EFFECT OF ZINC AND BORON ON THEGROWTH AND YIELD OF MUNGBEAN

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CERTIFICATE

This is to certify that the thesis entitled,***"Effect of zinc and boron on the growth and yield of mungbean"***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**MD. ASHIKUR RAHMAN,** Registration No.**09-03458**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.

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The author

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ABSTRACT

A field experiment was conducted at the central research field of Sher-e-Bangla Agricultural University(SAU), Dhaka, during the Robi season from March 2014 to June 2014, to study the effect of zinc and boron on growth and yield of mungbaen**.** The single factor experiment was consisted with eight treatments viz., T_1 = Zn 0 kg ha^{-1} + B 0 kg ha^{-1}, T_2 = Zn 0 kg ha^{-1} + B 1 kg ha^{-1}, T_3 = Zn 0 kg ha^{-1} + B 2 kg ha^{-}1, T^4= Zn 1 kg ha^{-1} + B 0 kg ha^{-1},T_5 = Zn 1 kg ha^{-1} + B 1 kg ha^{-1},T_6 = Zn 1 kg ha^{-1} + B 2 kg ha^{-1},T_7 = Zn 2 kg ha^{-1} + B 0 kg ha^{-1} andT_8 = Zn 2 kg ha^{-1} + B 1 kg ha^{-1}. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications.The results exhibited that plant height, number of leaves plant^{-1}, number of branches plant^{-1}, total pod weight plot^{-1}, pod length, number of pod plant^{-1}, number of seeds pod^{-1}, 1000 grain weight, grain yield, stover yield, biological yield, harvest index and post-harvest soil analysis wassignificantly influenced by the zinc and boron applications.Among the T_8 treatment were produced on maximum pod length (9.90 cm), number of pod plant^{-1} (13.70), number of seeds pod^{-1} (10.90), 1000 grains weight (38.50 g), grain yield (2.06 t ha^{-1}) and harvest index (63.19 %). This combination also exhibited highestpH (6.17), organic matter (1.45 %), total N (0.19 %), available P (24.13 ppm) and available K (0.25 meq) was recorded of post-harvest soil. From the growth, yield and post-harvest soil analytical reports, it is apparent that the combination of Zn 2 kg ha^{-1} + B 1 kg ha^{-1} of was suitable for mungbean cultivation.

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ABBREVIATIONS AND ACRONYMS

%	:	Percentage
@	:	At the rate of
Abstr.	:	Abstract
AEZ	:	Agro-Ecological Zone
Agric.	:	Agriculture
BARC	:	Bangladesh Agricultural Research Council
BARI	:	Bangladesh Agricultural Research Institute
BAU	:	Bangladesh Agricultural University
BBS	:	Bangladesh Bureau of Statistics
BCR	:	Benefit Cost Ratio
cm.	:	Centimeter
cv.	:	Cultivar
DAS	:	Day After Sowing
et al.	:	et alii (and others)
FAO	:	Food and Agriculture Organization of the United Nations
Fig.	:	Figure
FW	:	Fresh weight
FYM	:	Farm Yard Manure
G	:	Gram
Hort.	:	Horticulture
i.e.	:	That is
J.	:	Journal

K	:	Potassium
Kg	:	Kilogram
LSD	:	Least Significant Difference
M	:	Meter
MP	:	Muriate of Potash
N	:	Nitrogen
NS	:	Non-significant
^{O}C	:	Degree Celsius
P	:	Phosphorus
RCBD	:	Randomized Complete Block Design
Sci.	:	Science
Soc.	:	Society
T	:	Tonne
ton/ha	:	Ton per hectare
Tk.	:	Taka
TSP	:	Triple Super Phosphate
SAU	:	Sher-e-Bangla Agricultural University
UK	:	United Kingdom
UNDP	:	United Nations Development Program
Viz.	:	Namely

CHAPTER I

INTRODUCTION

Pulse crop belongs to seed legume under the family of Fabaceae. Bangladesh grows various types of pulse crops among them lentil, chickpea, cowpea, blackgram, mungbean, fieldpea and grasspea are important. 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}, where as it is 7.92 g day^{-1} in Bangladesh (BBS, 2011). This is because of fact that national production of the pulses is not adequate to meet our national demand. Both the area and production of the pulses are decreasing in Bangladesh day by day due to the inception of wheat, boro rice and maize in our cropping pattern with irrigation facilities.

Mungbean [*Vigna radiata* (L.)] is one of the most important pulse crops in Bangladesh. It holds the 3^{rd} in protein content and 4^{th} in both acreage and production in Bangladesh (Sarkar *et al.*, 2012). Its edible seed is characterized by higher digestibility, flavour, high protein content and absence of any flatulence effects (Ahmad *et al.*, 2008). 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). Mungbean seed contains 1-3% fat, 5.4% carbohydrates, 25.67%

protein, 3.5-4.5% fibers and 4.5-5.5% ash, while calcium and phosphorus are 132 and 367 mg per 100 grams of seed, respectively (Frauque *et al*., 2000).

Bangladesh is a developing country, where population is increasing and land is decreasing day by day, so we have to produce more food in our limited land. To meet up the basic demand of food, farmers are growing more cereal crops. So, at present the cultivation of pulse has gone to marginal land because farmers do not want to use their fertile land in pulse cultivation. Another cause of decreasing pulse cultivation is its lower yield. But the agroclimatic conditions of Bangladesh favor mungbaen cultivation almost throughout the year. The farmers of Bangladesh generally produce mungbean by one ploughing and hardly use minimum fertilizers and irrigations due to its lower productivity and also to their poor socio-economi condition and lack of proper knowledge. There is an ample scope for increasing the yield of mungbean with improved management practices.

Micronutrient (B, Zn, Mo, Mg etc.) is very important micro nutrient for increasing the yield of mungbean cultivation (Kulkarini, 1989). Boron is very important in cell division as well as seed formation and relation to water uptake. The chlorosis and browning of young leaves, killed growing points, distorted blossom development, lesions in pit and roots was the deficiency symptoms of some boron sensitive crops. 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). Zinc is involved in auxin formation, activation of dehydragenase enzymes and stabilization of ribosomal fractions (Aghatise and Tayo, 1994).

Delayed sowing after September in Kharif-I season hampers growth of mungbean plants. It is due to low temperature prevailing during the crop growing period. Micronutrients Boron and Zn are reported to have the positive effects on the stress tolerance, specially on the low temperature tolerance in crop plants. Delayed sowing of mungbean in Kharif-I season faces low temperature stress. Therefore, the micronutrients Boron and Zn might have the positive effects on low temperature stress tolerance on mungbean under late sowing condition in Kharif-I season.

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

1. To find out the effect of zinc and boron on the growth and yield of mungbean.

2. To find out the effect of zinc and boron fertilizer on the fertility status of post harvest soil.

CHAPTER II

REVIEW OF LITERATURE

Mungbean is one of the important pulse crops 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 studies related to yield and development of mungbean have been carried out in our country as well as many other countries of the world. So, the research as far done in Bangladesh is not adequate and conclusive. In this chapter, an attempt has been made to review the available information in home and abroad regarding the effect of micronutrients on the growth and yield of mungbean and other legumes.

Biswas *et al.* (2010) conducted a two-year field experiment during kharif season of 2005 and 2006 at the Pulse and Oilseeds Research Sub-station, Beldabga, Murshidabad, West Bengal, India to study the effect of zinc spray and seed inoculation on nodulation, growth and seed yield of mungbean. The results 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 rermarkbly 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.

Srivastava *et al.* (2005) observed that in absence of B application no pod and grain yield were formed, in comparison to a yield of 2.06t 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 mungbean.

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

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

Abdo (2001) conducted two field experiments at Giza Exparimental 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 DAS. The results showed that foliar spray with the adopted conc. 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) along followed by a mixture of micronutrients results in better morphological and physiological parameters. 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 lower level of Zn, Mn, B and their mixture on the internal structure of the vegetative growth of mungbean cv. VC-1000 was investigated.

Rizk and Adbo (2001) carried out two field experiments at Giza Exparimental Station, ARC, Egypt, during the 1998 and 1999 seasons to investigate the response of mungbean (*Vigna radiata*) to treatment with some micronutrients. Two cultivars of mungbean (V-2010 and VC-1000) were used inthis investigation. Zn (0.2 or 0.4g/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 DAS. The obtained results could be summarized in the following: Generally, cultivar VC-100 surpassed cultivar V-1000 in yield and its components as well as in the chemical composition of seeds with exception in 1000-seed weight and phosphorus percentage in seeds. All treatments increased significant yield and its components especially Zn (0.2 g/l) which showed a highly significant increase in all characters under investigation compared to the control. All adopted treatments increased significantly protein percentage in seeds of the two mungbean cultivars in both seasons. Among all treatments of micronutrients, B gave the highest percentage of crude protein. Seeds mungbean cv. VC-1000 exceeded those in both seasons.

Vrema and Mishra (1999) carried out a pot experiment with mungbean 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 boron ha^{-1} was applied at flowering.

Wang *et al.* (1999) reported that there is limited risk of B toxicity due to the of boron 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.

Verma *et al.* (1988) in a pot experiment with mungbean 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 in terms of seed yield/plant given when the equivalent of 5 kg borax ha^{-1} was applied at flowering.

Mishra and Masood (1998) in afield study at Kanpur, Uttar Pradesh, mungbean (*Vigna radiata*) 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. Yield component data are tabulated.

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.

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.

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

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.

Yang and Zhang (1998) observed that the addition of Zn promoted elongation of epicotyle and hypocotyle of mungbean and increased seedling height and dry weight. High concentration of Zn decreased soluble protein.

Bonilla *et al.* (1997) suggested that B is an oligatory 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. Moreover, B plays an important role in mediating cell surface interactions that lead to endocytosis of rhizobia by hoist cells and hence to the cporrect establishment of the symbiosis between pea and rhizobium (Bolanos *et al.*, 1994) .

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

Saha *et al.* (1996) conducted a filed experiment in pre-khraif seasons of 1993-94 at Pundibari, India, Yellow season was given 0, 2.5or 5.0 kg borax and 0, 1 or 2 kg $ZnSO_4$ ha^{-1} applied as soil, 66% soil + 33% foliar or foliar applications and the residual effects were studied on summer greengram. In both years green gram seed yield was highest with a combination of 5 kg borax + 2 kg $ZnSO_4$. Soil application gave higher yields than foliar or soil + foliar application.

Srivastava *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.* (1996a) conducted an experiment on mungbean and observed that application of B (2.0 kg ha^{-1}) produced 23.37% higher 1000 seed weight over control.

Zaman *et al.* (1996b) 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). 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.

Zaman *et al.* (1996c) observed that application of B (2 kg ha^{-1}) significant increased 23.57% 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 Zn is required for normal development and function of nodules in case of pea. In the absence of Zn, the number, size and weight of nodules decreased and nodules 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 significantly of groundnut.

Wu *et al.* (1994) observed that harvesting index in soybean were positively correlated with Zn concentration.

Gupta and Gupta (1993) reported that, the experiment in soil containing 0.4 mg kg^{-1} available B, chickpea 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 conc. in both crops was lower in the seeds than in the straw and was increased at higher B rates.

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

Bell *et al.* (1990) observed that leaf elongation was inhibited by interruption of the B supply 5 days late the appearance of B deficiency symptoms in the roots as observed in greengram (*Vigna radiata*).

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

Dwivedi *et al.* (1990) observed that under acute B stress flowering and grain formation of pulse, oil 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 pit and roots and plants, burning of the tips of the leaves and restricted root growth are the boron toxicity symptoms in most crops.

Sakaland Sinha (1990) carried out field trails at 7 sites inNorth Bihar, India. They observed the seed yield of chickpea increased from 1.4 t/ha with no B to 1.76 t/ha with 3 kg B/ha. The yield response to B application was grater on low B soils. It was conclude the on soils <0.35 ppm B, 3 kg B/ha was optimum and on soils >0.35 ppm B, 2kg B/ha was optimum.

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

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.

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.

Schon and Blevius (1987) 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 blackgram and greengram.

Rerkasem *et al.* (1987) observed that 10 kg borax ha^{-1} increased the number of leaves plant^{-1} in greengram.

Salinas*et al.* (1985) reported that Zn application increased the number of leaves of peas.

Dutta *et al.* (1984) stated that application of B (1 kg ha^{-1}) in mungbean increased leaf area ratio, leaf area index, crop growth rate, the number of leaves plant^{-1},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 but the relative growth rate, total dry matter and seed yield and some of other growth attributes were unaffected.

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.

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

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

Franco and Munns (1981) reported that seed yield and shoot weight in bean increase due to Zn 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 $ZnSO_4$ ha^{-1}.

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

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.

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}.

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

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

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at Sher-e-Bangla Agricultural University farm, Dhaka, Bangladesh during the period of March 2014 to June 2014 to study the effect of zinc and boron management on growth and yield of mungbaen.The details of the materials and methods have been presented below:

3.1. Description of the experimental site

3.1.1. Location

The present piece of research work was conducted in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka. The location of the site is 90°33´ E longitude and 23°77´ N latitude with an elevation of 8.2 m from the sea level. Location of the experimental site presented in Appendix I.

3.1.2. Soil

The soil belongs to “The Modhupur Tract”, AEZ – 28 (FAO, 1988). Top soil was silty clay in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH was 5.6 and has organic carbon 0.45%. The experimental area was flat having available irrigation and drainage system and above flood level. The selected plot was medium high land. The details were presented in Appendix II.

3.1.3. Climate

The geographical location of the experimental site was under the subtropical climate, characterized by 3 distinct seasons, winter season from November to

February and the pre-monsoon period or hot season from March to April and monsoon period from May to October.Details on the meteorological data of air temperature, relative humidity, rainfall and sunshine hour during the period of the experiment was collected from the Weather Station of Bangladesh, Sher-e-Bangla Nagar, presented in Appendix III.

3.2. Test crop and its characteristics

The plant attains a height of 35-40 cm, the leaves look light green and its life duration is about 75-80 days. Seeds are larger than local variety and light brown yellow in color. Seed contains 20-25 % protein. 1000 seeds weight is 35-40 g. Under proper management practices it may give 2.0-2.5 t ha^{-1} grain yield.

3.3. Experimental details

3.3.1. Treatments

The experiment comprised as single factor.

Doses of Micronutrients (Zn and B)

i. T_1 = Zn 0 kg ha^{-1} + B 0 kg ha^{-1}
ii. T_2 = Zn 0 kg ha^{-1} + B 1 kg ha^{-1}
iii. T_3 = Zn 0 kg ha^{-1} + B 2 kg ha^{-1}
iv. T_4 = Zn 1 kg ha^{-1} + B 0 kg ha^{-1}
v. T_5 = Zn 1 kg ha^{-1} + B 1 kg ha^{-1}
vi. T_6 = Zn 1 kg ha^{-1} + B 2 kg ha^{-1}
vii. T_7 = Zn 2 kg ha^{-1} + B 0 kg ha^{-1}
viii. T_8 = Zn 2 kg ha^{-1} + B 1 kg ha^{-1}

Every treatment received N, P and K as basal doses. The rates and sources of nutrients used in the study are given below:

Name of the Element	Rate (kg ha^{-1})	Name of the Fertilizer
N	45	Urea
P	100	Triple Super Phosphate(TSP)
K	58	Muriate of Potash(MoP)
Zn	0.0, 1.0, 2.0	Zinc Sulphet ($ZnSO_4$)
B	0.0, 1.0, 2.0	Boric acid

3.3.2. Experimental design and layout

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The layout of the experiment was prepared for distributing the combination of doses of micronutrient and sowing time. The 8 treatment combinations of the experiment were assigned at random into 8 plots of each replication. The size of each unit plot 2.5 × 2.5 m. The spacing between blocks and plots were 0.5 m and 0.25 m.

3.4. Growing of crops

3.4.1. Raising seedlings

3.4.1.1. Seed collection

Seeds of BARI Mung-5 was collected from Bangladesh Agricultural Research Institute (BARI), Joydevpur, Gazipur. After multilocation trials BARI released this variety for general cultivation with a popular name BARI Mung-5 in the year 2002.

3.4.1.2. Seed sprouting

Healthy seeds were selected by specific gravity method.

3.4.2. Preparation of the main field

The plot selected for the experiment was opened in the first week of March, 2014 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. Weeds and stubble were removed, and finally obtained a desirable tilth of soil for transplanting of seedlings.

3.4.3. Fertilizers and manure application

The fertilizer N, P and K were applied at 45, 100, 58 kg ha^{-1} in the form of urea, TSP and MP respectively during final land preparation as basal dose. Boron and Zinc were applied respectively from boric acid and $ZnSO_4$ as per treatment during final land preparation.

3.4.4. Intercultural Operation

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

3.4.4.1. 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.

3.4.4.2. Weeding

Several weedings were done to keep the plots free from weeds, which ultimately ensured better growth and development. First weeding was done at 20 days after sowing (DAS), 2nd and 3rd weeding was done at 35 and 50 DAS, respectively.

3.4.4.3. Plant protection

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.

3.5. Harvesting, threshing and cleaning

The crop was harvested at full maturity on 15 May, 2014 to 30 May, 2014 and harvesting was done manually from each plot. 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 mungbeanseed. 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.

Table 1. Dates of different operations done during the field study

Operations	Working Dates
First ploughing of the field	March 05, 2014
Second ploughing of the field	March 15, 2014
Final ploughing of the field	March 24, 2014
Application of fertilizers (Urea-1st split, TSP, MP, Gypsun, Boric Acid)	March 24, 2014
Seed sowing	March 26, 2014
Intercultural Operations	**Working Dates**

First weeding	April07, 2014
Second weeding	April19, 2014
Third weeding	April30, 2014
Insecticides application	April10, 2014 to May 05, 2014
Harvesting and threshing	15 May,2014 to 30 May, 2014

3.6 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 parameters were recorded at harvest:

- Plant height (cm)
- Number of leaves plant^{-1}
- Number of branches plant^{-1}
- Pod weight plot^{-1} (kg)
- Number of pods plant^{-1}
- Pod length plant^{-1} (cm)
- Number of seeds pod^{-1}
- Weight of 1000 grains (g)
- Grain yields (t ha^{-1})
- Stover yields (t ha^{-1})
- Biological Yield (t ha^{-1})
- Harvest index (%)
- Soil sample from each plot (post-harvest)

3.6.1. Plant height

The height of plant was recorded in centimeter (cm) at the harvesting time. Data were recorded as the average of 10 plants selected at random from the inner rows of each plot. The height was measured from the ground level to the tip of the leaves.

3.6.2. Number of leaves plant^{-1}

Number of leaves plant^{-1} was counted at the harvesting time. Leaves number plant^{-1} were recorded by counting all leaves from each plant of each plot and mean was calculated.

3.6.3. Number of branches plant^{-1}

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

3.6.4. Pod weight plot^{-1}

Pod weight of ten plants from each plot was noted and the mean weight was expressed per plot basis.

3.6.5. Number of pods plant^{-1}

Number of total pods of ten plants from each plot was noted and the mean number was expressed per plant basis.

3.6.6. Pod length plant^{-1}

Length of total pod of ten plants from each plot was noted and the mean number was expressed per pod basis.

3.6.7. 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.

3.6.8. Weight of 1000 seeds

One thousand cleaned and dried seeds were counted randomly form each sample and weight by using a digital electric balance and the weight was expressed in gram.

3.6.9. Grain yield

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}.

3.6.10. Stover yield

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}.

3.6.11. Biological yield

Grain yield and stover yield together were regarded as biological yield. The biological yield was calculated with the following formula:

Biological yield = Grain yield + Stover yield.

3.6.12. 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.

$$HI\ (\%) = \frac{\text{Economic yield (Grain yield)}}{\text{Biological yield (Grain yield + Stover yield)}} \times 100$$

3.7. Collection of Samples

3.7.1. Soil Sample

The initial soil samples were collected randomly from different spots of the field selected for the experiment at 0-15 cm depth before the land preparation and mixed thoroughly to make a composite sample for analysis. Post harvest soil samples were collected from each plot at 0-15 cm depth in December 6, 2013. The samples were air-dried, grounded and sieved through a 2 mm sieve and preserved for analysis.

3.8. Soil Sample Analysis

The initial and postharvest soil sample were analyzed for both physical and chemical properties in the laboratory of Soil Resource Development Institute (SRDI), Farmgate, Dhaka.

The properties studied included soil texture, pH, organic matter, total N, available P, exchangeable K and available S. The properties studied included soil pH, particle density, and organic matter, total N, available P, exchangeable K, available S and available Zn. The soil was analyzed by the following standard methods:

3.8.1. Particle Size Analysis

Particle size analysis of soil sample was done by hydrometer method. The textural class ascertained using USDA textural triangle.

3.8.2. Soil pH

Soil pH was determined by glass electrode pH meter in soil-water suspension having soil: water ratio of 1:2.5 as outlined by Jackson (1962).

3.8.3. Organic Carbon

Organic carbon of the soil was determined by wet oxidation method described by Walkley and Black (1934). To obtain organic matter content, the amount of organic carbon was multiplied by the van Bemmelen factor of 1.73. The result was expressed in percentage.

3.8.4. Organic Matter

The Organic Matter content was determined by multiplying the percent organic carbon with van Bemmelen factor 1.73.

3.8.5. Total Nitrogen

Total nitrogen of soil samples was estimated by Micro-kjeldahl Method where soils were digested with 30% H_2O_2 concentrated H_2SO_4 and catalyst mixture ($K_2SO_{4:}$ $CuSO_{4,}$ 5 H_2O: Selenium powder in the ratio of 100:10:1, respectively). Nitrogen in the digest was determined by distillation with 40% NaOH followed by titration of the distillate absorbed in H_3BO_3 with 0.01 H_2SO_4.

3.8.6. Available Phosphorous

Available phosphorous was extracted from the soil by shaking with 0.5 $MNaCO_3$ solution of pH 8.5. The phosphorous in the extract was then determined by developing blue color using $SnCl_2$ reduction of phosphomolybdate complex. The absorbance of the molybdophosphate blue color was measured at 660 mm wave length by spectrophotometer and available P was calculated with the help of a standard curve.

3.8.7. Exchangeable Potassium

Exchangeable Potassium in the soil sample was extracted with 1N neutral ammonium acetate (NH_4OAc) and the potassium content was determined by flame photometer (Black, 1965).

3.9. 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 the effect of zinc-boron management on growth and yield of mungbean. 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 IV-VII. The results have been presented and discussed with the help of tables and graphs and possible interpretation has been given under the following headings.

4.1. Crop growth characters

4.1.1. Plant height

Significant effects of zinc-boron management on plant height was observed at harvesting time (Appendix IV and Table 2). Plant height increased with advancing growing period irrespective of zinc-boron management. The tallest plant (59.48 cm) was obtained from T_8(2 kg Zn ha^{-1} + 1 kg B ha^{-1}) treatment which followed by T_5 (57.17 cm) treatment (1 kg Zn ha^{-1} + 1 kg B ha^{-1}), T_6 (56.72 cm) treatment (1 kg Zn ha^{-1} + 2 kg B ha^{-1}) and T_7 (55.22 cm) treatment (2 kg Zn ha^{-1} + 0 kg B ha^{-1}). The shortest plant (50.44 cm) was obtained from T_1(0 kg Zn ha^{-1} + 0 kg B ha^{-1}) treatment which followed by T_2 (52.22 cm) treatment (0 kg Zn ha^{-1} + 1 kg B ha^{-1}), T_3 (53.677 cm) treatment (0 kg Zn ha^{-1} + 2 kg B ha^{-1}) and T_4 (54.89 cm) treatment (1 kg Zn ha^{-1} + 0 kg B ha^{-1}). Plant height of a crop depends on the plant vigor, cultural practices, growing environment and agronomic management. In the present experiment since mungbean was grown in the same environment and were given same cultural practices except micronutrients. So, the variation of plant height might be due to the effect different level of zinc and boron fertilizer combinations.

Vrema and Mishra (1999) and Verma *et al.* (1988) reported that boron increased growth parameters of mungbean cv. PDM 54 when the equivalent of 5 kg boraxha^{-1} was applied at flowering.Chowdhury and Narayanan (1992) observed that the tallest plant height of mungbean (59.48 cm) and plant height increased 23.57% higher in plants receiving inoculums along with Zn (1 kg ha^{-1}) and B (1 kg ha^{-1}) over control. Zaman *et al.* (1996b) 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.* (1996c) observed that application of B (2 kg ha^{-1}) significantly increased 23.57% higher plant height of mungbean over control.

4.1.2. Number of leaves plant^{-1}

There was significant variation among the effect of zinc-boron management on the total numbers of leaves plant^{-1} at harvesting time (Appendix IV and Table 2). Number of leaves plant^{-1} increased with advancing growing period up to 50 DAS irrespective of zinc-boron management and thereafter decreased. The maximum number of leaves plant^{-1} (33.00) was recorded with the combination of 2 kg Zn ha^{-1} + 1 kg B ha^{-1} (T_8) treatment which followed by T_6 (31.00) treatment (1 kg Zn ha^{-1} + 2 kg B ha^{-1}), T_5 (30.89) treatment (1 kg Zn ha^{-1} + 1 kg B ha^{-1}) and T_7 (30.33) treatment (2 kg Zn ha^{-1} + 0 kg Bha^{-1}). The minimum number of leaves plant^{-1} (27.25) was recorded from the combination of 0 kg Zn ha^{-1} + 0 kg B ha^{-1} (T_1) treatment which followed by T_2 (28.94) treatment (0 kg Zn ha^{-1} + 1 kg B ha^{-1}), T_3 (29.11) treatment (0 kg Zn ha^{-1} + 2 kg B ha^{-1}) and T_4 (29.55) treatment (1 kg Znha^{-1}

+ 0 kg B ha^{-1}).Present study showed that 2 kg Zn ha^{-1} + 1 kg B ha^{-1} produced highest number of leaves.

Rerkasem *et al.* (1987) observed that 10 kg borax ha^{-1} increased the number of leaves plant^{-1} in greengram.Salins *et al.* (1985) reported that Zn application increased the number of leaves of peas.Dutta *et al.* (1984) stated that application of B (1 kg ha^{-1}) in mungbean increased the number of leaves plant^{-1}.

4.3. Number of branches plant^{-1}

Effect of zinc, boron management significantly influenced thenumber of branches plant $^{-1}$ (Appendix IV and Table 2). The highest number of branches plant^{-1} (7.77) was recorded from the combination of 2 kg Zn ha^{-1}+1 kg B ha^{-1} (T_8) treatment which was statistically similar to T_5 (7.00) treatment (1 kg Zn ha^{-1} + 1 kg B ha^{-1}) and T_6 (7.00) treatment (1 kg Zn ha^{-1} + 2 kg B ha^{-1}).The lowest number (6.00) of branches plant^{-1} was recorded from the combination of 0 kg Zn ha^{-1} + 0 kg B ha^{-1} (T_1) treatment which was statistically similar to T_2 (6.72) treatment (0 kg Zn ha^{-1} + 1 kg B ha^{-1}), T_3 (6.73) treatment (0 kg Zn ha^{-1} + 2 kg B ha^{-1}), T_4 (6.75) treatment (1 kg Zn ha^{-1} + 0 kg B ha^{-1}) and T_7 (6.78) treatment (2 kg Zn ha^{-1} + 0 kg B ha^{-1}). This study revealed that 2 kg Zn ha^{-1} + 1 kg B ha^{-1} produced maximum number of branches plant^{-1}.

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.Dutta *et al.* (1984) stated that application of B (1 kg ha^{-1}) in mungbean increased number of branches plant^{-1}.

Table 2. Effect of zinc-boron management on plant height, number of leaves plant^{-1} and number of branches plant^{-1} of mungbean

Treatments	Plant height (cm)	Number of leaves plant^{-1}	Number of branches plant^{-1}
T_1	50.44 g	27.25 e	6.00 c
T_2	52.22 f	28.94 d	6.72 bc
T_3	53.67 e	29.11 d	6.73 bc
T_4	54.89 d	29.55 cd	6.75 bc
T_5	57.17 b	30.89 b	7.00 ab
T_6	56.72 c	31.00 b	7.00 ab
T_7	55.22 d	30.33 bc	6.78 bc
T_8	59.48 a	33.00 a	7.77 a
$LSD_{(0.05)}$	0.39	0.84	0.94
CV (%)	5.28	5.71	7.12

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

Note: T_1 = 0 kg Zn ha^{-1} + 0 kg B ha^{-1},
T_2 = 0 kg Zn ha^{-1} + 1 kg B ha^{-1},
T_3 = 0 kg Zn ha^{-1} + 2 kg B ha^{-1},
T_4 = 1 kg Zn ha^{-1} + 0 kg B ha^{-1},
T_5 = 1 kg Zn ha^{-1} + 1 kg B ha^{-1},
T_6 = 1 kg Zn ha^{-1} + 2 kg B ha^{-1},
T_7 = 2 kg Zn ha^{-1} + 0 kg B ha^{-1} and
T_8 = 2 kg Zn ha^{-1} + 1 kg B ha^{-1}.

4.2. Pod characteristics

4.2.1. Total pod weight plot^{-1}

Total pod weight plot^{-1} of mungbean differed significantly due to zinc-boron management (Appendix V and Table 3). The highest pod weight plot^{-1} (2.40 kg) was recorded from 2 kg Zn ha^{-1} + 1 kg B ha^{-1}(T_8) treatment which followed by T_5 (2.05 kg) treatment (1 kg Zn ha^{-1} + 1 kg B ha^{-1}), T_6 (1.99 kg) treatment (1 kg Zn ha^{-1} + 2 kg B ha^{-1}), T_7 (1.99 kg) treatment (2 kg Zn ha^{-1} + 0 kg B ha^{-1}) and T_4 (1.98 kg) treatment (1 kg Zn ha^{-1} + 0 kg B ha^{-1}).The lowestpod weight plot^{-1}(1.32 kg) was found in 0 kg Zn ha^{-1} + 0 kg B ha^{-1} (T_1) treatment which was followed by T_2 (1.78 kg) treatment (0 kg Zn ha^{-1} + 1 kg B ha^{-1}) and T_3 (1.85 kg) treatment (0 kg Zn ha^{-1} + 2 kg B ha^{-1}). Present study showed that 2 kg Zn ha^{-1} + 1 kg B ha^{-1} produced maximumpod weight.

Talashikar and Chavan (1996) reported that increase of pod yield due to application of boron of groundnut cultivation.Mahajan *et al.* (1994) found that soil application of B (0.5 kg ha^{-1}) increased pod yield of groundnut.Dutta *et al.* (1984) stated that application of B (1 kg ha^{-1}) in mungbean increased weight of pod plant^{-1}.

4.2.2. Pod length

There was significant variation among the effect of zinc-boron management on the length of pod of mungbean (Appendix V and Table 3). Length of pod of mungbean increased with increasing the levels of micronutrient. The tallest length of pod (9.90 cm) was recorded with the combination of 2 kg Zn ha^{-1} + 1 kg B ha^{-1} (T_8) treatment which was followed by T_6 (9.00 cm) treatment (1 kg Zn ha^{-1} + 2 kg B ha^{-1}), T_5 (8.80 cm) treatment (1 kg Zn ha^{-1} + 1 kg B ha^{-1}), T_7 (8.70 cm) treatment (2 kg Zn ha^{-1} + 0 kg B ha^{-1}) and T_4 (8.60 cm) treatment (1 kg Zn ha^{-1} + 0 kg B ha^{-1}).The shortestlength of pod (7.50 cm) was recorded from the combination of 0 kg Zn ha^{-1} + 0 kg B ha^{-1} (T_1) treatment followed by T_2 (8.50 cm) treatment (0 kg Zn ha^{-1} + 1 kg B ha^{-1}) and T_3 (8.50 cm) treatment (0 kg Zn ha^{-1} + 2 kg B ha^{-1}).2 kg Zn ha^{-1} + 1 kg B ha^{-1} produced highestpod length in this study.

4.2.3. Number of pods plant^{-1}

Statistically significant differences were found for number of pods plant^{-1} of mungbean due to znic-boron management (Appendix V and Table 3). The highest number of pod plant^{-1} (13.70) was recorded from 2 kg Zn ha^{-1}+ 1 kg B ha^{-1}(T_8) treatment which was statistically similar to T_6 (13.00) treatment (1 kg Zn ha^{-1} + 2 kg B ha^{-1}) and which was followed by T_5 (12.80) treatment (1 kg Zn ha^{-1} + 1 kg B ha^{-1}) whereas, the lowest (9.67) was observed from the combination of 0 kg Zn ha^{-1} + 0 kg B ha^{-1} (T_1) treatment followed by T_3 (11.16) treatment (0 kg Zn ha^{-1} + 2 kg B ha^{-1}), T_4 (11.62) treatment (1 kg Zn ha^{-1} + 0 kg B ha^{-1}), T_2 (11.67) treatment (0 kg Zn ha^{-1} + 1 kg B ha^{-1}), T_7 (11.67) treatment (2 kg Zn ha^{-1} + 0 kg B ha^{-1}). This study revealed that 2 kg Zn ha^{-1} + 1 kg B ha^{-1} produced maximum number of pods.

Dwivedi *et al.* (1990) observed that under acute B stress flowering of pulse, oil and cereal crops were drastically reduced.Dutta *et al.* (1984) stated that application of B (1 kg ha^{-1}) in mungbean increased the no. of pod plant^{-1}.

4.2.4. Number of seeds pod^{-1}

Number of seeds pod^{-1} of mungbean differed significantly due to zinc boron management (Appendix V and Table 3). The maximum number of seeds pod^{-1} (10.90) was recorded from T_8(2 kg Zn ha^{-1} + 1 kg B ha^{-1}) treatment which was followed by T_6 (9.67) treatment (1 kg Zn ha^{-1} + 2 kg B ha^{-1}) and T_5 (9.40) treatment (1 kg Zn ha^{-1} + 1 kg B ha^{-1}) whereas, the minimum (8.00) was observed from the combination of T_1 (0 kg Zn ha^{-1} + 0 kg B ha^{-1}) treatment which was followed by T_2 (8.90) treatment (0 kg Zn ha^{-1} + 1 kg B ha^{-1}), T_3 (8.90) treatment (0 kg Zn ha^{-1} + 2 kg B ha^{-1}), T_4 (9.17) treatment (1 kg Zn ha^{-1} + 0 kg B ha^{-1}) and T_7 (9.17) treatment (2 kg Zn ha^{-1} + 0 kg B ha^{-1}). Present study showed that 2 kg Zn ha^{-1} + 1 kg B ha^{-1} produced maximum number of seeds.

Srivastava *et al.* (1996) cultivated the chickpea in boron deficient soil and observed the highest flower abortion and no seed production in the treatment with B addition.Dwivedi *et al.* (1990) observed that under acute B stress grain formation of pulse, oil and cereal crops were drastically reduced.Islam and Sarkar (1993) found higher number of seeds pod^{-1} of mustard due to application of B @ 1.5 kg ha^{-1}.

4.2.5. 1000 grain weight

Effect of zinc and boron exhibited significant variation in 1000 grain weight of mungbean (Appendix V and Table 3). The highest 1000 grain weight (38.50 g) was recorded from the T_8(2 kg Zn ha^{-1} + 1 kg Bha^{-1}) treatment which was statistically similar to T_6 (37.94 g) treatment (1 kg Zn ha^{-1} + 2 kg B ha^{-1}) and followed by T_5 (37.67g) treatment (1 kg Zn ha^{-1} + 1 kg B ha^{-1}). The lowest 1000 grain weight (34.85 g) was observed from the combination of 0 kg Zn ha^{-1} + 0 kg B ha^{-1} (T_1) treatment which was statistically similar to T_2 (34.67 g) treatment (0 kg Zn ha^{-1} + 1 kg B ha^{-1}), T_3 (35.40 g) treatment (0 kg Zn ha^{-1} + 2 kg B ha^{-1}) and followed by T_4 (35.50 g) treatment (1 kg Zn ha^{-1} + 0 kg B ha^{-1}), T_7 (35.91 g) treatment (2 kg Zn ha^{-1} + 0 kg B ha^{-1}). 2 kg Zn ha^{-1} + 1 kg B ha^{-1} produced maximum 1000 grain weight in this study.

Results obtained fromRizk and Adbo (2001) could be summarized in the following: cultivar VC-100 surpassed cultivar V-1000 increased 1000-seed weight when increased zinc and boron concentration.Zaman *et al.* (1996a) observed that application of B (2.0 kg ha^{-1}) produced 23.37% higher 1000 seed weight of mungbean over control.Gupta and Gupta (1993) reported that B conc. in chickpea and lentils was increased seeds.

Table 3. Effect of zinc-boron management on pod characteristics and 1000 grain weight of mungbean

Treatments	Total pod weight (kg)	Pod length (cm)	Number of pods plant^{-1}	Number of seeds pod^{-1}	1000 grain weight (g)
T_1	1.32 d	7.50 d	9.67 d	8.00 e	34.85 de
T_2	1.78 c	8.50 c	11.67 c	8.90 d	34.67 e

T_3	1.85 bc	8.50 c	11.16 c	8.90 d	35.40 c-e
T_4	1.98 bc	8.60 bc	11.62 c	9.17 cd	35.50 cd
T_5	2.05 b	8.80 bc	12.80 b	9.40 bc	37.67 b
T_6	1.99 bc	9.00 b	13.00 ab	9.67 b	37.94 ab
T_7	1.99 bc	8.70 bc	11.67 c	9.17 cd	35.91 c
T_8	2.40 a	9.90 a	13.70 a	10.90 a	38.50 a
$LSD_{(0.05)}$	0.26	0.49	0.72	0.39	0.73
CV (%)	7.47	3.17	3.43	2.38	1.15

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

Note: T_1 = 0 kg Zn ha^{-1} + 0 kg B ha^{-1},
T_2 = 0 kg Zn ha^{-1} + 1 kg B ha^{-1},
T_3 = 0 kg Zn ha^{-1} + 2 kg B ha^{-1},
T_4 = 1 kg Zn ha^{-1} + 0 kg B ha^{-1},
T_5 = 1 kg Zn ha^{-1} + 1 kg B ha^{-1},
T_6 = 1 kg Zn ha^{-1} + 2 kg B ha^{-1},
T_7 = 2 kg Zn ha^{-1} + 0 kg B ha^{-1} and
T_8 = 2 kg Zn ha^{-1} + 1 kg B ha^{-1}.

4.3. Yield characteristics

4.3.1.Grain yield

Statistically significant difference was recorded for theeffect of zinc-boron managementon grain yield of mungbean (Appendix VI and Table 4). The maximum grain yield (2.06 t ha^{-1}) was observed from the combination of 2 kg Zn ha^{-1}+ 1 kg B ha^{-1} (T_8) treatment which was followed by T_5 (1.86 t ha^{-1}) treatment (1 kg Zn ha^{-1} + 1 kg B ha^{-1}), T_6 (1.82 t ha^{-1}) treatment (1 kg Zn ha^{-1} + 2 kg B ha^{-1}) and T_7 (1.76 t ha^{-1}) treatment (2 kg Zn ha^{-1} + 0 kg B ha^{-1}) whereas, the minimum (1.25 t ha^{-1}) was observed from the T_1 (0 kg Zn ha^{-1} + 0 kg B ha^{-1}) treatment which was followed by T_2 (1.57 t ha^{-1}) treatment (0 kg Zn ha^{-1} + 1 kg B ha^{-1}), T_3 (1.59 t ha^{-1}) treatment (0 kg Zn ha^{-1} + 2 kg B ha^{-1}) and T_4 (1.68 t ha^{-1}) treatment (1 kg Zn ha^{-1} + 0 kg B ha^{-1}). This study revealed that 2 kg Zn ha^{-1} + 1 kg B ha^{-1} produced highest grain yield.

Biswas *et al.* (2010) revealed that in mungbean 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%.Bharti *et al.* (2002) reported that the mean seed yield increased when Zn and B content increased in soil.Vrema and Mishra (1999) and Verma *et al.* (1988) reported that boron increased yield when the equivalent of 5 kg boron ha^{-1} was applied at flowering.Mandal *et al.* (1998) noted that the application of B fertilizer thus increasing the yield of pulse crops.Patra (1998) observed that the yield increase in soybean by the application of Zn (5 kg ha^{-1}).Saha *et al.* (1996) conducted that green gram seed yield was highest with a combination of 5 kg borax + 2 kg $ZnSO_4$.Sakaland Sinha (1990) observed the seed yield of chickpea increased from 1.4 t/ha with no B to 1.76 t/ha with 3 kg B/ha.Yang *et al.* (1989) reported that combined application of N, K, Zn and B increased seed yield in rapeseed.Sakal *et al.* (1988) reported that application of 2.0 and 2.5 kg B ha^{-1} increased grain yields of blackgram and chickpea by 63 and 38%, respectively.Schon and Blevins (1987) 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 blackgram and greengram.Dutta *et al.* (1984) stated that application of B (1 kg ha^{-1}) was unaffected seed yield in mungbean. Pandey and Singh (1981) reported that seed yields of greengram grown with NPK were increased by applying 10 kg $ZnSO_4$ ha^{-1}.Howeler *et al.* (1978) observed that yield of mungbeans was nearly doubled with the application of 1 kg Zn ha^{-1}.

4.3.2. Stover yield

Stover yield of mungbean were significantly influenced by zinc boron management (Appendix VI and Table 4). The highest stover yield (2.40 t ha^{-1}) was observed from 0 kg Zn ha^{-1} + 0 kg B ha^{-1} (T_1) treatment which was followed by T_2 (2.00 t ha^{-1}) treatment (0 kg Zn ha^{-1} + 1 kg B ha^{-1}) and T_4 (2.00 t ha^{-1}) treatment (1 kg Zn ha^{-1}

+ 0 kg B ha^{-1}). The lowest stover yield (1.20 t ha^{-1}) was observed from the combination of 2 kg Zn ha^{-1} + 1 kg B ha^{-1} (T_8) treatment followed byT_6 (1.46 t ha^{-1}) treatment (1 kg Zn ha^{-1} + 2 kg B ha^{-1}), T_5 (1.47 t ha^{-1}) treatment (1 kg Zn ha^{-1} + 1 kg B ha^{-1}), T_7 (1.70 t ha^{-1}) treatment (2 kg Zn ha^{-1} + 0 kg B ha^{-1}) and T_3 (1.70 t ha^{-1}) treatment (0 kg Zn ha^{-1} + 2 kg B ha^{-1}).

Bharti *et al.* (2002) reported that the stover yield decreased with the increasing B and Zn rate.Gupta and Gupta (1993) reported that boron conc. in chickpae and lentils was lower straw and was increased at higher B rates.

4.3.3. Biological yield

Effect of zinc boron managementshowed significant variation in biological yield of mungbean (Appendix VI and Table 4). The maximum biological yield (3.68 t ha^{-1}) was observed from the combination of 1 kg Zn ha^{-1} + 0 kg B ha^{-1} (T_4) treatment which was statistically identical to T_1 (3.65 t ha^{-1}) treatment (0 kg Zn ha^{-1} + 0 kg B ha^{-1}) and T_2 (3.57 t ha^{-1}) treatment (0 kg Zn ha^{-1} + 1 kg B ha^{-1}) and followed by T_7 (3.46 t ha^{-1}) treatment (2 kg Zn ha^{-1} + 0 kg B ha^{-1}). The minimum biological yield (3.26 t ha^{-1}) was observed from the combination of 2 kg Zn ha^{-1} + 1 kg B ha^{-1} (T_8) treatment which was statistically identical to T_6 (3.28 t ha^{-1}) treatment (1 kg Zn ha^{-1} + 2 kg B ha^{-1}), T_3 (3.29 t ha^{-1}) treatment (0 kg Zn ha^{-1} + 2 kg B ha^{-1}) and T_5 (3.33 t ha^{-1}) treatment (1 kg Zn ha^{-1} + 1 kg B ha^{-1}).

4. 3.4. Harvest Index

A significant difference was found in harvest index due to zinc-boron management (Appendix VI and Table 4). The maximum harvest index (63.19 %) was recorded from the combination of 2 kg Zn ha^{-1} + 1 kg B ha^{-1} (T_8) treatmentwhich was followed by T_5 (55.85 %) treatment (1 kg Zn ha^{-1} + 1 kg B ha^{-1}), T_6 (55.49 %) treatment (1 kg Zn ha^{-1} + 2 kg B ha^{-1}), T_7 (50.87 %) treatment (2 kg Zn ha^{-1} + 0 kg

B ha^{-1}) whereas, the minimum (34.03 %) was found in the combination of 0 kg Zn ha^{-1} + 0 kg B ha^{-1} (T_1) treatment which was followed byT_2 (43.98 %) treatment (0 kg Zn ha^{-1} + 1 kg B ha^{-1}),T_4 (45.65 %) treatment (1 kg Zn ha^{-1} + 0 kg B ha^{-1}) and T_3 (48.33 %) treatment (0 kg Zn ha^{-1} + 2 kg B ha^{-1}). This study revealed that 2 kg Zn ha^{-1} + 1 kg B ha^{-1} produced maximum harvest index.

Mahajan *et al.* (1994) found that soil application of B (0.5 kg ha^{-1}) increased and harvest index significantly of groundnut.Wu *et al.* (1994) observed that harvesting index in soybean were positively correlated with Zn concentration.

Table 4. Effect of zinc-boron management on yield characteristics of mungbean

Treatments	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
T_1	1.25 e	2.40 a	3.65 a	34.03 e
T_2	1.57 d	2.00 b	3.57 ab	43.98 d
T_3	1.59 d	1.70 c	3.29 c	48.33 c
T_4	1.68 cd	2.00 b	3.68 a	45.65 d
T_5	1.86 b	1.47 d	3.33 c	55.85 b
T_6	1.82 bc	1.46 d	3.28 c	55.49 b
T_7	1.76 bc	1.70 c	3.46 b	50.87 c
T_8	2.06 a	1.20 e	3.26 c	63.19 a
$LSD_{(0.05)}$	0.17	0.25	0.11	4.54
CV (%)	5.46	5.22	5.04	3.01

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

Note: T_1 = 0 kg Zn ha^{-1} + 0 kg B ha^{-1},
T_2 = 0 kg Zn ha^{-1} + 1 kg B ha^{-1},
T_3 = 0 kg Zn ha^{-1} + 2 kg B ha^{-1},
T_4 = 1 kg Zn ha^{-1} + 0 kg B ha^{-1},
T_5 = 1 kg Zn ha^{-1} + 1 kg B ha^{-1},
T_6 = 1 kg Zn ha^{-1} + 2 kg B ha^{-1},
T_7 = 2 kg Zn ha^{-1} + 0 kg B ha^{-1} and
T_8 = 2 kg Zn ha^{-1} + 1 kg B ha^{-1}.

4.4. Nutrient Status of cultivated mungbean of post-harvest soil as affected by Zinc-Boron management system

4.4.1. Soil pH

Application of zinc boron has significant effect on pH of post-harvest soil(Appendix VII and Table 5). The highest pH (6.17) was recorded in treatment T_8 receiving 2.0 kg Zn ha^{-1}+1.0 kg B ha^{-1} and the lowest pH value (5.73) in T_1 treatment receiving 0.0 kg Zn ha^{-1} + 0.0 kg B ha^{-1}.

4.4.2. Organic Matter Content of Soil (%)

Application of zinc boron has significant effect on organic matter of post-harvest soil (Appendix VII andTable 5). The highest OM (1.45 %) was recorded in treatment T_8 where 2.0 kg Zn ha^{-1}+1.0 kg B ha^{-1} were applied and the lowest OM value (1.10 %) in T_2 treatment where 0.0 kg Zn ha^{-1} + 1.0 kg B ha^{-1} was applied.

4.4.3. Total Nitrogen Content of Soil (%)

Total nitrogen content of post-harvest soil was significantly influenced by application of zinc boron (Appendix VII andTable 5). The highest N content (0.19 %) of soil was observed in case of T_8 treatment with 2.0 kg Zn ha^{-1} +1.0 kg B ha^{-1}. In contrast, the lowest N content (0.14%) was obtained in the $T_2$and T_3treatment where 0.0 kg Zn ha^{-1}+1.0 kg B $ha^{-1}$and 0.0 kg Zn ha^{-1} + 2.0 kg B ha^{-1}fertilizer were applied.

4.4.4. Phosphorus Content of Soil (ppm)

Phosphorus content of post-harvest soil was significantly influenced by the application of zinc boron (Appendix VII andTable 5). Among the different treatments, T_8(2.0 kg Zn ha^{-1} + 1.0 kg B ha^{-1}) treatment showed the highest P content (24.13 ppm) in post-harvest soil. On the other hand, the lowest P content (14.15 ppm) was observed in T_1treatment with 0.0 kg Zn ha^{-1} + 0.0 kg B ha^{-1} fertilization.

4.4.5. Potassium Content of Soil (meq/ 100gm soil)

The effect of zinc boron management has no significant effect on potassium content of post-harvest soil (Appendix VII andTable 5). However the highest K content (0.25 meq/ 100 gm soil) was recorded in T_8 treatment that receiving 2.0 kg Zn ha^{-1} and 1.0 kg B ha^{-1} and the lowest potassium content of post harvested soil (0.17 meq/ 100 gm soil) was recorded in T_0 treatment (control i.e.; 0.0 kg Zn ha^{-1} and 0.0 kg B ha^{-1}).

Table 5. Effect of zinc-boron on the pH, organic matter, total N, available P and K in the soil after harvest of mungbean

Treatments	pH	Organic matter (%)	Total N (%)	Available P (ppm)	Available K (meq/ 100 g soil)
T_1	5.73 f	1.28 b	0.16 c	14.47 f	0.17
T_2	5.75 e	1.10 f	0.14 de	19.41 c	0.18
T_3	5.77 e	1.34 c	0.14 de	17.79 e	0.19
T_4	5.87 cd	1.38 b	0.16 c	19.32 c	0.20
T_5	5.97 b	1.38 b	0.15 cd	21.23 b	0.22
T_6	5.89 c	1.30 d	0.15 cd	17.00 e	0.19
T_7	5.90 c	1.27 d	0.17 b	21.01 b	0.21
T_8	6.17 a	1.45 a	0.19 a	24.13 a	0.25
$LSD_{(0.05)}$	0.03	0.03	0.01	1.00	NS
CV (%)	3.26	4.37	4.36	5.29	2.03

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

Note: T_1 = 0 kg Zn ha^{-1} + 0 kg B ha^{-1},
T_2 = 0 kg Zn ha^{-1} + 1 kg B ha^{-1},
T_3 = 0 kg Zn ha^{-1} + 2 kg B ha^{-1},
T_4 = 1 kg Zn ha^{-1} + 0 kg B ha^{-1},
T_5 = 1 kg Zn ha^{-1} + 1 kg B ha^{-1},
T_6 = 1 kg Zn ha^{-1} + 2 kg B ha^{-1},
T_7 = 2 kg Zn ha^{-1} + 0 kg B ha^{-1} and

T_8 = 2 kg Zn ha^{-1} + 1 kg B ha^{-1}.

In this study it was found that T_8(2.0 kg Zn ha^{-1} + 1.0 kg B ha^{-1}) treatment always gave better result over growth and yield parameter of mungbean. So this combination of micronutrients (Zinc & Boron) is suggested for better results on mungbean cultivation.

CHAPTER V

SUMMARY AND CONCLUSION

The selected plot was medium high land.The geographical location of the experimental site was under the subtropical climate, characterized by 3 distinct seasons, winter season from November to February and the pre-monsoon period or hot season from March to April and monsoon period from May to October.Seeds of BARI Mung-5 was collected from Bangladesh Agricultural Research Institute (BARI), Joydevpur, Gazipur.The experiment consists of eight treatments. Followed by:T_1 = Zn 0 kg ha^{-1} + B 0 kg ha^{-1}, T_2 = Zn 0 kg ha^{-1} + B 1 kg ha^{-1}, T_3 = Zn 0 kg ha^{-1} + B 2 kg ha^{-}1, T^4= Zn 1 kg ha^{-1} + B 0 kg ha^{-1},T_5 = Zn 1 kg ha^{-1} + B 1 kg ha^{-1},T_6 = Zn 1 kg ha^{-1} + B 2 kg ha^{-1},T_7 = Zn 2 kg ha^{-1} + B 0 kg ha^{-1} andT_8 = Zn 2 kg ha^{-1} + B 1 kg ha^{-1}.The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications.The size of each unit plot 2.5 × 2.5 m. The spacing between blocks and plots were 0.5 m and 0.25 m. Chemical fertilizers were applied as per its recommended dose. The crop was harvested at full maturity on 15 May, 2014 to 30 May, 2014 and harvesting was done manually from each plot.

Results showed that plant height, number of leaves plant^{-1}, number of branches plant^{-1}, total pod weight plot^{-1}, pod length, number of pod plant^{-1}, number of seeds pod^{-1}, 1000 grain weight, grain yield , stover yield, biological yield and harvest indexwassignificantly influenced by zinc boron management.

The tallest plant (59.48 cm) was obtained from T_8 (2 kg Zn ha^{-1} + 1 kg B ha^{-1}) treatment whereas, the shortest (50.44 cm) was obtained from T_1 (0 kg Zn ha^{-1} + 0 kg B ha^{-1}) treatment. The maximum number of leaves plant^{-1}(33.00) was recorded with the combination of 2 kg Zn ha^{-1} + 1 kg B ha^{-1} (T_8) treatment and the minimum (27.25) was recorded from the combination of 0 kg Zn ha^{-1} + 0 kg B ha^{-1} (T_1) treatment.The highest number of branches $plant^{-1}$ (7.77) was recorded from the combination of 2 kg Zn ha^{-1} + 1 kg B ha^{-1} (T_8) treatment whereas, the lowest (6.00) was recorded from the combination of 0 kg Zn ha^{-1} + 0 kg B ha^{-1} (T_1) treatment.

The highest pod weight $plot^{-1}$ (2.40 kg) was recorded from 2 kg Zn ha^{-1} + 1 kg B ha^{-1} (T_8) treatment which the lowest (1.32 kg) was found in 0 kg Zn ha^{-1} + 0 kg B ha^{-1} (T_1) treatment.The tallest length of pod (9.90 cm) was recorded with the combination of 2 kg Zn ha^{-1} + 1 kg B ha^{-1} (T_8) treatmentand the shortest (7.50 cm) was recorded from the combination of 0 kg Zn ha^{-1} + 0 kg B ha^{-1} (T_1) treatment.The highest number of pod $plant^{-1}$ (13.70) was recorded from 2 kg Zn ha^{-1} + 1 kg B ha^{-1} (T_8) treatment whereas, the lowest (9.67) was observed from the combination of 0 kg Zn ha^{-1} + 0 kg B ha^{-1} (T_1) treatment.The maximum number of seeds pod^{-1} (10.90) was recorded from T_8 (2 kg Zn ha^{-1} + 1 kg B ha^{-1}) treatment whereas, the minimum (8.00) was observed from the T_1 (0 kg Zn ha^{-1} + 0 kg B ha^{-1}) treatment. The highest 1000 grain weight (38.50 g) was recorded from the T_8(2 kg Zn ha^{-1} + 1 kg B ha^{-1}) treatment and the lowest 1000 grain weight (34.85 g) was observed from the combination of 0 kg Zn ha^{-1} + 0 kg B ha^{-1} (T_1) treatment.

The maximum grain yield (2.06 t ha^{-1}) was observed from the combination of 2 kg Zn ha^{-1} + 1 kg B ha^{-1} (T_8) treatment whereas, the minimum (1.25 t ha^{-1}) was observed from the combination of T_1 (0 kg Zn ha^{-1} + 0 kg B ha^{-1}) treatment.The highest stover yield (2.40 t ha^{-1}) was observed from 0 kg Zn ha^{-1} + 0 kg B ha^{-1} (T_1) treatment and the lowest (1.20 t ha^{-1}) was observed from the combination of 2 kg Zn ha^{-1} + 1 kg B ha^{-1} (T_8) treatment. The maximum biological yield (3.68 t ha^{-1}) was observed from the combination of 1 kg Zn ha^{-1} + 0 kg B ha^{-1} (T_4) treatment and the minimum (3.26 t ha^{-1}) was observed from the combination of 2 kg Zn ha^{-1}

+ 1 kg B ha^{-1} (T_8) treatment.The maximum harvest index (63.19 %) was recorded from the combination of 2 kg Zn ha^{-1} + 1 kg B ha^{-1} (T_8) treatment whereas, the minimum (34.03 %) was found in the combination of 0 kg Zn ha^{-1} + 0 kg B ha^{-1} (T_1) treatment.

Application of zinc boron has significant effect on pH, organic matter, total nitrogen, phosphorus content and potassium content of post-harvest soil. The highest pH (5.6), OM (0.78 %), N content (0.077 %), P content (24.13 ppm) and K content (0.25 meq/ 100 gm soil) was recorded in treatment T_8 receiving 2.0 kg Zn ha^{-1} + 1.0 kg B ha^{-1}.

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

i) The effect of zinc-boron management had positive effect on morphological characters, yield and yield attributesmungbean.

ii) Application of 2.0 kg Zn ha^{-1}+ 1.0 kg B ha^{-1} combination 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.

1. Further study may be needed for ensuring the different levels of zinc and boron fertilizers in relation to growth, yield, quality and storage performance in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability.
2. More closer and different treatments of zinc and boron fertilizers may be needed to include for future study as sole or different combination.

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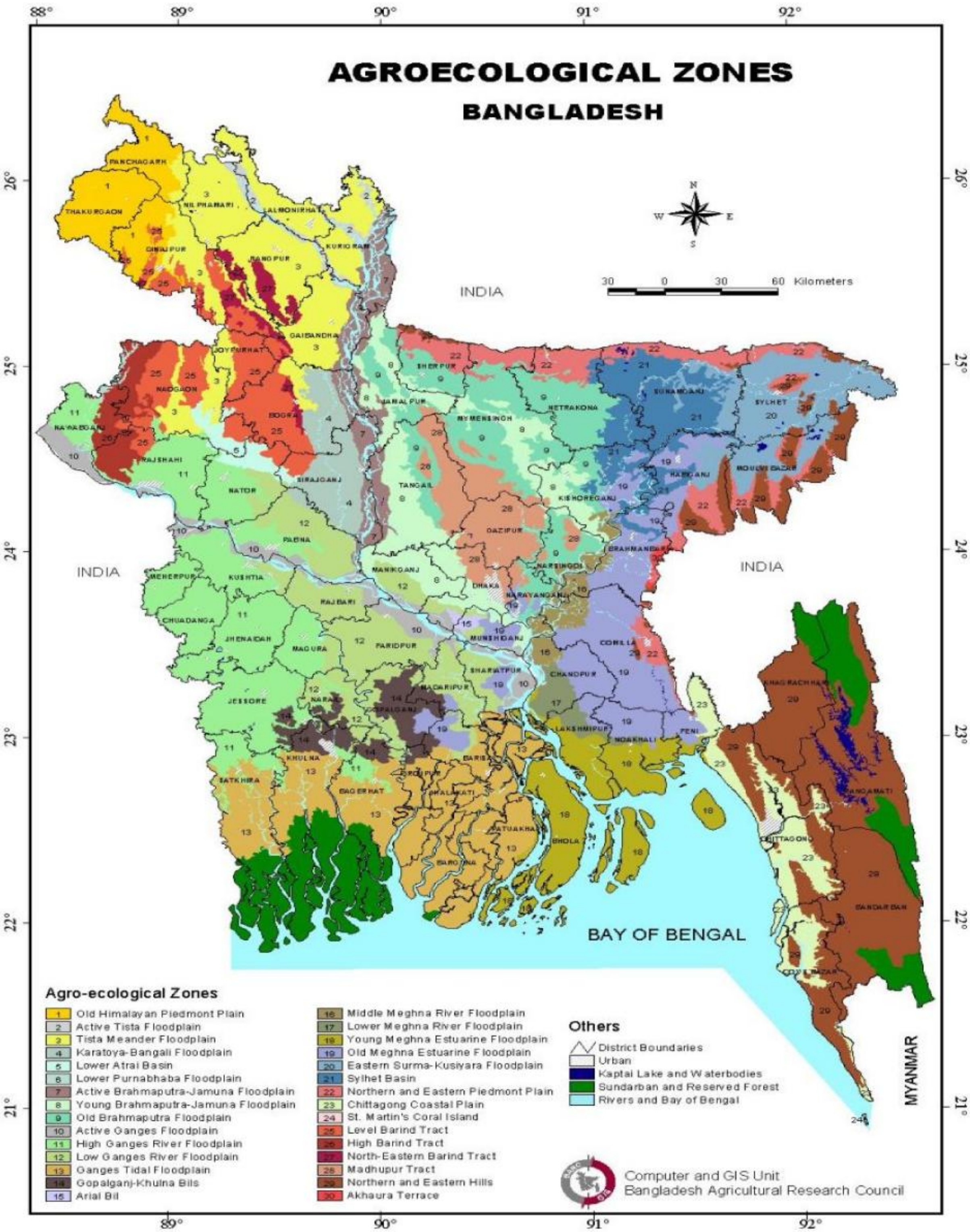
APPENDICES

Appendix I. Agro-Ecological Zone of Bangladesh



Appendix II. Morphological Characteristics of Sher-e-Bangla Agricultural University Farm soil is analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

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
Cropping Pattern	T. Aman-Fallow-Mungbean

Physical and chemical properties of the initial soil

Characteristics	Value
%Sand	27
%Silt	43
%clay	30
Textural class	Silty-clay
pH	6.17
Organic carbon (%)	0.45
Organic matter (%)	1.45
Total N (%)	0.19
Available P (ppm)	20.00
Exchangeable K (mel/100 g soil)	0.10
Available S (ppm)	45

Source : SRDI, 2014

Appendix III. Monthly record of air temperature, rainfall, relativehumidity, soil temperature and Sunshine of the experimentalsite during the period from July 2014 to December 2014

Month	Average air temperature (°C)			Average relative humidity (%)	Total rainfall (mm)	Total Sunshine per day (hrs)
	Maximum	Minimum	Mean			
September, 2014	36.0	24.6	30.3	83	227	3.1
October, 2014	36.0	23.6	29.8	81	319	4.0
November,2014	34.8	24.4	29.6	81	279	4.4
December, 2014	34.8	18.0	26.4	77	563	5.8

Source: Bangladesh Meteorological Department (Climate & weather division), Agargoan. Dhaka – 1212

Appendix IV: Error mean square values for Plant height, number of leaves plant^{-1} and number of branches plant^{-1} of mungbean

Source of variation	Degrees of freedom	Plant height	No. of leaves plant^{-1}	No. of branches plant^{-1}
Replication	2	0.034	0.459	0.219
Zn × B	7	24.893*	8.828*	0.711**
Error	14	0.049	0.229	0.290

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

Appendix V: Error mean square values for pod length, number of pods plant^{-1}, number of seeds pod^{-1} and 1000-grain weight of mungbean

Source of variation	Degrees of freedom	Pod weight plot^{-1}	Number of pod plant^{-1}	Pod length	Number of seeds pod^{-1}	1000-grain weight
Replication	2	0.025	0.303	0.219	0.080	0.509

Zn × B	7	0.277*	4.699**	1.315**	2.032*	6.758**
Error	14	0.021	0.167	0.076	0.049	0.174

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

Appendix VI: Error mean square values for grain yield, stover yield, biological yield and harvest index of mungbean

Source of variation	Degrees of freedom	Seed yield	Stover yield	Biological yield	Harvest index
Replication	2	0.022	0.026	0.096	0.204
Zn × B	7	0.201*	0.883**	0.322**	451.839*
Error	14	0.009	0.007	0.028	2.498

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

Appendix VII: Error mean square values for P^H, Organic matter, total N, available P and K of in the soil after harvest of mungbean

Source of variation	Degrees of freedom	P^H	Organic matter	Total N	Available P	Available K
Replication	2	0.005	0.003	0.029	0.057	0.944
Zn × B	7	0.001*	0.008**	0.006*	0.050*	0.503**
Error	14	0.002	0.058	0.007	0.008	1.447

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