg/ha applied through soil application.

Patra*et al*. (2009) found that, the combined application of 0.05% solution of ammonium molybdate and 0.2% solution of borax resulted in 78.4% (726.7 kg ha^{-1}) increase in seed yield compared to control treatment. Under control treatment the number of pods per plant was only 9.4 which increased to 14.8, an increase to the tune of 57.5% with combined application of 0.05% solution of ammonium molybdate and 0.2% solution of borax.

Application of B and/or Mo resulted in better Rhizobial growth, more N fixation and in better crop growth (Singh, 1993).

Renjel (2001) showed that zinc fertilizer application causes root and shoot growth during the growing season and therefore, lead to increased seed yield.

Bhuiyan*et al*. (1997a) 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.

Johansen *et al*. (2005) found that chickpea grown on residual soil moisture after rice harvest 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 (pH 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%.

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

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 (Vignaradiata) 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.

Singh *et al*. (2014) found that, Grain yield was significantly maximum with boron @ 3.75 kg/ha followed by molybdenum @ 0.75 kg/ha.

Alam and Islam (2016) observed that,the combined application of zinc and boron showed significant effect on mungbean yield than the single application of zinc and boron. Results showed that the combination of Zn1.0B1.5 produced significantly higher yield (1.677ton/ha) than the control. Combined application of zinc and boron were observed superior to their single application.

Praveena*et al*. (2018) revealed that, growth parameters viz. plant height, no. of branches per plant, no. of nodules, plant dry weight, Crop growth rate (CGR) and yield attributes viz. no. pods per plant, no. of grains per pod, grain yield, straw yield were significantly recorded higher under treatment 0.2% foliar spray of boron+5.0kg ha^{-1} of zinc.

Zaman*et al*. (1996) conductcd an experiment on mungbean and observed that application of 2 kg B/ha in combination with 2 kg Mo/ha produced 176% and 229% higher nodules/plant over control in 1989 and 1990, respectively.

Quddus*et al*. (2011) found that the combination of Zn1.5 kg&B1.0 kg/ha produced significantly higher yield (30-58 kg/ha) and (26-31 kg/ha), in the year 2008 and 2009, respectively.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at Sher-e-Bangla Agricultural University Farm, Dhaka, Bangladesh during the Kharif season from April 2017 to July 2017 to study the response of mungbean to zinc, boron and molybdenum application.This chapter presents a brief description about location, soil and climatic condition of the experimental area, crop or planting materials, treatments, experimental design and layout, crop growing procedure, intercultural operations, data collection and statistical analysis. The details of the materials and methods have been presented below:

3.1. Description of the experimental site

3.1.1 Location

The experiment was conducted at Sher-e-Bangla Agricultural University Farm, Dhaka 1207.The location of the experimental area was situated at 23°77´N latitude and 90°33´ E longitude at an altitude of 8.5 meter above the sea level.The experimental field belongs to the Agro-ecological zone of “The Madhupur Tract”, AEZ-28.

3.1.2 Climate

The geographical location of the experimental site was under the subtropical climate, having 3 distinct seasons, winter season from November to February, the pre-monsoon period or hot season from March to April and monsoon period from May to October. The climate was 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.

3.1.3 Soil

The soil of the experimental site belongs to the general soil type, Shallow Red Brown Terrace Soils under Tejgaon Series. Top soil was clay loam in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH was 5.6 and had organic matter 1.3%. The experimental area was flat having available irrigation and drainage system and above flood level. The morphological, physical and chemical characteristics of initial soil were presented in Table-1.

Table-1. Morphological, physical and chemical characteristics ofSher-e-Bangla Agricultural University Farm soil

A. Morphological characteristics of the initial soil

Morphological features	Characteristics
Location	Sher-e-Bangla Agricultural University 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 propertics of the initial soil

Characteristics	Value
%Sand	27
%Silt	43
%clay	30
Textural class	Clay loam
pH	5.6

Organic carbon (%)	0.77
Organic matter (%)	1.33
Total N (%)	0.06
Available P (ppm)	18.50
Exchangeable K (meq/100 g soil)	0.10
Available S (ppm)	22.0

3.1.4 Seeds and Variety

The Mungbean variety "BARIMung-6" released by Bangladesh Agricultural Research Institute (BARI) 2003, Joydevpur, Gajipur, was used as planting materials. BARIMung-6 is a recommended variety of mungbean. The plant attains a height of 40-45 cm, photo insensitive and can be grown in kharif-I, kharif-II and late rabi season. Grain large and 1000 seed weight is 51-52 g. Crop duration is 55-60 days. The variety is resistant to*Cercospora* leaf spot and yellow mosaic virus. Average seed yield is 1.5 t ha^{-1}. Seed contains 21.20% protein and 46.80% carbohydrate.

3.1.5 Treatments

The experiment comprised eight treatments. They are as follows-

1. T_1= Control
2. T_2= Zn 2.0 kg ha^{-1}
3. T_3= B 1.5 kg ha^{-1}
4. T_4= Mo 1.0 kg ha^{-1}
5. T_5= Zn+B
6. T_6= Zn+Mo
7. T_7= B+Mo
8. T_8= Zn+B+Mo

Blanket dose= $N_{15}P_{20}K_{30}S_{10}$kg ha^{-1}

Every treatment received ½ N, P, K and S as basal doses. Blanket doses of all fertilizer were applied after final land preparation and treatment wise fertilizer dose were applied after bed preparation.

3.1.6 Experimental design and lay out

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. There were 8 plots in each replication.The 8 treatment combinations of the experiment were assigned at random into 8 plots of each replication. The size of the unit plot was 3.0 m × 1.75 m (5.25 m^2) and the distance between plot to plot was 0.5 m and replication to replication was 1.0 m. Total number of plots in the experimental field were 24.

3.1.7 Land preparation

The plot selected for the experiment was opened in the last week of March, 2017 with a power tiller, and was exposed to the sun for a week, after which the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilth. The land was prepared thoroughly and leveled by ladder. Weeds and stubbles were removed from the field.

3.1.8 Application of Fertilizer

Urea, Triple Super Phosphate (TSP), Muriate of Potash (MOP) and Gypsum were used as a source of nitrogen, phosphorous, potassium and sulphur, respectively. The fertilizer N, P, K and S were applied at 15, 20, 30 and 10 kg ha^{-1} in the form of urea, TSP, MOP and gypsum, respectively. Half amount of urea and total of TSP, MOP and gypsum were applied during final land preparation as basal dose. Rest of the urea was applied as top dressing at 25 DAS. Zinc, boron and molybdenum were applied respectively from ZnO, boric acid and ammonium molybdate as per treatment during final land preparation.

3.1.9 Seed collection and Sowing of seed in the field

Seeds of BARIMung-6 were collected from Bangladesh Agricultural Research Institute (BARI), Joydevpur, Gazipur. The Seeds of mungbean were sown on 1 April 2017. The seeds were treated with the fungicide Bavistin before sowing the seeds to control the seed borne disease. The seeds were sown in rows in the furrows having a depth of 2-3 cm. Row to Row distance was 30 cm.

3.1.10 Intercultural Operation

After establishment of seedlings, various intercultural operations were accomplished for better growth and development of the mungbean. They were described below:

3.1.10.1 Irrigation and drainage

Over-head irrigation was provided with a watering can to the plots once immediately after germination in every alternate day in the evening. Further irrigation was done when needed. Stagnant water was effectively drained out at the time of heavy rains.

3.1.10.2 Thinning

Seeds were germinated four days after sowing (DAS). Thinning was done twice; first thinning was done at 7 days after sowing (DAS) and second was between row to row and plant to plant to obtain proper plant population in each plot.

3.1.10.3 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 weeding was done at 45 DAS.

.

3.1.10.4 Plant protection measures

The crops were infested by insects. These were effectively and timely controlled by applying recommended insecticides.The plots were infested by caterpillar, which was successfully controlled by applying Basudin 10 G at the rate of 16.8 kg ha^{-1}. There was no disease infestation on the crop.

3.1.11 Harvesting and processing

The crops were harvested plot wise according to the maturity of the crops by hand picking. Maturity of crop was determined when 90% of the pod became brown to black in color. Harvesting was done in four times.The harvesting were done on 29th May, 2017; 6th June, 2017; 13th June, 2017 and 23th June, 2017. Before harvesting 10 sample plants from each plot was marked and harvested for recording data of yield and yield contributing characters. The harvested crop of each plot was bundled separately, properly tagged and brought to threshing floor. Enough care was taken for harvesting, threshing and also cleaning of mungbean seed. Fresh weight of grain and stover were recorded plot wise. The grains were cleaned and finally the weight was adjusted to a moisture content of 12%. The stover was sun dried and the yields of grain and stover plot^{-1} were recorded and converted to t/ha.

3.1.12 Data Collection and Recording

Ten plants were selected randomly from each unit plot prior to harvest for recording data on crop parameters and the yield of grain and straw were taken plot wise.The following data were recorded from the experiment:

i. Plant height
ii. Number of branches plant^{-1}
iii. Number of pods plant^{-1}
iv. Pod length
v. Number of seeds pod^{-1}
vi. Weight of 1000 grains
vii. Grain yields
viii. Stover yields
ix. Biological Yield
x. Harvest index (%)
xi. Soil sample from each plot (post-harvest)

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

a. Plant height

The height of ten 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 thinner rows of each plot and data were taken from 20 to 65 DAS at 15 days interval.

b.Number of branches plant^{-1}

The branches were counted from the 10 randomly selected plant at harvest time and mean value was determined.

c. 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.

d. Pod length

Length of 10 pods from each plot were measured randomly and averaged after harvesting.

e. Number of seeds pod^{-1}

Number of total seeds from ten randomly selected pods of ten plants from each plot was noted and the mean number was expressed per pod basis.

f. Weight of 1000 grains

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. Grain yields

The plants of the central 1.0 m^2 from the plot were harvested for taking grain yield. The grains
were threshed from the plants, cleaned, dried and then weighed. The yield of grain in kg plot^{-1} was adjusted at 12% moisture content of grain and then it was converted to t ha^{-1}.

h. Stover yields

The stover of the harvested crop in each plot was sun dried to a constant weight. Then the stovers were weighted and thus the stover yield plot^{-1} was determined. The yield of stover in kg plot^{-1} was converted to t ha^{-1}.

i. Biological Yield

The sum of grain yield and Stover yield is regarded as biological yield. Biological yield was determined by the using the following formula –
Biological yield = Grain yield + Stover yield.

j. Harvest index (%)

Harvest index was calculated from the ratio of grain yield to biological yield and expressed in percentage. It was calculated by using the following formula.

$$\text{HI (\%)} = \frac{\text{Grain Yield (t/ha)}}{\text{Biological Yield (t/ha)}} \times 100$$

k. Soil sample from each plot (post-harvest)

Post-harvest soil samples were collected from each plot at 0-15 cm depth. The samples were air-dried, grounded and sieved through a 2 mm sieve and preserved for analysis.The properties studied included soil texture, pH, organic matter, total N, available P and available K.

3.1.13 Soil analysis

Soil samples were analyzed for both physical and chemical characteristics viz. pH, organic matter, total N, available P and Exchangeable K contents. The soil samples were analyzed by the following standard methods as follows:

3.1.13.1 Soil pH

Soil pH was measured with the help of a glass electrode pH meter, the soil water ratio being maintained at 1: 2.5 as described by Page *et al*., 1982.

3.1.13.2 Organic matter

Organic carbon in soil sample was determined by wet oxidation method (Page *et al*., 1982). The underlying principle was used to oxidize the organic matter with an excess of 1N $K_2Cr_2O_7$ in presence of conc. H_2SO_4 and conc. H_3PO_4 and to titrate the excess $K_2Cr_2O_7$ solution with 1N $FeSO_4$. To obtain the content of organic matter was calculated by multiplying the percent organic carbon by 1.724 (Van Bemmelen factor) and the results were expressed in percentage.

3.1.13.3 Total nitrogen

Total nitrogen**c**ontent of soil were determined followed by the Micro Kjeldahl method. One gram of oven dry ground soil sample was taken into micro kjeldahl flask to which 1.1 gm catalyst mixture (K_2SO_4: $CuSO_4$. $5H_2O$: Se in the ratio of 100:10:1), and 6 ml H_2SO_4 were added. The flasks were swirled and heated 2000c and added 3 ml H_2O_2 and then heating at 3600c was continued until the digest was clear and colorless. After cooling, the content was taken into 100 ml volumetric flask and the volume was made up to the mark with distilled water. A reagent blank was prepared in a similar manner. These digests were used for nitrogen determination (Page *et al*., 1982). Then 20 ml digest solution was transferred into the distillation flask, Then 10 ml of H_3BO_3 indicator solution was taken into a 250 ml conical flask which is marked to indicate a volume of 50 ml and placed the flask under the condenser outlet of the distillation apparatus so that the delivery end dipped in the acid. Add sufficient amount of 10N-NaOH solutions in the container connecting with distillation apparatus. Water runs through the condenser of distillation apparatus was checked. Operating switch of the distillation apparatus collected the distillate. The conical flask was removed by washing the delivery outlet of the distillation apparatus with distilled water. Finally the distillates were titrated with standard 0.01 N H_2SO_4 until the color changes from green to pink. The amount of total nitrogen was calculated using the following formula:

$$\% \text{ N} = (\text{T-B}) \times \text{N} \times 0.014 \times 100/\text{W}$$

Where,

T = Sample titration (ml) value of standard H_2SO_4

B = Blank titration (ml) value of standard H_2SO_4

N = Strength of H_2SO_4

W = Sample weight in gram

3.1.13.4 Available phosphorus

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

3.1.13.5 Exchangeable potassium

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

Statistical analysis

The data obtained for different characters were statistically analyzed to observe the significant difference among the treatment by using the MSTAT- C computer package program. The mean values of all the characters were calculated and analysis of variance was performed. The significance of the difference among the treatments 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 find out theresponse of mungbean to zinc, boron and molybdenum application. The results obtained from the study have been presented, discussed and compared in this chapter through different tables, figures and appendices. The analyses of variance of data in respect of all the parameters have been shown in Appendix I-III.

4.1 Plant Height

Zinc, boron and molybdenum showed significant effects on plant height of mungbean (Appendix I and Fig 1). The tallest plant (44.40 cm) was obtained from T_8 (2kg Zn+1.5 kg B+1 kg Mo) treatment which was statistically similar to T_2 treatment (43.30 cm) and T_4treatment (43.80 cm) whereas, the shortest plant (40.70 cm) was obtained from T_1 (control) treatment which was statistically similar to T_7 treatment (41.00 cm) (Fig 1). The results are quite similar to the findings of Zaman*et al*. (1996a) who conducted an experiment on mungbean and observed that the application of Zn (1 kg ha^{-1}) with B (2 kg ha^{-1}) produced maximum plant height (35.03 cm) compared to control (21.53 cm). Zaman*et al*. (1996b) found 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 Number of branches plant^{-1}

Zinc, boron and molybdenum management significantly influenced the number of branches plant $^{-1}$ (Appendix I and Fig 2).The highest number of branches plant^{-1} (9.50) was recorded from T_8 (2kg Zn+1.5 kg B+1 kg Mo) treatment whereas,lowest number of branches plant^{-1} (5.50) was recorded from T_1 (control) treatment which was statistically similar to T_5 (6.00) treatment (2kg Zn+1.5 kg B) (Fig 2).Rahman and Alam (1998) observed that application of B (1.5 kg ha^{-1}) produced significant 10.17% higher branches plant^{-1} over control in groundnut.

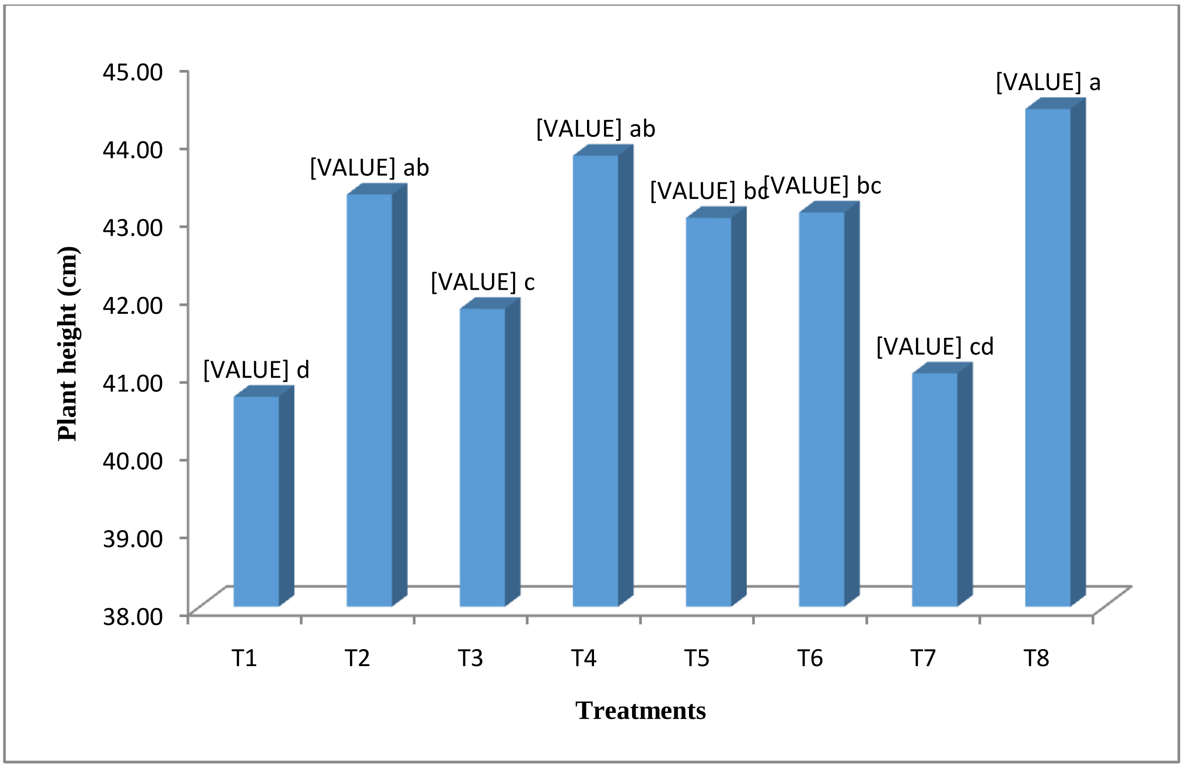

Fig. 1. Effect of Zinc, Boron and Molybdenum on plant height of mungbean

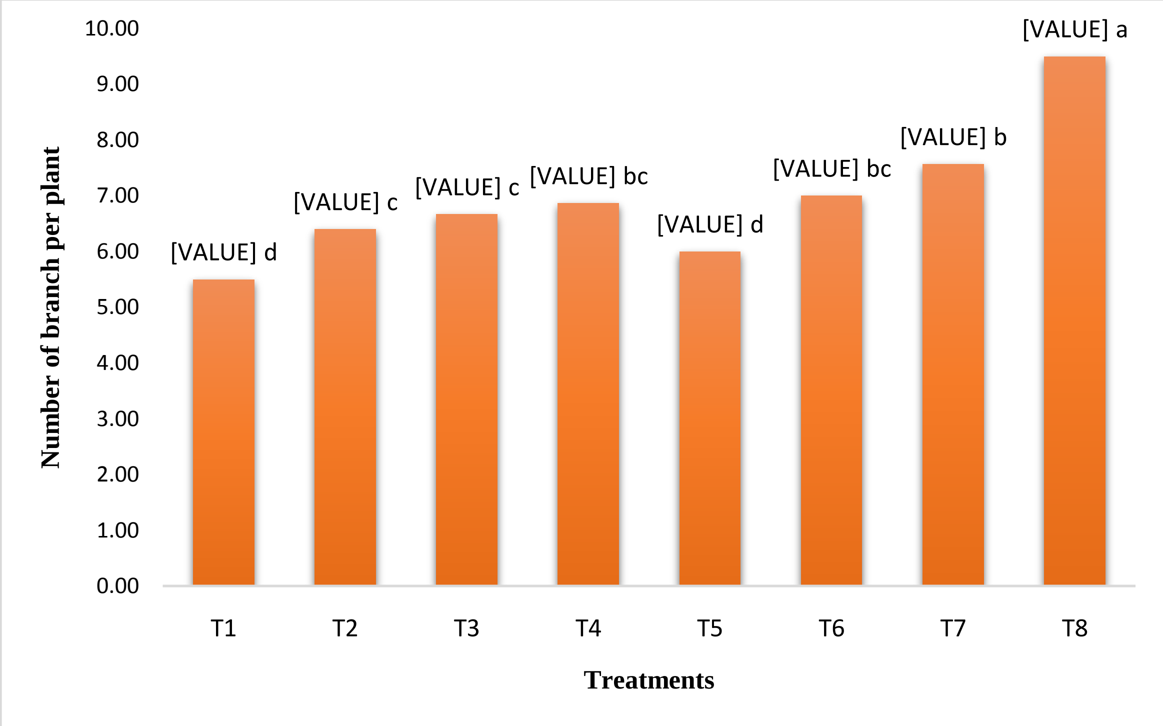

Fig. 2. Effect of Zinc, Boron and Molybdenum on number of branches of mungbean

T_1= Control, T_2= Zn 2.0 kg ha^{-1}, T_3= B 1.5 kg ha^{-1}, T_4= Mo 1.0 kg ha^{-1}, T_5= Zn+B, T_6= Zn+Mo, T_7= B+Mo and T_8= Zn+B+Mo

4.3 Number of pods plant^{-1}

Number of pods per plants of mungbean varied significantly due to application of zinc, boron and molybdenum. The maximum number of pods plant^{-1} (13.0) was recorded from T_8 (2kg Zn+1.5 kg B+1 kg Mo) treatment which was statistically similar to T_5 (11.67), T_6 (11.33) and T_7 (11.33) treatments.While the minimum number of pods per plant (8.0) was recorded from T_1 (control) treatment which was statistically similar to T_2 (9.0) treatment (Table 2 and Fig 3).

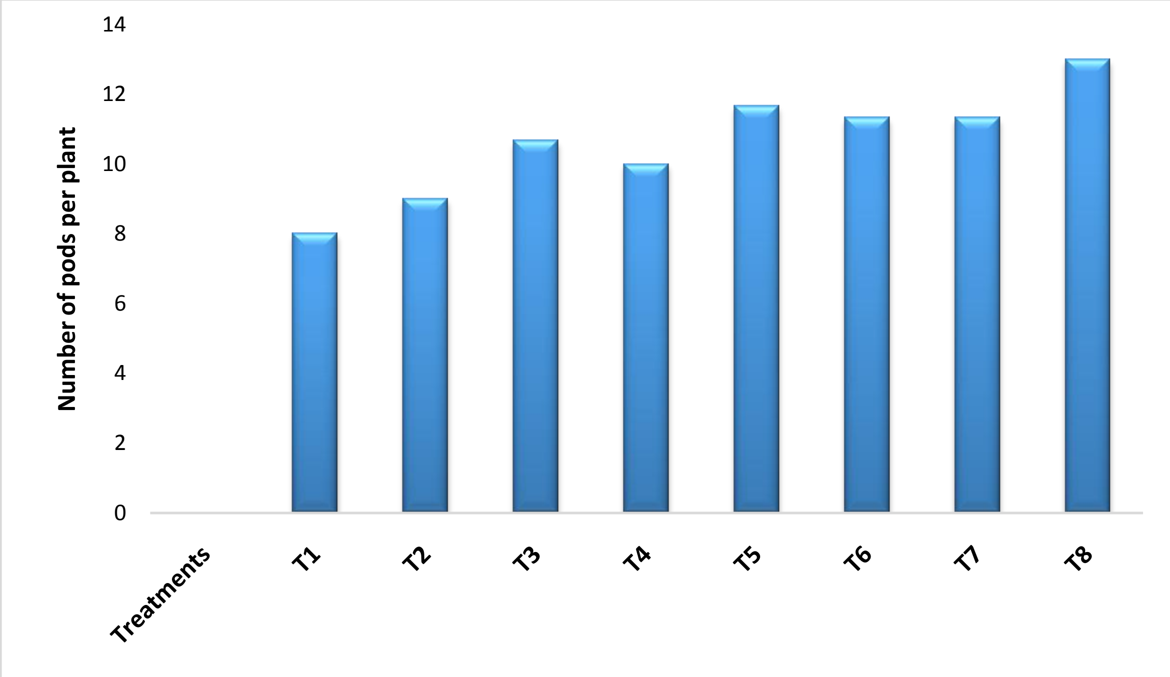

Fig. 3. Effect of Zinc, Boron and Molybdenum on Number of pods plant^{-1} of mungbean

T_1= Control, T_2= Zn 2.0 kg ha^{-1}, T_3= B 1.5 kg ha^{-1}, T_4= Mo 1.0 kg ha^{-1}, T_5= Zn+B, T_6= Zn+Mo, T_7= B+Mo and T_8= Zn+B+Mo

4.4 Pod length (cm)

Statistically significant variation was observed on pod length due to the application of zinc, boron and molybdenum. The tallest length of pod (9.60 cm) was recorded from T_8 (2kg Zn+1.5 kg B+1 kg Mo) treatment which was statistically similar to T_5 (9.13 cm) and T_6 (8.67 cm) treatment.The shortest length of pod (7.07 cm) was recorded from T_1 (control) treatment which was statistically similar to T_2 (7.30 cm) treatment (Table 2 and Fig 4).

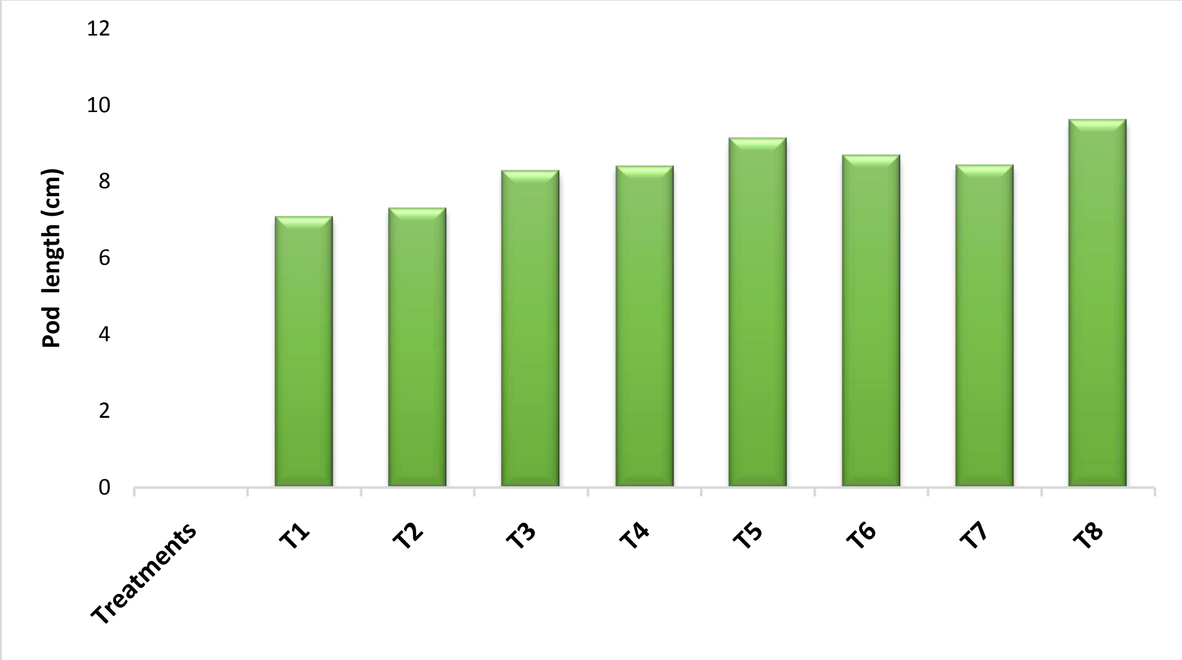

Fig. 4. Effect of Zinc, Boron and Molybdenum on Pod length of mungbean

T_1= Control, T_2= Zn 2.0 kg ha^{-1}, T_3= B 1.5 kg ha^{-1}, T_4= Mo 1.0 kg ha^{-1}, T_5= Zn+B, T_6= Zn+Mo, T_7= B+Mo and T_8= Zn+B+Mo

4.5 Number of seeds pod^{-1}

Number of seeds pod^{-1} of mungbean differed significantly due to the application of zinc, boron and molybdenum. The maximum number of seeds pod^{-1} (10.00) was recorded from T_8 (2kg Zn+1.5 kg B+1 kg Mo) treatment which was statistically similar to T_3 (9.33), T_4 (9.33) and T_7 (9.00) treatments whereas, the minimumnumber of seeds pod^{-1}(8.0) was recorded from T_1 (control) treatment which was statistically similar to T_2 (8.0) treatment (Table 2 and Fig 5). Islam and Sarkar (1993) found higher number of seeds pod^{-1} of mustard due to application of B @ 1.5 kg ha-^{1}.

4.6. 1000-grain weight (g)

Weight of 1000 grain was not differ significantly due to application of zinc, boron and molybdenum. The highest 1000 grain weight (50.80g) was obtained from T_8 (2kg Zn+1.5 kg B+1 kg Mo) treatment whereas, the lowest 1000 grain weight (47.50 g) was observed from T_1 (control) treatment(Table 2 and Fig 6).

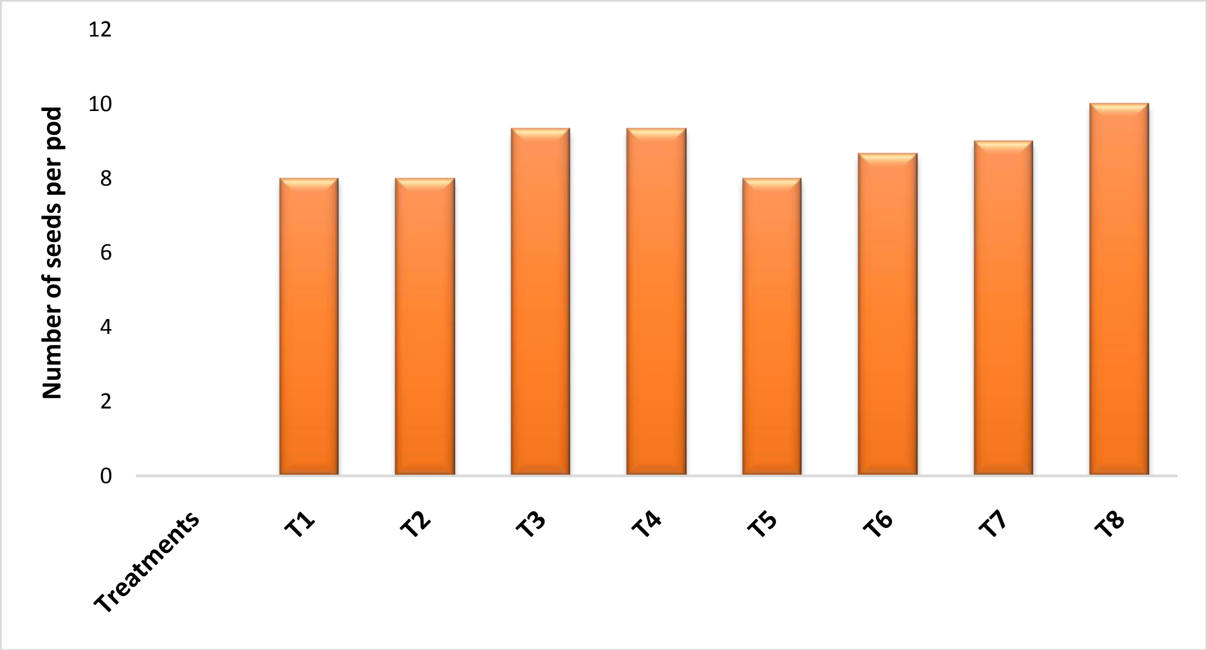

Fig. 5. Effect of Zinc, Boron and Molybdenum on Number of seeds pod^{-1} of mungbean

T_1= Control, T_2= Zn 2.0 kg ha^{-1}, T_3= B 1.5 kg ha^{-1}, T_4= Mo 1.0 kg ha^{-1}, T_5= Zn+B, T_6= Zn+Mo, T_7= B+Mo and T_8= Zn+B+Mo

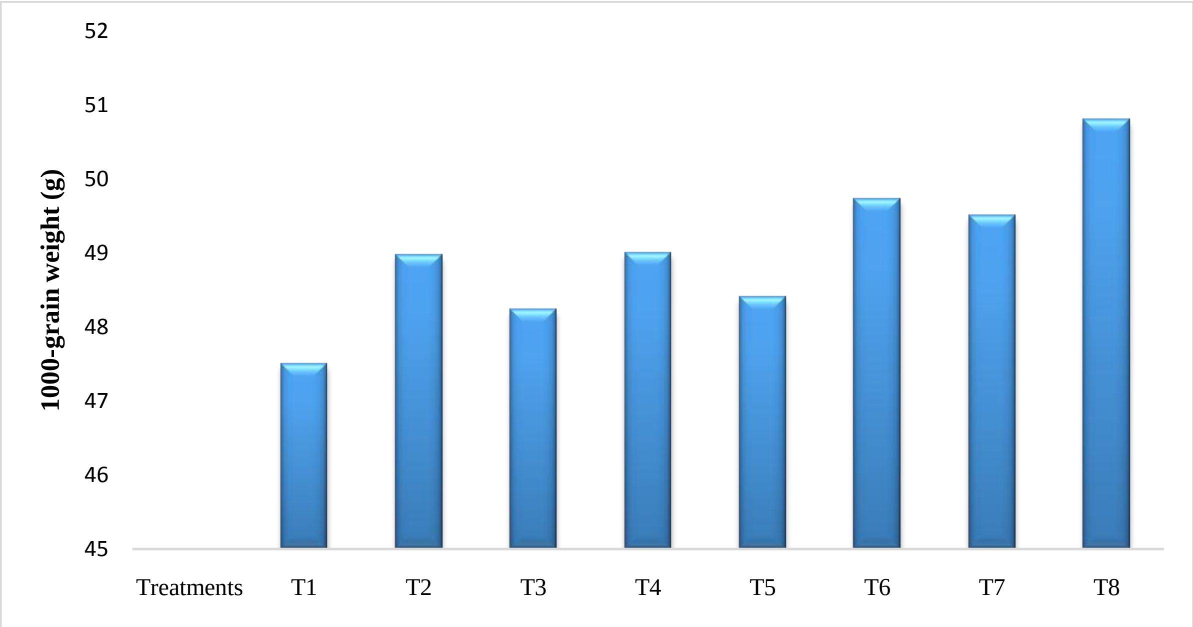

Fig. 6. Effect of Zinc, Boron and Molybdenum on 1000-grain weight of mungbean

T_1= Control, T_2= Zn 2.0 kg ha^{-1}, T_3= B 1.5 kg ha^{-1}, T_4= Mo 1.0 kg ha^{-1}, T_5= Zn+B, T_6= Zn+Mo, T_7= B+Mo and T_8= Zn+B+Mo

Table. 2. Effect of zinc, boron and molybdenumon number of pods per plant, pod length, number of seeds per pod and thousand grain weight of mungbean

Treatment	Number of pods per plant		Pod length (cm)		Number of seeds per pod		Thousand grain weight (g)
T_1	8.00	d	7.07	d	8.00	c	47.50
T_2	9.00	cd	7.30	cd	8.00	c	48.97
T_3	10.67	bc	8.27	bc	9.33	ab	48.23
T_4	10.00	bc	8.40	b	9.33	ab	49.00
T_5	11.67	ab	9.13	ab	8.00	c	48.40
T_6	11.33	ab	8.67	ab	8.67	bc	49.73
T_7	11.33	ab	8.43	b	9.00	abc	49.50
T_8	13.00	a	9.60	a	10.00	a	50.80
LSD (0.05)	1.71		1.00		1.06		NS
CV (%)	9.21		6.83		11.74		9.83

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

T_1= Control, T_2= Zn 2.0 kg ha^{-1}, T_3= B 1.5 kg ha^{-1}, T_4= Mo 1.0 kg ha^{-1}, T_5= Zn+B, T_6= Zn+Mo, T_7= B+Mo and T_8= Zn+B+Mo

NS= Not Significant, CV= Coefficient of Variation

4.7Grain yield (t ha^{-1})

Zinc, boron and molybdenum management significantly influenced grain yield of mungbean. The highest grain yield (1.40 t ha^{-1}) was produced by the treatment of T_8 (2kg Zn+1.5 kg B+1 kg Mo) which was statistically similar to T_7 (1.29 t ha^{-1}) treatment. While treatment T_1 (control) produced the lowest grain yield (0.85 t ha^{-1}) which was statistically similar to T_5 (0.89) treatment (Table 3 and Fig 7).

Biswas *et al*. (2010) revealed that in mungbean two rounds of foliar spray of 0.05% ZnSO4 solution at 25 and 40 days after sowing (DAS) increased seed yield by 9.02%. Bharti *et al*. (2002) reported that the mean seed yield increased when Zn and B content increased in soil.Saha*et al*. (1996) conducted that green gram seed yield was highest with a combination of 5 kg borax + 2 kg ZnSO4.Singh *et al.* (2014) found that Grain yield was significantly maximum with boron @ 3.75 kg/ha followed by molybdenum @ 0.75 kg/ha. Patra*et al*.

(2009) observed thatthe combined application of 0.05% solution of ammonium molybdate and 0.2% solution of borax resulted in 78.4% (726.7 kg ha^{-1}) increase in seed yield compared to control treatment.

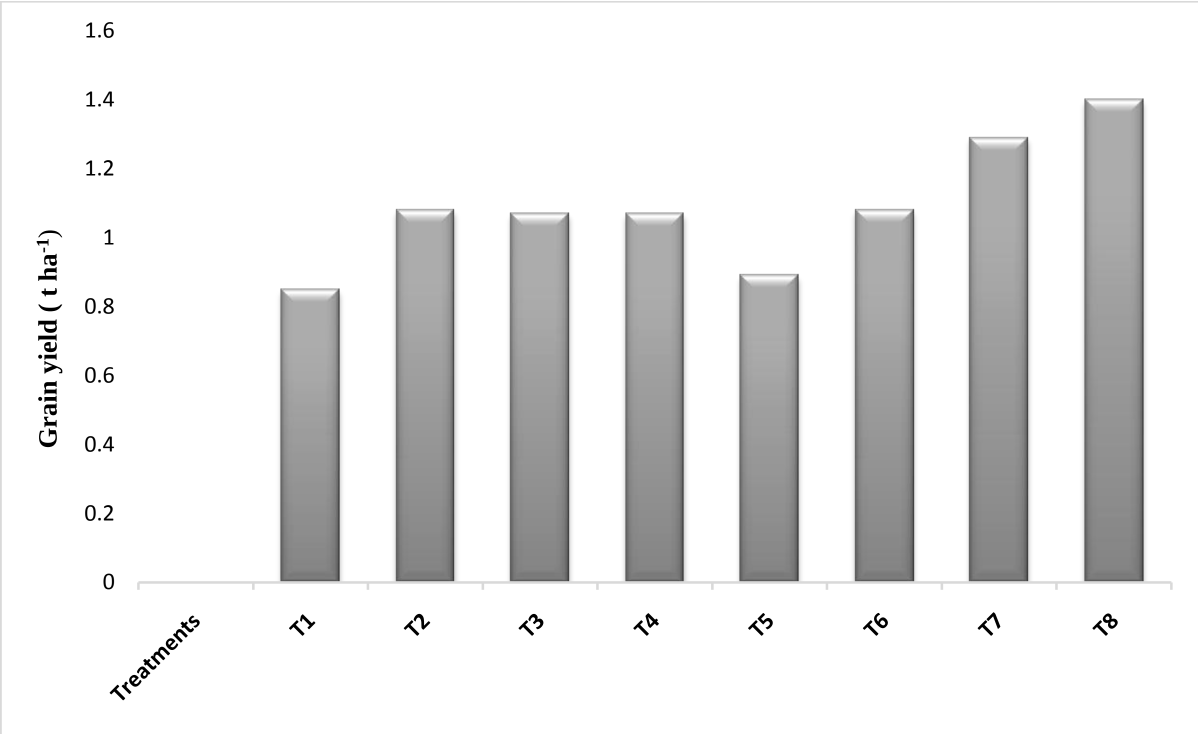

Fig. 7. Effect of Zinc, Boron and Molybdenum on Grain yieldof mungbean

T_1= Control, T_2= Zn 2.0 kg ha^{-1}, T_3= B 1.5 kg ha^{-1}, T_4= Mo 1.0 kg ha^{-1}, T_5= Zn+B, T_6= Zn+Mo, T_7= B+Mo and T_8= Zn+B+Mo

4.8 Stover yield (t ha^{-1})

Stover yieldwas significantly affected by the application of zinc, boron and molybdenum.The highest stover yield(2.04 t ha^{-1}) was observed from T_6 (2kg Zn +1 kg Mo) treatment which was statistically similar to T_3 (1.83 t ha^{-1}) and T_7 (1.90 t ha^{-1}) treatments. The lowest stover yield(1.25 t ha^{-1}) was observed from the treatment of T_8 (2kg Zn+1.5 kg B+1 kg Mo) which was statistically similar to the treatment of T_1 (1.56 t ha^{-1}), T_2 (1.51 t ha^{-1}), T_4 (1.42 t ha^{-1})and T_5 (1.56 t ha^{-1}) (Table 3 and Fig 8).

Praveena*et al*. (2018) found that 0.2% foliar spray of boron+5.0kg ha^{-1} of zinc produced higher straw yield (2.96 t ha^{-1}).Bharti *et al*. (2002) reported that the stover yield decreased with the increasing B and Zn rate.

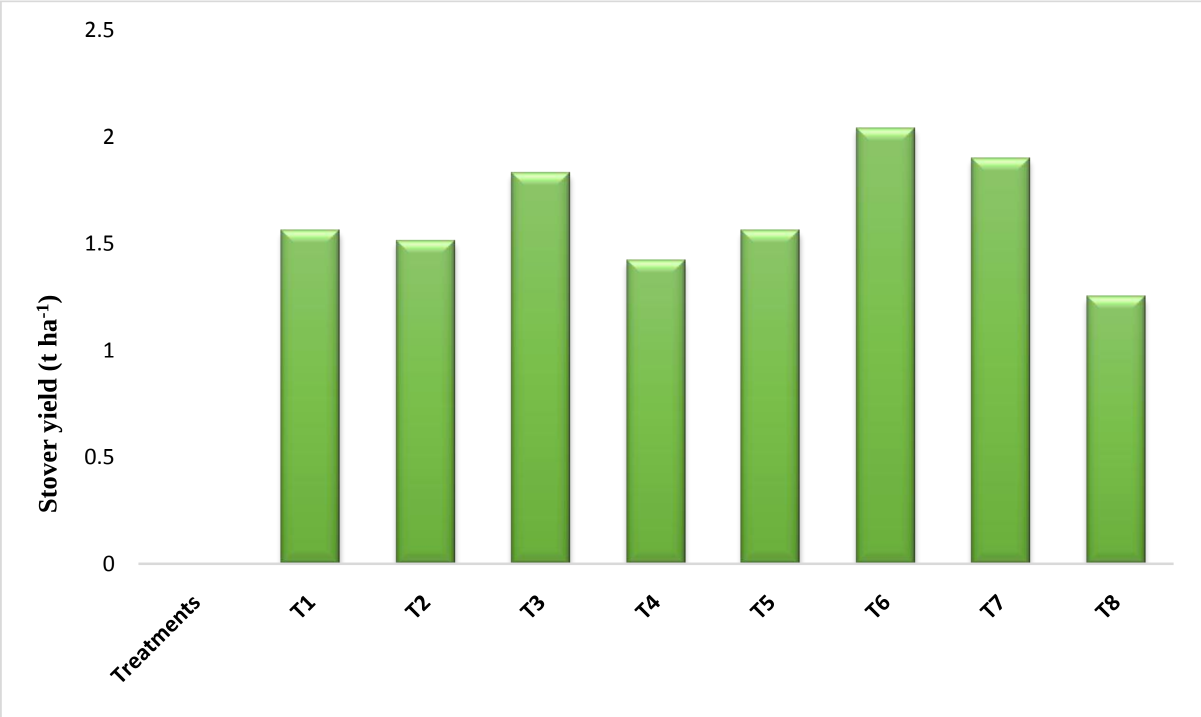

Fig. 8. Effect of Zinc, Boron and Molybdenum on Stover yieldof mungbean

T_1= Control, T_2= Zn 2.0 kg ha^{-1}, T_3= B 1.5 kg ha^{-1}, T_4= Mo 1.0 kg ha^{-1}, T_5= Zn+B, T_6= Zn+Mo, T_7= B+Mo and T_8= Zn+B+Mo

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

Biological yield was significantly affected by the application of zinc, boron and molybdenum. The highestbiological yield (3.19 t ha^{-1}) was obtained from T_7 (1.5 kg B+1 kg Mo) treatment which was statistically similar to the treatment of T_3 (2.90 t ha^{-1}) and T_6 (3.12 t ha^{-1}). The lowestbiological yield (2.41 t ha^{-1}) was obtained from T_1 (control) treatment which was statistically similar to all other treatment except T_3, T_6 and T_7 treatments (Table 3 and Fig 9).

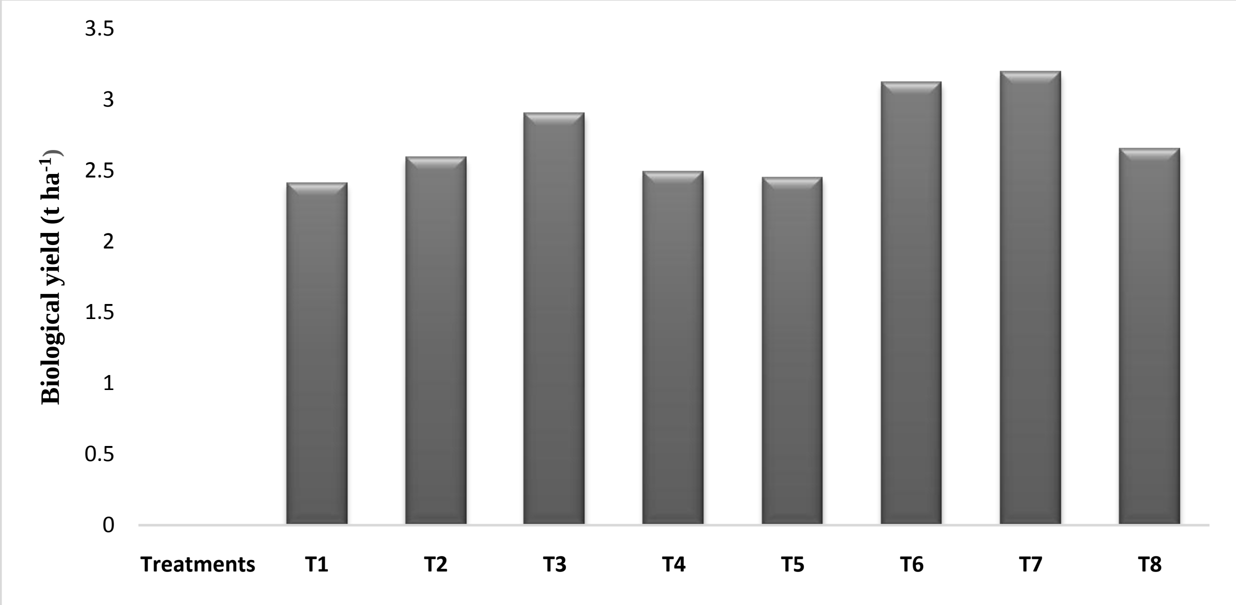

Fig. 9. Effect of Zinc, Boron and Molybdenum on Biological yieldof mungbean

T_1= Control, T_2= Zn 2.0 kg ha^{-1}, T_3= B 1.5 kg ha^{-1}, T_4= Mo 1.0 kg ha^{-1}, T_5= Zn+B, T_6= Zn+Mo, T_7= B+Mo and T_8= Zn+B+Mo

4.10 Harvest index (%)

Harvest index was influenced significantly by the application of zinc, boron and molybdenum. The maximum harvest index (52.84%) was recorded from the treatment of T_8 (2kg Zn+1.5 kg B+1 kg Mo) which was statistically dissimilar to all other treatments whereas, the minimum (34.70 %) was found in the treatment of T_6 (2kg Zn +1 kg Mo) which was statistically similar to the treatment of T_1 (35.33 %), T_3 (36.75%) and T_5 (36.90%) (Table 3). Wu *et al*. (1994) observed that harvesting index in soybean were positively correlated with Zn concentration.

Table 3. Effect of zinc, boron and molybdenum on yield and yield contributing characters of mungbean

Treatment	Grain yield ($t\ ha^{-1}$)	Stover yield ($t\ ha^{-1}$)	Biological yield ($t\ ha^{-1}$)	Harvest index (%)
T_1	0.85 c	1.56 bc	2.41 c	35.33 d
T_2	1.08 b	1.51 c	2.59 bc	41.63 b
T_3	1.07 b	1.83 ab	2.90 ab	36.75 cd
T_4	1.07 b	1.42 c	2.49 c	42.96 b
T_5	0.89 c	1.56 bc	2.45 c	36.90 cd
T_6	1.08 b	2.04 a	3.12 a	34.70 d
T_7	1.29 a	1.90 a	3.19 a	40.45 bc
T_8	1.40 a	1.25 c	2.65 bc	52.84 a
LSD (0.05)	0.12	0.29	0.35	4.45
CV (%)	6.37	10.02	7.28	6.32

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

T_1= Control, T_2= Zn 2.0 kg ha^{-1}, T_3= B 1.5 kg ha^{-1}, T_4= Mo 1.0 kg ha^{-1}, T_5= Zn+B, T_6= Zn+Mo, T_7= B+Mo and T_8= Zn+B+Mo

CV= Coefficient of Variation

4.11 Nutrient status of post-harvest soil as affected by Zinc, Boron and Molybdenum management

4.11.1 Soil pH

Application of zinc, boron and molybdenum has no significant effect on pH of post-harvest soil (Appendix III and Table 4). The highest pH (6.05) was recorded in treatment T_8 receiving (2kg Zn+1.5 kg B+1 kg Mo) and the lowest pH value (5.80) in T_1 (control) treatment.

4.11.2. Organic Matter (%)

Application of zinc, boron and molybdenum has no significant effect on organic matter content of post-harvest soil (Appendix III and Table 4). The highest organic matter (1.39 %) was recorded in treatment T_8 (2kg Zn+1.5 kg B+1 kg Mo) and the lowest organic matter (1.29 %) in T_1 (control)) treatment.

4.11.3. Total Nitrogen Content of Soil (%)

Total nitrogen was not significantly influenced by different treatment. The highest total nitrogen (0.092%) was recorded in T_8 (2kg Zn+1.5 kg B+1 kg Mo) treatment where lowest total nitrogen (0.063%) was recorded in T_1 (control) treatment (Table 4).

4.11.4. Available phosphorus content of soil (ppm)

Available phosphorus content of post-harvest soil was significantly influenced by the application of zinc, boron and molybdenum (Appendix III and Table 4). Among the different treatments, T_8 (2kg Zn+1.5 kg B+1 kg Mo) treatment showed the highest available phosphorus content (23.45 ppm) in post-harvest soil. On the other hand, the lowest available phosphorus content (12.50 ppm) was observed in T_1 (control) treatment.

4.11.5. Exchangeable potassium (meq/ 100gm soil)

Exchangeable potassium was significantly influenced by different treatments. However the highest exchangeablepotassium content (0.24 meq/ 100 gm soil) was recorded in T_8 (2kg Zn+1.5 kg B+1 kg Mo) treatment which was statistically similar to T_4 (0.21 meq/ 100 gm soil), T_6 (0.21 meq/ 100 gm soil) and T_7 (0.22 meq/ 100 gm soil) treatments and the lowest exchangeable potassium content (0.16 meq/ 100 gm soil) of post-harvest soil was recorded in T_1 (control) treatment which was statistically similar to T_2 (0.17 meq/ 100 gm soil), T_3 (0.19 meq/ 100 gm soil) and T_5 (0.18 meq/ 100 gm soil) treatments (Table 4).

Table. 4. Effect of zinc, boron and molybdenum on pH, organic matter, total N, available P and exchangeable K content of post-harvest soil

Treatment	pH	Organic matter (%)	Total N (%)	Available P (ppm)		Exchangeable K (meq/ 100 g soil)	
T_1	5.80	1.29	0.063	12.50	f	0.16	d
T_2	5.85	1.31	0.068	14.25	e	0.17	d
T_3	5.85	1.32	0.087	18.50	c	0.19	bcd
T_4	5.90	1.32	0.075	16.49	d	0.21	abc
T_5	5.95	1.35	0.072	19.32	c	0.18	cd
T_6	5.96	1.38	0.075	21.45	b	0.21	abc
T_7	5.92	1.36	0.086	20.88	b	0.22	ab
T_8	6.05	1.39	0.092	23.45	a	0.24	a
$LSD_{(0.05)}$	NS	NS	NS	1.04		0.03	
CV (%)	10.41	10.88	8.52	5.24		8.31	

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

T_1= Control, T_2= Zn 2.0 kg ha^{-1}, T_3= B 1.5 kg ha^{-1}, T_4= Mo 1.0 kg ha^{-1}, T_5= Zn+B, T_6= Zn+Mo, T_7= B+Mo and T_8= Zn+B+Mo

NS= Not Significant, CV= Coefficient of Variation

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at Sher-e-Bangla Agricultural University Farm, Dhaka, Bangladesh during the Kharif season from April 2017 to July 2017 to study the response of mungbean to zinc, boron and molybdenum application.The variety BARIMung- 6 was used as the test crop. The experiment comprised eight treatments: T_1= Control, T_2= Zn 2.0 kg ha^{-1}, T_3= B 1.5 kg ha^{-1}, T_4= Mo 1.0 kg ha^{-1}, T_5= Zn+B, T_6= Zn+Mo, T_7= B+Mo and T_8= Zn+B+Mo. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The size of the unit plot was 3.0 m × 1.75 m (5.25 m^2) and the distance between plot to plot was 0.5 m and replication to replication was 1.0 m. Data on different yield contributing characters and yield were recorded to find out the influence of zinc, boron and molybdenum.

Results showed that plant height, number of branches plant^{-1}, number of pod plant^{-1},pod length, number of seeds pod^{-1}, 1000 grain weight, grain yield, stover yield, biological yield and harvest index was significantly influenced by zinc, boron and molybdenum application.

The tallest plant (44.40 cm) was obtained from T_8 (2kg Zn+1.5 kg B+1 kg Mo) treatmentwhereas, the shortest plant (40.70 cm) was obtained from T_1 (control) treatment. The highest number of branches plant^{-1} (9.5) was recorded from T_8 (2kg Zn+1.5 kg B+1 kg Mo) treatment whereas,lowest number of branches plant^{-1} (5.5) was recorded from T_1 (control) treatment. The maximum number of pods plant^{-1} (13.0) was recorded from T_8 (2kg Zn+1.5 kg B+1 kg Mo) treatment whereas, the minimum number of pods per plant (8.0) was recorded from T_1 (control) treatment. The maximum length of pod (9.60 cm) was recorded from T_8 (2kg Zn+1.5 kg B+1 kg Mo) treatment whereas, the minimum length of pod (7.07 cm) was recorded from T_1 (control) treatment.

The maximum number of seeds pod^{-1} (10.00) was recorded from T_8 (2kg Zn+1.5 kg B+1 kg Mo) treatmentwhereas, the minimumnumber of seeds pod^{-1} (8.0) was recorded from T_1 (control) treatment. The highest 1000 grain weight (50.80 g) was obtained from T_8 (2kg Zn+1.5 kg B+1 kg Mo) treatment whereas, the lowest 1000 grain weight (47.50 g) was obtained from T_1 (control) treatment. The highest grain yield (1.40 t ha^{-1}) was produced by the treatment of T_8 (2kg Zn+1.5 kg B+1 kg Mo) whereas, the lowest grain yield (0.85 t ha^{-1}) was recorded from T_1 (control) treatment. The highest stover yield(2.04 t ha^{-1}) was observed from T_6 (2kg Zn +1 kg Mo) treatment whereas, the lowest stover yield(1.25 t ha^{-1}) was observed from the treatment of T_8 (2kg Zn+1.5 kg B+1 kg Mo). The highestbiological yield (3.19 t ha^{-1}) was obtained from T_7 (1.5 kg B+1 kg Mo) whereas, the lowestbiological yield (2.41 t ha^{-1}) was obtained from T_1 (control) treatment. The maximum harvest index (52.84%) was recorded from the treatment of T_8 (2kg Zn+1.5 kg B+1 kg Mo)whereas, the minimum (34.70 %) was found in the treatment of T_6 (2kg Zn +1 kg Mo).

Application of zinc, boron and molybdenum has no significant effect on pH, organic matter and total N content of soil. Phosphorus content and potassium content of post-harvest soil was significantly influenced by the application of zinc, boron and molybdenum. The highestpH (6.05), organic matter (1.39 %), total nitrogen content (0.092%), available phosphorus content (23.45 ppm) and exchange potassium content (0.24 meq/ 100 g soil) was recorded in treatment T_8 (2kg Zn+1.5 kg B+1 kg Mo).

Based on the experimental results, it may be concluded that-

- The application of zinc, boron and molybdenum had positive effect on morphological characters, yield and yield attributes of mungbean.
- Application of 2kg Zn+1.5 kg B+1 kg Mo per hectare seemed to be more suitable for getting higher yield in mungbean.

Recommendation

Considering the above observations of the present study could be made the following recommendations.

- ❖ Further study may be needed for ensuring the different levels of zinc, boron and molybdenum fertilizers in relation to growth, yield, quality and storage performance in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability.

REFERENCES

Abdo, F.A. (2001). The response of two mungbean cultivars to zinc, manganese and boron. Morphological, physiological and anatomical aspects. Bulletin of Faculty of Agriculture, Cairo University.52 (3): 45-46.

Agrawal, S.C., Sharma, P.N. Chatterjee, C. and Sharma, C.P. (1981). Development and enzymatic changes during pollen development in boron deficient maize plats. Journal of PlantNutrition, 3:329-336.

Alam, M. S. and Islam, M. F. (2016). Effect of zinc and boron on seed yield and yield contributing traits of mungbean in acidic soil. Journal of Bioscience and Agriculture Research, 11(02), 941-946.

Ali, M.Y., Krishnamurthy, L., Sexena, N.P., Pipela, O.P., Kumar, J. and Johansen.C. (2002).Scope for genetic manipulation of mineral acquisition in chickpea.Plant Soil.245 (1): 123-134.

Amadi, T. H. (1994). The response of soybean to the molybdenum at the condition of calcareous soil in Iraq. Journal of Agricultural Science. 25(1): 18-24.

Awomi, T.A., Singh, A.K., Singh, A.P. and Bordoloi, L.J. (2011). Effect of phosphorus, molybdenum and cobalt on growth yield and nutrient content of mungbean and soil fertility. J. Soil & Crops, 21(2): 158-164.

BBS (Bangladesh Bureau of Statistics). (2005). Monthly Statistical Bulletin. Statistics Div., Ministry of Planning. Government of the Peoples Republic of Bangladesh. Dhaka. p. 57.

BBS (Bangladesh Bureau of Statistics). (2010). Agricultural Year Book of Bangladesh.Statistics Div., Ministry of Planning. Government of the People"sReublic of Bangladesh, Dhaka.pp.144-151.

BBS (Bangladesh Bureau of Statistics). (2011). Yearbook of Statistics of Bangladesh.Statistics Division.Ministry of Planning, Government of the Peoples Republic of Bangladesh, Dhaka.

BBS (Bangladesh Bureau of Statistics). (2013). Yearbook of Statistics of Bangladesh. Statistics Division. Ministry of Planning, Government of the Peoples Republic of Bangladesh, Dhaka.

BBS (Bangladesh Bureau of Statistics). (2014). Regional Estimates of Agricultural Crop Production: 1985/86-1999/2000, Dhaka, Bangladesh.

Bharti, N, Murtaza, M. and Singh, A.P. (2002). Effect of boron-rhizobium relationship on yield, nitrogen and boron nutriation of chickpea (*Cicerarietinum*). J. Res. Birsaagril. Univ. 14(2):175-179.

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

Biswas, P. K., Bhowmick, M. K. and Bhattacharyya, A. (2010). Effect of molybdenum and seed inoculation on nodulation, growth and yield in mungbean [*Vignamungo* (L.)]. J. of Crop and Weed. 5(1):119-121.

Bolanos, L., Esteban, E. and Lorenzo, C. D. (1994).Essentiality of boron for symbiotic dinitrogen fixation in pea rhizobium noduls.Plant Physiol. USA104 (1):85-90.

Bonilla, I., Perex, H., Cassab, G., Lara, M. and Sanchez, F. (1997). The effect of boron deficiency on development of nodules in bean: changes in cell wall pectin contents and nodule polypeptide expression. Boron in Soils and Plants Pub., pp. 213-220.

Chakravarty, S. K., Sinha, H. and Singh, K. P. (1979). Note in boron nutrition of cereals and legumes in sand culture study. Ind. J. Agric. Sci. 49(5): 382-383.

Chowdhury, M. I. and Narayanan, R. (1992). Comparison of phosphorus deficiency effects on the growth parameters of mashbean, mungbean and soyabean.Soil Science and plant nutrition. 44:1, 19-30.

Coleman, J.E. (1992). Zinc proteins: Enzymes, storage protein, transcriptional factors and replication proteins.Annu.Rev.Biochem.61: 897-946.

Dutta, R.K., Uddin, M., Rahman, L., (1984). Productivity of mungbean, rice and mustard in relation toboron in Brahmaputra floodplain soil. Bangladesh J. Soil. Sci., 20, 77-83.

Dwivedi, B.S., Ram, M., Singh, B.P., Das, A.N. and Prasad, R.N. (1990). Different response of crop to boro fertilization in acid Alfisol. Indian J. Agric. Sci., 60(20): 122-127.

El Yazeid, A.A., AbouAly, H.E., Mady, M.A. and Moussa, SAM. (2007). Enhancing growth, productivity and quality of squash plant using phosphate dissolving microorganism combined with boron foliar spray. Res. J. Agric. & Biol. Sci., 3(4): 274-286.

FAO (Food and Agriculture Organization). (1982). Application of nitrogen fixing systems in soil management. FAO Soils Bulletin 49. Food and Agriculture Organization. Rome. P. 9.

FAO (Food and Agriculture Organization). (1983). Micro-nutrients. FAO Fertilizer and Plant Nutrition Bulletin 7. Food and Agriculture Organization. Rome.

FAO (Food and Agriculture Organization). (2013). FAO Yearbook Production.p. 53.

FAO. (1988). Food and Agricultural Organization of the United Nations, Soil Survey Project of Bangladesh. Soil Resources Tech. Rep. pp. 101-159.

Franco, A. A. and D. N. Munns. (1981). Response of *Phaseolus vulgaris* L. to molybdenum under acid conditions. Soil Sci. Soc. Amer. J., 45:1145-1148.

Ganie, M.A., Akhter, F., Najar, G.R. and Bhat, M.A. (2014). Influence of sulphur and boron supply onnutrient content and uptake of French bean (*Phaseolus vulgaris*L.) under inceptisols of North Kashmir. Afr. J. Agr. Res., 9(2): 230-239.

Gerath, B., Berchmann, W. and Zajone, I. (1975). The effect of micronutrient, boron on yield development in winter rape. Boron in Agriculture. 116: 13.

Gomez, K.A. and Gomez, A.A. (1984).Statistical procedure for agricultural research.Second Edn. Intl. Rice Res. Inst., John Wiley and Sons. New York. pp. 139-240.

Gupta, M. (1993). Growth and yield in *Viciafaba* L. in relation to mineral spray. Indian J. Appl. & Pure Biol., 4(2): 179-183.

Gupta, U. C. (1979). Boron nutrition of crops. Adv. Agron. 31: 273-307.

Hazra, A. M.andTripathi, P.N. (1998). Effect of secondary micronutrient on yield and quality of forage. Fertilizer News. Ind. J. Agril. Sci. 69 (11): 798-799.

Howeler, R.H., Flor, C.A. and Gonzalog, C.S. (1978). Correction of B deficiency in beans and mungbean in a willisol from the cauca valley Colombia. Colombian Agron. J., 70: 493-497.

Islam, M. B. and Sarkar, M. A. Z. (1993). Effect of different levels of boron on the yield of mustard. Research Report 1992-93. Bangladesh Agricultural Research Institute, On farm Research Division, Agricultural Research Station, Rangpur. pp. 1-4.

Islam, M.S., Hasana, k., Sarkar, N., EL Sabagh, A., Rashwan, E. and Barutçular, C. (2017). Yield and yield contributing characters of mungbean as influenced by zinc and boron. Agr. Adv., 6(1), 391-397.

Jahiruddin, M. (2006). Influence of boron, copper and molybdenum on grain formation of wheat. In: Proc. Workshop Bangladesh Agril. Univ. Res. Pros. Mymensingh (Banbladesh). pp. 105-106.

Johansen, S.E., Lauren, J.G., Welch, R.M. and Duxbury, J.M. (2005). A comparison of the effect of micronutrient , seed priming and soil fertilization on the mineral nutrition of chickpea (*Cicerarietimum*), lentil (*Lens culinaris*), rice (*Oryza sativa*) and wheat (*Triticumaestivum*) in Nepal. Expt. Agric. 41(4):427-448.

Kaul, A.K. (1982). Pulses is Bangladesh. BARC, Farm gate, Dhaka. p. 27.

Khan, M.R.I. (1981). Nurtitional quality characters in in pulses. In: Proc. National Workshop on Pulses. pp. 199-206.

Kulkarni, J.H., Sojitra, V.K. and Bhatt, D.M. (1989). Effect of micronutrient application on nodulation and pod yield of groundnut (*Arachis hypogeal* L.). Legume Res. 12(1): 49-51.

Lewis, D.H. (1980). Boron, lignifications and the origin of vascular plants infiekdhypothsis. New phytol. 84. 109-229.

Mahajan, T.S.; Chavan, A.S. and Dongale, J.H. (1994). Effect of boron on yield and quality of groundnut (*Arachis hypogea*) on laterite soil. Indian J. Agric. Sci. 64(8): 532-535.

Mandal, B., Pal, S. and Mandal, L.N. (1998). Available boron and zinc content in some alluvial acidic soils of north Bengla. Ind. J. Agri. Sci.61 (7): 502-504.

Mendel, R.R. (2007). Biology of the molybdenum cofactor. Journal of Experimental Biology. 58 (9): 2289-2296.

Mensah, J. K. &Ihenyen, J. (2009). Effects of salinity on germination, seedling establishment and yield of three genotypes of mungbean in Edo State, Nigeria. Nigerian Ann. of Natural Sciences, 8, 17- 24.

Micronutrients in agriculture. Soil Sci. Soc. of Americ, Madison Wiconsin p.731-742.

Ministry of Agriculture (MoA). (2013). Hand Book of Agricultural Statistics, December.p.14.

Mishra, J. P. and Masood, A. (1998). Phosphorus and molybdenum management in summer mungbean. Indian Journal of Pulses Research. 11(1): 100-102.

Mohan, K.K. and Rao, I. M. (1997). Effect of phosphors and molybdenum on growth, nitrogen fixation and yield of soybean. Journal of Research ANGRAU. 25(4): 77-80.

Mortvedt, J.J. (1981). Nitrogen and molybdenum uptake and dry matter relationships of soybean and forage legumes to applied molybdenum on acid soil. Journal of plant Nutrition. 3(1-4): 245-256.

Niranjana, H. G., Prakash, S. S., Ywlladhalli, N. A. and Chandranath, H. T. (2005). Effect of micronutrient seed treatment on growth and yield of groundnut. Journal of Seed Research. 33(2): 138-141.

Novoselova, A.S., and Ryabov, A.A. (1977). Effect of boron and molybdenum on seed yield of tetraploid red clove. SbornikNauchnykhRaboot, VsesoyuznyiNauchnoissledovatel ski InstitrtKormov. No. 16, 140-144.

Obata, H., Kawamura, S., Senoo, K. and Tanaka, A. (1999). Changes in the level of protein and activity of Cu/Zn superoxide dismutase in zinc deficient rice plant, *Oryza sativa* L. Soil Sci. Plant Nutr. 45: 891-896.

Oliveira, S. A.; de; and Kato, E. (1983). Infuuence of boron on yield and mineral nutrition of beans. PesuisaAgropecuariaBrasileira. Brazil. 18: 1373-1375.

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

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

Pandey, J. and Singh, C. P. (1981). Response of gram to micronutrients in calcarious soils. Ind. J. of Agron. 26(3): 344-345.

Paricca, P.C., N.C. Sahoo and M. Kar. (1983). Significance of molybdenum and applied nitrogen on the chemical composition and seed yield of green gram (*Vignaradiata* L.). Ind. J. Plant Physiol. 26(3): 305-313.

Patra, A.R. (1998). Productivity of soybean as affected by different micronutrient. Environment and Ecology. 14(4): 763-765.

Patra, P. K. and Bhattacharya, C. (2009). Effect of different levels of boron and molybdenum on growth and yield of mung bean [*Vignaradiata* (L.) Wilczek (cv. BaisakhiMung)] in Red and Laterite Zone of West Bengal. Journal of Crop and Weed, 5(1): 111-114.

Pilbeam D.J. and Kirkby, E.A. (1983). The Physiological role of boron in plants. J. Plant Nutr.6:563-582.

Price, C.A., Clark, H.E. and Funkhouser, U.E. (1972). Functions of micronutrients in plants.

Quddus, M. A., Rashid, M. H., Hossain, M. A. and Naser, H. M. (2011). Effect of zinc and boron on yield and yield contributing characters of mungbean in low ganges river floodplain soil at Madaripur, Bangladesh. Bangladesh J. Agril. Res. 36(1): 75-85.

Rahman, M.A. and Ali, M.O. (2007).The Causes of Decrease in Pulse Production and its Remedy.Indian J. Agron.10 (2): 5-6.

Rahman, M.M. and Alam, M.S. (1998). Response of groundnut to phosphorus and boron nutrition.Bangladesh J. Agril. Res. 23(2): 237-245.

RajanaPraveena, Gautam Ghosh and Vikram Singh. (2018). Effect of Foliar Spray of Boron and Different Zinc Levels on Growth and Yield of KharifGreengram*(Vignaradiata*). Int.J.Curr.Microbiol.App.Sci. 7(08): 1422-1428.

Rengel, (2001), Communication in soil science and plant analysis, 32, 1163-1186.

Rerkasem, B. and Jamjod, S. (1997). Genotypic variation in plant response to low boronand implications for plant breeding. Plant and Soil, 193, 169-180.

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

Sakal. R., Sinha, R.B. and Singh, A.P. (1988). Effect of boron application on blackgram and chickpea production in calcareous soil. Fertilizer-News. 33(2): 27-30.

Salinas, R. M., Caro, M., Cerda, A. and Santa, C.F. (1985). The interaction effect of B and K on pea growth. Anales de Edafolgia Y. Agrobiologia. 44(11-12): 1727-1733.

Santos, O. S. dos. (1979). Importance of Mo and Co for legumes. LavouraArrozeira. Brazil. 32. 315, 26, 28-32.

Shil, N. C., Noor, S., Bhuiyan, M.A.H. and Farid, A.T.M. (2007). Response of mungbean to boron and molybdenum fertilization. Bangladesh J. Agron. Environ. 3(1): 17-24.

Singh, A.K., Khan, M.A. and Srivastava, A., (2014). Effect of boron and molybdenum application on seed yield of mungbean. Asia. J. Biol. Sci., 9(2), 169-172.

Singh, K. P. (1993). Response of boron and molybdenum in soil of Singbhum and SantalParganas. Annals of Agricultural Research, 14:100-102.

Singh, R.N., Singh, S. and Kumar, B. (2006). Interaction effect of sulphur and boron on yield and nutrient uptake and quality characters of soybean (*Glycine max* L. Merill) grown in acidic upland soil. J. Ind. Soc. Soil Sci. 54:516-518.

Singh. A., Singh, B.B. and Patel, C.S. (1992). Response of vegetable pea (*Pisumsativum*) to zinc, boron, and molybdenum. Indian J. Agron., 31(3): 615-616.

SohidulIslam, M., EL Sabagh, A., Hasan, K., Akhter, M. and Barutçular, C. (2017). Growth andyieldresponseofmungbean(*Vignaradiata* L.) as influenced by sulphur and boron application. Scientific JournalofCropScience, 6(1), 153-160.

Srinivasan, S., Selvi, R.V., Ramesh, S., Pandiyan, M., Sunder, M., Kannan, R. and Marimuthu, R. (2007). Response of mungbean to different methods and levels of molybdenum application under acid soil conditions. Acta Hort., 752: 473-476.

Srivastava, S. P., Johansen,S. P. C., Neupana, R. K. and Joshi, M. (2005). Severe boron deficiency limiting grain legumes in the inner Teraiof Nepal. Micronutrients in the South and South East Asia; Proceeding of an international workshop held in Katmandu, Nepal, 8-11 September, 2004. pp. 67-76.

Talashilkar. S.C. and Chaven, A. S. (1996). Response of groundnut to calcium, sulphur and boron with and without FYM on Inceptisol. J.Indian Soc. Sci. 44(2): 343-344.

Tsou, S. C. S. & Hsu, M. A. (2000). Proc. First international mungbean symposium February 1978. AVRDC. Taiwan.

Vallee, B.L. and Auld, D.S. (1990). Zinc coordination, function and structure of zinc physiology. Enzymes and other proteins, Biochemistry 24: 5647-5659.

Velu, G. and P. Savithri. (1982). Molybdenum requirement for enhancing the yield of blackgram and greengram. Madras Agril. J. 70:629-630.

Verma, L.P., Ram, P. C. and Maurya, B.R. (1988). Response of chickpea to phosphorus and molybdenum in alluvium of eastern Uttar Pradesh, India. Inter. Chickpea Newsletter. 18: 31-33.

Vimalan, B. P., Gayathri, S., Thiyageshwari, j. And Prabhaharan (2017). Effects of Boron on the Seed Yield and Protien Content of Green Gram [*Vignamungo*] var.CO 8. Life Sciences International Research Journal: Volume 4 Issue 1.

Vinay-Singh and Singh, S. P. (1984). Studies on boron toxicity in lentil and barley. Ind. J.ofAgron. 29(4): 545-546.

Vitosh, M. L., Wameke, D.D. and Lucas, R. E. (1997). Boron. Mishigan State University Extension Soil and Management Fertilizer.

Wu, M., Xiao, C., Wu, M. C and Ziao, C. Z. (1994). A study of molybdenum in soyabean. Soyabean Sci. 13(3): 245-251.

Yang, Y.A., Xu, H.K., Jie, Z.Q. and Wang, B.Y. (1989). Influence of B, Zn, N and K nutritional level on boron uptake, quality and yield of rapeseed. Sci. Agric. Sinica.22 (1): 44-51.

Zaman, A.K.M.M., Alam, M.S., Biswas, B.K., Roy, B. and Beg, A.H. (1996b). Effect of B and Mo application on mungbean. Bangladesh J. Agr. Res., 21(1), 118-124.

Zaman, A.K.M.M., Roy, B., Beg, A.H. and Khan, M.H. (1996a). Effect of NPK with and without B, Zn, Mo and Mg application on mungbean. Indian J. pluses Res.47 (16): 173-184.

APPENDICES

Appendix I. Analysis of variance of the data on plant height, number of branch, number of pods per plant, pod length, number of seed per pod, thousand grain weightof mungbean as influenced by zinc, boron and molybdenum

Sourceof variation	Degrees of freedom	Mean square				
		Plant height (cm)	Number of branch per plant	Number of pods per plant	Pod length	Number of seed per pod
Replication	2	3.526	1.145	4.625	0.268	4.542
Factor A	7	5.269*	4.405*	7.565*	2.161*	1.708*
Error	14	4.611	0.454	0.958	0.326	1.065

* = Significant at 5% level of probability

Appendix II. Analysis of variance of the data on yield and yield contributing charactersof mungbean as influenced by zinc, boron and molybdenum

Sourceof variation	Degrees of freedom	Mean square				
		Thousand grain weight(g)	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield(t ha^{-1})	Harvest index (%)

Replication	2	11.29	0.008	0.011	0.001	12.394
Factor A	7	0.079^{NS}	0.099*	0.211*	0.279*	105.59*
Error	14	0.508	0.005	0.027	0.039	6.463

* = Significant at 5% level of probability

NS-non significant

Appendix III. Analysis of variance of the data on pH, organic matter, total N, available P and exchangeable Kcontent of post-harvest as influenced by zinc, boron and molybdenum

Sourceof variation	Degrees of freedom	Mean square				
		pH	Organic matter (%)	Total N (%)	Available P (ppm)	Exchangeable K (meq/ 100 g soil)
Replication	2	13.78	7.22	1.14	13.781	0.014
Factor A	7	0.045^{NS}	0.055^{NS}	0.012^{NS}	41.776*	0.002*
Error	14	0.353	0.006	0.001	0.353	0.0001

NS-non significant

* = Significant at 5% level of probability

Appendix IV. Commonly used symbols and abbreviations

Abbreviations	Full word
%	Percentage
@	At the rate
AEZ	Agro-Ecological Zone
ANOVA	Analysis of variance
BBS	Bangladesh Bureau of Statistics
cm	Centi-meter
CV%	Percentage of coefficient of variation
LSD	Least Significant Difference

et al.	and others
FAO	Food and Agricultural Organization
g	Gram
kg ha^{-1}	Kilograms per hector
t ha^{-1}	Ton per hectare
MOA	Ministry of Agriculture
RCBD	Randomized Complete Block Design
Sci.	Science
DAS	Day After Sowing
Fig.	Figure
J.	Journal
NS	Non-significant
ton/ha	Ton per hectare
SAU	Sher-e-Bangla Agricultural University
Viz.	Namely