RESPONSE OF DIFFERENT POPULAR VARIETIES OF MUNGBEAN TO ZINC FERTILIZATION

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JULY, 2018

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A Thesis

Submitted to the Department of Agricultural Chemistry
Sher-e-Bangla Agricultural University, Dhaka
In partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE (MS)

IN

AGRICULTURAL CHEMISTRY

SEMESTER: JULY- DECEMBER, 2017

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CERTIFICATE

This is to certify that the thesis entitled **"RESPONSE OF DIFFERENT POPULAR VARIETIES OF MUNGBEAN TO ZINC FERTILIZATION"** submitted to the Department of Agricultural Chemistry, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTERS OF SCIENCE (M.S.)** in **AGRICULTURAL CHEMISTRY**, embodies the result of a piece of bonafide research work carried out by **TANVIR AHAMMAD**, **Registration No. 12-04982** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that any help or source of information, received during the course of this investigation has been duly acknowledged.

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Dedicated to

My

Beloved Parents

ACKNOWLEDGEMENTS

The author seems it a much privilege to express his enormous sense of gratitude to the almighty Allah for there ever ending blessings for the successful completion of the research work.

The author wishes to express his gratitude and best regards to his respected Supervisor, ***Dr. Md. Ashraf Hossain****, Chief Scientific Officer, Department of Soil science, Bangladesh Agricultural Research Institute, Gazipur, Bangladesh for his continuous direction, constructive criticism, encouragement and valuable suggestions in carrying out the research work and preparation of this thesis.*

The author wishes to express his earnest respect, sincere appreciation and enormous indebtedness to his reverend Co-supervisor, ***Dr. Md. Sirajul Islam Khan****, Associate Professor, Department of Agricultural Chemistry, Sher-e-Bangla Agricultural University, Dhaka, for his scholastic supervision, helpful commentary and unvarying inspiration throughout the research work and preparation of the thesis.*

The author feels to express his heartfelt thanks to the honorable Chairman, ***Dr. Md. Sirajul Islam Khan,*** *Department of Agricultural Chemistry along with all other teachers and staff members of the Department of Agricultural Chemistry, Sher-e-Bangla Agricultural University, Dhaka, for their co-operation during the period of the study.*

The author feels proud to express his deepest and endless gratitude to all of his course mates and friends to cooperate and help him during taking data from the field and preparation of the thesis. The author wishes to extend his special thanks to his lab mates, class mates and friends for their keen help as well as heartiest co-operation and encouragement.

The author expresses his heartfelt thanks to his beloved parents, Elder Sister and Brother and all other family members for their prayers, encouragement, constant inspiration and moral support for his higher study. May Almighty bless and protect them all.

The Author

RESPONSE OF DIFFERENT POPULAR VARIETIES OF MUNGBEAN TO ZINC FERTILIZATION

ABSTRACT

An experiment was carried out at the experimental field central Farm of Bangladesh Agricultural Research Institute (BARI), Gazipur during the period from 21 March 2018 to 12 June 2018 to find out the response of different popular varieties of Mungbean to zinc fertilization. The experiment consisted of five different Mungbean varieties, *viz*. V_1 = BARI Mung-4, V_2 = BARI Mung-5, V_3 = BARI Mung-6, V_4 = BARI Mung-7 and V_5 = BARI Mung-8 and two levels of Zn *viz*. Zn_0 = 0 Kg Zn ha^{-1} and Zn_1 = 2.0 Kg Zn ha^{-1}. The experiment was laid out in Randomized Complete Block Design with three replications. Among the varieties, V_3 (BARI Mung-6) showed the highest number of pods $plant^{-1}$ (27.33), pod length (9.40 cm), 100 seed weight (4.88 g), seed yield ha^{-1} (988.80 kg), stover yield ha^{-1} (2361.70 kg) and biological yield ha^{-1} (3350.50 kg) where the lowest seed yield ha^{-1} (781.80 kg) was obtained from the variety V_5 (BARI Mung-8). The Zn level, Zn_1 (2.0 Kg Zn ha^{-1}) gave the highest plant height (43.96 cm), number of pods $plant^{-1}$ (27.80), pod length (8.04 cm), number of seeds pod^{-1} (11.10), 100 seed weight (4.21 g), seed yield ha^{-1} (941.40 kg), stover yield ha^{-1} (2288 kg) and biological yield ha^{-1} (3229.40 kg) compared to control. Regarding, combined effect of variety and Zn, the treatment combination of V_3Zn_1 produced the highest number of pods $plant^{-1}$ (29.00), pod length (9.50 cm), 100 seed weight (5.06 g), seed yield ha^{-1} (1044.00 kg), stover yield ha^{-1} (2483.30 kg) and biological yield ha^{-1} (3527.30 kg) compared to other treatment combinations. Considering nutrient concentration in seed and stover, V_3Zn_1 also showed better performance in respect of N, K, Zn and B content where P and S concentration in seed and stover was not significant by variety and Zn combinations.

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ABBREVIATIONS AND ACRONYMS

AEZ	=	Agro-Ecological Zone
BBS	=	Bangladesh Bureau of Statistics
BCSRI	=	Bangladesh Council of Scientific Research Institute
cm	=	Centimeter
CV %	=	Percent Coefficient of Variation
DAS	=	Days After Sowing
DMRT	=	Duncan's Multiple Range Test
et al.,	=	And others
e.g.	=	exempli gratia (L), for example
etc.	=	Etcetera
FAO	=	Food and Agricultural Organization
g	=	Gram (s)
i.e.	=	id est (L), that is
Kg	=	Kilogram (s)
LSD	=	Least Significant Difference
m^2	=	Meter squares
ml	=	MiliLitre
M.S.	=	Master of Science
No.	=	Number
SAU	=	Sher-e-Bangla Agricultural University
var.	=	Variety
^oC	=	Degree Celceous
%	=	Percentage
NaOH	=	Sodium hydroxide
GM	=	Geometric mean
mg	=	Miligram
P	=	Phosphorus
K	=	Potassium
Ca	=	Calcium
L	=	Litre
μg	=	Microgram
USA	=	United States of America
WHO	=	World Health Organization

CHAPTER I

INTRODUCTION

Pulses, also known as grain legumes, are next to cereals in terms of agricultural importance and have been considered best options for diversification and intensification of agriculture across the globe because of their intrinsic values such as nitrogen fixing ability (15-35 kg N/ha), high protein content and ability to thrive well in less endowed environment (Anonymous, 2016).

Among pulse crops, Mungbean [*Vigna radiate* (L.)] is an important grain legume in Bangladesh. It holds the 3thin 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). The total production of pulses in Bangladesh is only 0.65 million tons against the requirement 2.7 million tons (MoA, 2013). This means the shortage is almost 76% of the total requirement and this is mostly due to low yield (MoA, 2013). 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). Genetic potential of legume is not obtained at field due to poor soil nutrient status, mineral deficiency etc. (Maskey *et al*., 2004).

At present the population of Bangladesh is increasing and land is decreasing day by day, so it is essential to produce more food from our limited or confined land. Farmers are growing more cereal crops to meet up the basic demand of food. For this reason farmers do not want to use their fertile land in pulse cultivation. Mungbean can be cultivated almost throughout the year in the agro-climatic condition of Bangladesh. Due to its lower productivity of Mungbean, our poor socio-economi condition and lack of proper knowledge, the farmers of our country generally produced Mungbean by minimum ploughing and hardly use minimum fertilizers and irrigations. Moreover over lack of improved variety is an important reason for low yield of Mungbean where variety can play a vital role to maximize yield. So, there is an ambient scope to increase the Mungbean yield through high yielding or hybrid variety and proper fertilizers management practices.

Growth behavior of crop differs in different seasons due to variation in temperature and photoperiod, humidity, etc. accordingly, there are large variations among varieties with respect to growth habit, maturity duration, seed size and colour, and yield performance (Dodwadiya and Sharma, 2012). Among the various reasons responsible for its low yield, use of low potential varieties and primitive agro-technology are of primary importance. Mungbean varieties vary in yield and yield components (Sharar *et al*., 1999). Different genotypes showed significant variations in different growth and yield characters (plant height, branches per plant, pods per plant, seeds per pod, 100-seed weight, seed yield, biological yield and harvest index) and improved variety presents higher yield compared to local check (Singh *et al*., 2006). Gosami *et al*. (2009) also found significant variations among different genotypes in respect of physiological traits at different growth stages and also observed stomata conductance, photosynthetic rate, transpiration rate, total leaf chlorophyll and leaf nitrate reductase activity were significantly higher in high yielding genotypes. High yielding genotypes also shows higher seed yield and harvest index and identified as physiologically more efficient (Gosami *et al*., 2009). Varietal difference also shows great variation in plant height, number of branches plant^{-1}, number of effective pods and total pods plant^{-1} and number of seeds pod^{-1} which resulted seed yield variation (Bhowal and Bhowmick, 2014).

The farmers are normally used NPK containing fertilizers for cultivation of Mungbean but micro-nutrients like zinc play an important role in Mungbean productivity. Zinc is involved in auxin formation, activation of dehydrogenase enzymes and stabilization of ribosomal fractions (Hafeez *et al*., 2013). The involvement of Zn in physiological processes during early seedling development, possibly in protein synthesis, cell elongation membrane function and resistance to abiotic stresses were reported by Cakmak (2000). Ozturk et al. (2000) found that newly developed radicles and coleoptiles in germinating seeds contained Zn as much higher as up to 200 mg kg^{-1}. Zinc deficiency in plants affect photosynthesis due to altered chloroplast pigments (Kosesakal and Unal, 2009). Zn enriched seeds performs better with respect to seed germination, seedling growth and yield of crops (Cakmak *et al*., 1996).

Production of Mungbean can be increased through varietal development and proper management practices (Uddin *et al*. 2009) considering addition of Zn in balanced fertilization schedule increased N, P and K utilization efficiency which highlights the role of micronutrients in increasing macronutrient use efficiency (Shukla, 2011).

Hence, keeping the above facts in view, the present investigation entitled “Response of different popular varieties of Mungbean to zinc fertilization” has been made with the following objectives.

1. To identify suitable Mungbean varieties
2. To evaluate the response of Zinc on different Mungbean varieties under different zinc level
3. To improve the nutrient levels of Mungbean

CHPTER 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 less concentration by the researcher on various aspects because normally it grows with less care and management practices. 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 zinc on the growth and yield of Mungbean and other legumes.

2.2 Varietal performance of Mungbean on growth and yield

Lema *et al*. (2018) conducted the experiment the experiment to investigate the performance of 3 different Mungbean varieties (Sunian, MH-97-6 and Gofa local) on response of different growth parameters to assess the performance of Mungbean cultivars in relation to growth parameters and to estimate the analysis of growth characteristics using the primary values generated from these cultivars. There is significant difference among cultivars observed for total dry biomass. The SLA (specific leaf area) and LAR (leaf area ratio) of all cultivars increment from first sample to second sample as crop development progressed. The highest SLA and LAR were attributed suniana variety. Gofa local cultivar is highest total dry biomass, since in this study genetic factor and environment are key factors for achieving optimum growth and dry matter production of Mungbean cultivars.

Singh and Sharma (2014) conducted the experiment at Simbhaoli and identify stable genotype of Mungbean under varying environment. Forty indigenous genotypes of Mungbean collected from different institute/organizations were evaluated under eight artificially created environments for stability analysis for seed yield and its components. On the basis of stability parameters, genotypes

KM 2194, KM 2224, KMU 41, KMU 42, and KMU 55 were identified as desirable for seed yield.

Singh *et al*. (2014) conducted the experiment at Simbhaoli and identify stable genotype of Mungbean under varying environment. Forty indigenous genotypes of Mungbean collected from different institute/organizations were evaluated under eight artificially created environments for stability analysis for seed yield and its components. On the basis of stability parameters, genotypes KM 2194, KM 2224, KMU 41, KMU 42, and KMU 55 were identified as desirable for seed yield.

Bhowal and Bhowmick (2014) reported that variety and date of harvest had significant influences on various crop characters and seed yield. The variety Bina Mung 7 showed superiority in plant height, number of branches plant^{-1}, number of effective pods and total pods plant^{-1} and number of seeds pod^{-1} over other two varieties resulting in highest seed yield of 1856 kg ha^{-1}.

Dodwadiya and Sharma (2012) reported that variety SML 668 gave the highest seed yield in both seasons, followed by Pusa Vishal and Pusa 9531. Zero tillage was more profitable in summer, while conventional tillage was the best practice in the rainy season. It is recommended to grow newly-released variety SML 668 during summer as well as rainy season for higher productivity and profitability.

Rasul *et al*. (2012) conducted afield trial was conducted to establish suitable variety evaluation. Three Mungbean varieties V_1, V_2, V_3 (NM-92, NM-98, and M-1 respectively) were tested. Highest seed yield was obtained for variety V2 at 30 cm spacing. Among varieties V2 exhibited the highest yield 727.02 kg ha^{-1} while the lowest seed yield 484.79 kg ha^{-1} was obtained with V_3. Low potential varieties and improper agronomic practices may be a serious cause of low productivity in pulses.

Singh *et al*. (2011) found varietal performance in Mungbean on different yield parameters. Genotypes; Pusa Vishal, SML 668, Pusa 9531, UPM 98-1 and MH 96-1 were considered for varietal evaluation. Genotypes Pusa Vishal (selection from AVRDC material NM 92), SML 668 (selection from NM 94) and Pusa 9531 were on at par in the grain yield and were better than UPM 98-1 and MH 96-1. Pusa Vishal and SML 668 had significantly larger seed size compared to Pusa 9531 and MH 96-1. Genotypes NM 92 and VC 3890-A were superior to NM 94 and SML 134 in grain yield.

Verma *et al*. (2011) reported that Mungbean cv. HUM 12 gave significantly higher plant height, number of trifoliate leaves/plant, number of branches/plant, dry matter accumulation/plant, pod length, number of pods/plant, number of seed/pods, 1000 grain weight, grain yield, harvest index, protein content and protein yield (kg/ha) than K 851 and NDM 1.

Goswami *et al*. (2010) reported that significant variations were observed among the genotypes with respect to the morphological triats, dry matter partitioning pattern and yield. Among the morphological traints, number of primary branches, trifoliate leaves and root nodules were found significantly higher in high yielding genotypes. The high yielding genotypes were found to possess higher leaf dry weight, stem dry weight and total dry weight as compared to medium yielding, low yielding genotypes and checks. Among the genotypes, M-446 and M-100 had higher seed yield and other yield components and may be used as genetic source for improvement of yield potentials in greengram.

Gosami *et al*. (2009) found that significant variations were observed among the genotypes with respect to the physiological traits analysed at different stages of plant growth. Among the various parameters; stomata conductance, photosynthetic rate, transpiration rate, total leaf chlorophyll and leaf nitrate reductase activity were found significantly higher in high yielding genotypes.

However, the high yielding genotypes were found to possess lower seed protein as compared to medium yielding, low yielding genotypes and checks. Among the genotypes, M-446 and M-100 had higher seed yield and harvest index and identified as physiologically more efficient.

Kumar *et al*. (2009) reported that the Variety 'SML 668' gave the highest grain yield (1332 kg/ha) which was significantly higher than the 'Pusa Vishal' (1229 kg/ha) and 'Samrat' (1227 kg/ha).

Bhowmick *et al*. (2008) reported from Mushidabad (W.B.) that genotype WBM 29 significantly yielded the highest (983.28kg/ha) and was followed by WBM 4-34-1-1 (869.90 kg/ha), the later matured earlier than the other including B1 (state check) and PDM 54 (national check). Sowing on March resulted in higher growth and yield of all the genotypes excepting PDM 54, which performed better under growth and yield of all the genotypes excepting PDM 54, which performed better under sowing on first week of March.

Katiyar *et al*. (2008) carried out a study on morphological characterization of greengram [*Vigna radiata* (L.) Wilezek] and established distinctness of the candidate variety from all other varieties. A total of 73 released Indian cultivars of green gram were grouped for several agro-morphological descriptors. Wide diversity (38 to 70 cm) has been observed in plant height. Maximum varieties were of medium seed size (3-5 g/100-seed weight) except 'Pusa Vishal' and 'SML 668' (large seeded > 5 g/100 seed).

Malik *et al*. (2008) conducted studies on eighteen genotypes of black gram *(Vigna mungo)* to evaluate their comparative performance under rainfed conditions. Highly significant differences were observed for all the traits except leaf area which showed non-significant differences. Leaf area, pods/plant, plant height and biological yield/plant showed high genotypic and phenotypic variances exhibiting greater variability in these traits. The magnitude of heritability was high for 100-seed weight (94%), pods/plant (91%), pod length (91%), biological yield (87%), grain yield (85%), days to maturity (80%), harvest index (76%), branches/plant (75%) and plant height (71%) indicating additive type of gene action. Pods/ plant, branches/plant and biological yield/ plant showed highly significant and positive correlation with grain yield showing that these traits have good positive effect on grain yield.

Sadeghipour Omid (2008) reported that Mungbean variety Partow, gave significantly higher number of pods per plant, number of seed per pod and seed yield than variety BARI Mung-2 and VC 638, against variety VC 6368 had higher 100-seed weight. The highest seed yield (243.39 g m^{-2}) was recorded in irrigation throughout the growing period by variety Partow and the lowest seed yield (32.77 g m^{-2}) was obtained where irrigation was stopped at the flowering stage in VC 6368.

Sharma *et al*. (2007) examined the different varieties of Mungbean genotypes for their physio-chemical and cooking quality characteristics. ML-1270 (1.34 g/ml), ML-1191 and ML-1165 (1.32 g/ml each) and NM 92 (1.33 g/ml) had highest density. Water absorption and volume expansion was observed highest in ML-1191 (121.82% and 180.0%). Protein content was found highest in NM-92 (25.37%), followed by ML-1165, ML-1271 and ML-1299 (24.5% each). ML-1165 took minimum time (19 minutes) to cook. ML-1191 exhibited higher water absorption and volume expansion after cooking (167.09% and 195.45%), followed by ML-1109 (159.55% and 150.00%) and ML-1260.21% and 172.70%). Solid dispersion after cooking was also registered highest in ML-1109 (26.76%) and ML 1260 (21.37%).

Rao *et al*. (2006) evaluated 180 germplasm lines of Mungbean comprising both indigenous and exotic collections along with checks. The checks were found to be superior to the test material for all the characters studied except for 100 seed weight. The ANOVA for yield indicated highly significant differences among test varieties and check. The traits plant height and number of clusters per plant recorded highly significant and positive association with grain yield, while number of seeds per pod showed negative association with seed yield.

Singh *et al*. (2006) concluded that six genotypes of Mungbean namely IC-39535, IC-39429, IC-39358, IC-39447, IC-39283 and IC-39313 (check) in a randomized block design. The genotypes showed significant variations in plant height, branches per plant, pods per plant, seeds per pod, 100-seed weight, seed yield, biological yield and harvest index. IC-39358 followed by IC- 39535 produced significantly higher seed yield than national check and rest of genotypes. Significantly higher number of pods and branches per plant mainly attributes toward increased seed yield in IC-39358 and IC-39535. In general, short duration genotypes IC-39535, IC -9429 and IC-39283 in comparison to normal duration genotypes showed efficient biological yield and yield attributes which resulted in higher overall harvest index and seed yield.

Flores *et al*. (2005) characterized the agronomical behavior, yield components and its correlation to the yield in genotypes of the Vigna genera identified as JA-01-00-02, JA-01-00-02, JA-01-00-05, MEM-02-00-19,AM-02-00- 016, MS-01-00-09 and the commercial variety "Tuy". Essays were carried out at Saman Mocho, Carabobo state and Maracay, Aragua state. The genotype that reached higher height of the plant was MEM-02-00-19. The variance analysis and the means test of Duncan detected significant differences for yield in Maracay. Materials with highest yield were of *Vigna unguiculata* species: MS - 0100-09 (2114.1 kg/ha) and JA-01-00-05 (1605.6 kg/ha). Pods of highest longitude and total seeds by pods were observed in MS-01-00-09 with 4.2 cm of longitude and total number of seeds per pods 10.9 seed/pods. In genotype of *Vigna unguiculata,* MEM-02-00-19 recorded the highest number of pods per plant 17.5.

Reddy *et al*. (2003) determined the performance of 13 urdbean cultivars (LBG

685, LBG 648, LBG 611, LBG 645, LBG 22, LBG 623, LBG 695, LBG 703, LBG 708, LBG 709, LBG 719, LBG 17 and LBG 402). LBG645 recorded the highest number of branches per plant (6.3), biomass production (4.80 tonnes), number of pods per plant (11.4), seed yield (10.82 q/ha) and nitrogen reductase activity (51.80 nmol/h/g). LBG 703, LBG 685 and LBG 719 recorded the tallest plants (37.9 cm), highest number of seeds per pod (6.73) and harvest index (37.2), respectively.

Parameswarappa and Lamani (2003) conducted experiments to evaluate the performance of 6 green gram cultivars (SEI-4, GMBL-1, GMBL-2, TM-97-55, SEL-3 and M-1), compared with 4 controls (Chaina Mung, PS-16, TAP-7 and Pusabaisaki), under rainfed conditions on medium black soil of the Northern Transitional Zone of Karnataka. Data for seed yield, plant height, pods per plant, test weight, days to flowering and days to maturity indicated that SEI-4 was the most suitable genotype for cultivation in the area.

Ahmad *et al*. (2003) concluded that Mungbean cultivar NM-46-7-2 applied with 50 and 100 kg/ha NP, produce more number of grain per plant, 100- seed weight, grain yield and grain protein content than the other cultivars.

Varma and Garg (2003) evaluated thirty two Mungbean genotypes. A high range was observed for plant height, pod number per plant, biological yield, harvest index and days to 50% flowering. Narrow range was observed for the characters 100-seed weight, seed yield per plant, pod length, seed number per pod and primary branch number per plant. Generally, the magnitudes of phenotypic coefficient of variation were higher than those of genotypic coefficient of variation for all the characters.

Mahalakshmi *et al*. (2002) studied the performance of 5 black gram genotypes (LBG 20, LBG 623, LBG 685, LBG 708 and LBG 709) under rainfed conditions in the field (on deep Vertisols). LBG 708 was taller (43.5 cm) and had higher total biomass production (15 g/plant), number of leaves/ plant (12.4), number of branches per plant (7.0), leaf area index (5.62 dm^2), nitrate reductase activity (65.0 moles of NO_2/h g^{-1}), number of pods per plant (27), harvest index (28.5) and seed yield (10.3 q/ha) under rainfed conditions compared to the other genotypes.

Bishwas *et al*. (2002) conducted an experiment to determine the highest seed yield of different varieties of blackgram in region of Bangladesh and reported that Barimash 3, produced the highest seed yield (972 kg/ha) which was statistically similar to that of Baramashi (960 kg/ha).

Patra *et al*. (2000) found that variety 'Nayagarh Local' gave the maximum seed yield (978 kg/ha), followed by 'Sujata' (937 kg/ha) and 'PAM 54' (878 kg/ha). Sowing on 10th September was the best date with seed yield of 969 kg/ha. A delay of 10 and 20 days in sowing reduced the seed yield by 14.2 and 30.0% respectively. Most yield components varied significantly due to varieties but not due to dates of sowing.

Effect of zinc (Zn) on Mungbean

Ahmad *et al*. (2018) conducted an experiment to study the influence of different levels of phosphorous and zinc on yield and yield attributes of Mung bean (BARI Mung-6). Three zinc (Zn) levels (0, 1.5 and 4kg Zn ha^{-1}) was used in the study. The results of the study shown that stover and seed yield of Mung bean improved with increasing zinc levels up to positive level. In terms of Zn, the significant maximum stover yield (2.77 t ha^{-1}) and maximum seed yield (1.77 t ha^{-1}) were obtained with the treatment Zn_2 (4 kg Zn ha-1) and the significant minimum stover yield (2.19 t ha^{-1}) and minimum seed yield (1.38 t ha^{-1}) were achieved with the treatment Zn_0 (0 kg Zn ha^{-1}).

Islam *et al*. (2017) carried out a field experiment to investigate the effect of zinc on growth and yield characteristics of Mungbeen (BARI Mung-5). In this study Mungbean plant was affected by three zinc levels (0, 1.5 and 3.0 kgha^{-1}). The yield and yield contributing characteristics of Mungbean plant was significantly affected by the different levels of zinc. The maximum plant height, number of branches plant^{-1}, number of pod plant^{-1}, pod length, number of grains pod^{-1}, 100-grains weight, grain yield, stover yield, biological yield and harvest index were recorded from in the treatment combination of Zn_1 (1.5 kg Zn ha^{-1}) among all the treatments.

Rahman *et al*. (2015) conducted a field experiment to study the effects of Phosphorus and Zinc on the growth and yield of Mungbean (BARI Mung-6). Four levels of phosphorus (P) (0, 15, 20 and 25 kg P ha^{-1}) and three levels of zinc (Zn) (0, 1.5 and 3 kg Zn ha^{-1}) were used in the study. The results revealed that seed and stover yield of Mungbean increased with increasing levels of phosphorus and zinc up to certain level. Incase of Zn the maximum significant seed yield (1.45 t ha^{-1}) and stover yield (2.42 t ha^{-1}) were obtained with the treatment Zn_2 (3 kg Zn ha^{-1}) and the minimum significant seed yield (1.27 t ha^{-1}) and stover yield (2.21 t ha^{-1}) were obtained with the treatment Zn_0 (0 kg Zn ha^{-1}). The maximum significant plant height (52.05 cm), number of branch plant^{-1} (2.87), number of pods plant^{-1} (20.86), number of seeds pod^{-1} (12.65) and weight of 1000-seeds (45.11 g) were also obtained with the treatment of Zn_2 (3 kg Zn ha^{-1}). Karmakar *et al*. (2015) conducted a field experiment during the kharif season of 2014 to study the effects of Zinc on the concentrations of N, P, K, S and Zn in Mungbean stover and seed (BARI Mung-6). Three levels of zinc (Zn) (0, 1.5 and 3 kg Zn ha_{-1}) were used in the study. The results revealed that The N, P, K and S concentration of ungbean plant increased significantly from control to Zn_2 (3 kg Zn ha^{-1}) treatment. Application of zinc increase organic carbon, N, P, K and S status of postharvest soil significantly. Zn_2 (3 kg Zn ha^{-1}) treatment also produced highest pods plant^{-1}, seeds pod^{-1} and seed yield ha^{-1}.

Malik *et al*. (2015) conducted an experiment during the years 2011-2012 to study the effect of zinc on plant height (cm), number of productive branches, number of leaves, leaf area (sq.cm.), fresh weight (g), dry weight (g), number of pods per plant, seed yield per plant and 1000 seeds weight (g) (Test weight) of Mungbean (*Vigna radiata* L.) Var. Pant Mung-4 and Narendra-1. The doses of zinc were 5, 10, 15 and 20 ppm. The results were found significant of both varieties of Mungbean with Zn application of different rates. All the parameters were significantly influenced by Zn and highest seed yield per plant was from 10 ppm Zn.

Usman *et. al.* (2014) observed that soil application of zinc sulphate at 20 kg/ha recorded significantly higher 1000-seed weight, seed yield, biological yield and harvest index as compared to other treatments in greengram.

Tak *et al.* (2014) conducted a field experiment on greengram on loamy soil with low organic matter. They found that foliar spray of zinc sulphate (0.5%) significantly increased the test weight, grain yield, straw yield, biological yield and harvest index in comparison to control.

Ram and Katiyar (2013) conducted a field experiment to evaluate the influence of sulphur and zinc on Mungbean for two consecutive summer seasons i.e. 2008-09 and 2009-10. The results revealed that application of 10 Kg Zn ha^{-1} significantly increased the plant height, number of branches plant^{-1}, number of nodules plant^{-1}, number of pods plant^{-1}, number of seeds pod^{-1}, seed yield, protein content (%) and test weight was non-significant. The control (0 Kg Zn ha^{-1}) had the poorest performance in respect of yield and protein content of Mungbean seed during both the years, respectively. The highest seed yield (14.40 q ha^{-1}) was observed in 10 Kg Zn ha^{-1} which was significantly superior over rest of the treatments during both the year, respectively. The minimum seed yield (9.56 and 10.06 q ha^{-1}) was achieved with 5 Kg Zn ha^{-1} and least was in control during both the years.

Samreen*et al*. (2013) conducted an experiment using four varieties of Mungbeans (Ramazan, Swatmung I, NM92 and KMI) with nutrient solutions with and without Zn. Each variety was applied with Zn solutions at three levels i.e. 0, 1 and 2 μM concentrations. Plant growth, chlorophyll contents, crude proteins and Zn contents were noted to be higher when greater supply of zinc doses was applied. Plant phosphorous contents declined with supply of Zn from 1 μM to 2 μM compared to the control signifying a Zn/P complex foundation possibly in roots of plant, preventing the movement of P to plant. Zinc application at 2 μM concentrations in solution culture turned out to be the best treatment for improving the growth and quality parameters of Mungbean.

Quddus*et al*. (2011) carried out an experiment in AEZ 12, in 2008 and 2009 to evaluate the effect of zinc (Zn) and boron (B) on the yield and yield contributing characters of Mungbean (*Vigna radiata L*. Wilczek). Results showed that the combination of Zn1.5+B1.0 produced significantly higher yield (3058 kg/ha) and (2631 kg/ha, in the year 2008 and 2009, respectively. The lowest yield (2173 kg/ha) and (1573 kg/ha, were found in control (Zn_0B_0) combination. The combined application of zinc and boron were observed superior to their single application in both the years.

Patel *et al.* (2011) found that soil application of zinc sulphate @ 25 kg/ha and its foliar spray @ 0.5% at 25 and 45 DAS increased the seed yield of cowpea by 43% and 34%, respectively as compared to control.

Biswas *et al.* (2010) conducted a two-year field experiment during kharif season of 2005 and 2006 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}).

Singh *et al.* (2008) reported that application of zinc sulphate at 15 kg/ha significantly increased the test weight, grain, straw and biological yield of Mungbean as compared to control. Yadav*et al.* (2008) also found that two spray of zinc sulphate at 25 and 45 DAS resulted in significantly higher grain yield, grains/pod, pods/plant and 1000-seed weight in clusterbean in comparison to control. Shanti *et al.* (2008) also reported that application of zinc sulphate at 25 kg/ha gave maximum grain (1280 kg/ha) and haulm (1261 kg/ha) yields of blackgram.

Jain (2007) observed that application of Zn at 5.0 kg/ha, being at par with 7.5 kg/ha, significantly increased the number of pods per plant, number of seeds per pod, test weight, seed, straw and biological yields of mothbean over 2.5 kg/ha and control. Sammauria (2007) also found that pod length, seed, straw and biological yields and test weight in fenugreek were significantly improved due to application of zinc at 5.0 kg/ha over control. Singh and Mann (2007) also observed that application of zinc at 5 kg/ha significantly increased the pod yield of groundnut.

Choudhary (2006) found that zinc fertilization in clusterbean up to 5 kg/ha registered significant enhancement in pods per plant, seeds per pod, seed, straw and biological yields over preceding levels. Again, Singh and Sharma (2005) in their study observed that application of 6 kg Zn/ha significantly increased the grain yield by 77.9, 31.8 and 11.5 per cent over control, 2 and 4 kg Zn/ha, respectively but found at par with 8 kg Zn/ha in mothbean.

Singh and Yadav (2004) reported from U.P. that zinc fertilization at 5 kg/ha produced the highest grain and straw yield of greengram. It also resulted significant increase in yield component of greengram like number of pods per plant and seeds per pod. Sharma and Jain (2004) also found that application of Zn at 4 kg/ha in clusterbean gave significantly more number of pods per plant, grains per pod and test weight as compared to control.

Krishnaveni *et al.* (2004) studied the effect of foliar nutrition on performance of greengram during summer 2001. Results revealed that the number of pods per plant, pod length, number of grains per pod, leaf area index, number of branches per plant and biological yield were significantly improved due to application of DAP (2%) + KCl (1%) + $ZnSo_4$ (5%) sprayed at 15, 30 and 45 DAS. This was followed by two sprays of DAP (2%) + KCl (1%) + $ZnSo_4$ (0.5%) at 30 and 45 DAS.

Gupta *et al.* (2003) found that Zn application at 2.5 mg/kg soil proved the best treatment and produced 14.3 per cent higher yield as compared to the control and 0.5 per cent foliar spray of zinc sulphate in Mungbean. At the same place, Mali *et al.* (2003) recorded that application of zinc @ 5 kg/ha increased the grain yield of pigeonpea to the extent of 10.9 per cent over control.

Saini (2003) observed that application of zinc @ 5 kg/ha significantly increased the yield attributes viz. number of pods per plant, seeds per pod and test weight as well as seed, straw and biological yield of Mungbean over control. Similarly, results of the experiment conducted by Sunder *et al.* (2003) revealed that significantly higher seed yield of clusterbean over the control was obtained due to application of 5 kg Zn/ha.

Ali *et al.* (2002) reported that yield losses of varying magnitude in chickpea, e.g., 22-50% due to Zinc (Zn). Genotypic differences in response to application of Zn have also been found among Mungbean genotypes.

Bharti *et al.* (2002) carried out a field experiment during the winter of 1997-98 to observe the effect of Zn (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, pod number $plat^{-1}$ and pod length increased when Zn content increased, whereas stover yield decreased with the increasing Zn rate.

Abdo (2001) conducted two field experiments 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.

Zada *et al.* (2001) observed that application of zinc @ 5 kg/ha in soybean significantly increased the grain yield over control but found statistically at par with 10 kg Zn/ha. Ram *et al.* (2002) obtained significantly higher test weight and grain yield of Mungbean with the application of 15 kg Zn/ha as compared to control at Kanpur. Wasmatkar *et al.* (2002) at Akola (M.H.) also reported significant improvement in grain and straw yields of soybean due to application of zinc at 5 kg/ha over control.

Rizk and Adbo (2001) carried out two field experiments during the 1998 and 1999 seasons to investigate the response of Mungbean (*Vigna radiata*) to treatment with some micronutrients. Zn (0.2 or 0.4g/l), Mn (1.5 or 2.0 g/l), B (3.0 or 5.0 g/l) and distilled water as control. 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.

Sunder (2001) conducted a field experiment on clusterbean and reported that application of 5 kg Zn/ha significantly increased the number of pods per plant, number of seeds per pod, test weight, seed, straw and biological yields over preceding levels. The percent increase in seed yield due to application of this level of zinc fertilization was 22.3 and 6.6 over control and 2.5 kg/ha, respectively. Majumdar *et al.* (2001) also reported that the number of pods per plant and shelling percentage in groundnut increased significantly with the application of 20 kg Zn/ha over control.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at central farm of Bangladesh Agricultural Research Institute (BARI), Gazipur during the period from 21 March 2018 to 12 June 2018to study the response of different popular varieties of Mungbean to zinc fertilization. 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 soil science division (SSD) of Bangladesh Agricultural Research Institute, Gazipur**.** The location of the site is90°33′ E longitude and 23°77′ N latitude with an elevation of 8.2 m from 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 6.1 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, Bangladesh Agricultural Research Institute, presented in Appendix III.

3.2 Plant materials

Seeds of BARI Mung-4, BARI Mung-5, BARI Mung-6, BARI Mung-7 and BARI Mung-8 were considered as plant materials.

3.3 Experimental details

3.3.1 Treatments

The experiment comprised two factors.

Factor A: Variety (V) – 5varieties

1. V_1 = BARI Mung-4
2. V_2 = BARI Mung-5
3. V_3 = BARI Mung-6
4. V_4 = BARI Mung-7
5. V_5 = BARI Mung-8

Factor B: Zinc (Zn) – two doses

1. Zn_0= 0 Kg Zn ha^{-1}
2. Zn_1= 2.0 Kg Zn ha^{-1}

Treatment combination: Ten treatment combinations

V_1Zn_0, V_1Zn_1, V_2Zn_0, V_2Zn_1, V_3Zn_0, V_3Zn_1, V_4Zn_0, V_4Zn_1, V_5Zn_0, V_5Zn_1.

3.3.2 Experimental design and layout

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The layout of the experiment was prepared for distributing the combination of varieties and doses of Zinc (Zn). The 10 treatment combinations of the experiment were assigned at random into 30 plots. The size of each unit plot 3.0m× 3.0 m. The distance between blocks and plots were 2.0 m and 1.0 m respectively.

3.4 Growing of crops

3.4.1 Seed collection

The seeds of the test crop i.e., BARI Mung-4, BARI Mung-5, BARI Mung-6, BARI Mung-7 and BARI Mung-8 were considered as plant materials and seed were collected from Bangladesh Agricultural Research Institute (BARI), Joydevpur, Gazipur.

3.4.2 Preparation of the main field

The plot selected for the experiment was opened in the first week of March, 2018with 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 sowing.

3.4.3 Seed Sowing

At first seeds were cleaned and germination test was done. Seeds are sown on21 March 2018.

3.4.4 Fertilizers and manure application

The fertilizer N, P, K, S and B were applied @ 20.7 kg N/ha, 20 kg P/ha, 30 kg K/ha, 10 kg S/ha and 1kg B/ha in the form of urea, TSP, MOP, Gypsum and Boric acid respectively during final land preparation as basal dose. Zn was applied 0 and 2 kg/ha from $ZnSO_4.H_2O$ as per treatment during final land preparation.

3.4.5 Intercultural Operation

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

3.4.5.1 Irrigation and drainage

Over-head irrigation was provided with a watering can to the plots once immediately after germination. Stagnant water was effectively drained out at the time of heavy rains.

3.4.5.2 Weeding

Several weeding 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 45 DAS, respectively.

3.4.5.3 Plant protection

At early stage of growth few hairy caterpillar and virus vectors (jassid) attacked the young plants and at later stage of growth pod borer attacked the plant. Pod borer was successfully controlled by the application of Ripcord @ 1 L ha^{-1} on the time of 50% pod formation stage.

3.5 Harvesting, threshing and cleaning

Mungbean pod was harvested at maturity from 25 May, 2018. Harvesting was done manually from each plot. The harvested pod of each plot was packet separately, properly tagged and brought to threshing floor. Enough care was taken for harvesting, threshing and also cleaning of Mungbean seed. Fresh weight of seed and stover were recorded plot wise. The grains were cleaned and finally the weight was adjusted to a moisture content of 9%. The stover was sun dried and the yields of seed and stover $plot^{-1}$ were recorded and converted to t ha^{-1}.

3.6 Data Collection and Recording

Ten plants were selected randomly from each unit plot for recording data on crop parameters and the yield of seed and stovers were taken plot wise. The following parameters were recorded during the study:

1. Plant height (cm)
2. Number of pods plant^{-1}
3. Number of seeds plant^{-1}
4. Pod length (cm)
5. Seed yield without husk (kg ha^{-1})
6. Weight of 100 seeds (g)
7. Stover yield (kg ha^{-1})
8. Biological yield (kg ha^{-1})
9. Nutrient content of seed
10. Nutrient content of stover

3.7 Procedure of recording data

3.7.1 Plant height (cm)

The height of plant was recorded in centimeter (cm) at different days after sowing of crop duration. 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.

3.7.2 Number of pods plant^{-1}

Number of total pods of 10 plants from each plot was noted and the mean number was expressed per plant basis.

3.7.3 Number of seeds plant^{-1}

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

3.7.4 Pod length (cm)

Length of 10 pods of 10 selected plants from each plot was noted and the mean number was expressed per pod basis.

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

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}.

3.7.6 Weight of 100 seeds (g)

One hundred cleaned and dried seeds were counted randomly form 1m^2 area and weight by using a digital electric balance and the weight was expressed in gram.

3.7.7 Stover yield (kg ha^{-1})

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 kg ha^{-1}.

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

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

Biological yield = Seed yield + Stover yield.

3.7.9 Nutrient content of seed

Harvested seed of Mungbean were collected of N, P and K analyses. The seed samples were analysed for the determination of N, P and K.

3.7.10 Nutrient content of stover

The stover of the harvested crop were dried at oven 70^0C for 12 hours and then ground by a grinding machine (Wiley-mill) to pass through a 20-mesh sieve. The sample were stored vial for analyses of N, P and K.

3.8 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 Least Significant Deferent Test (LSD) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to find out the response of different popular varieties of Mungbean to zinc fertilization. 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 V-VIII. The results have been presented and discussed and possible interpretation has been given under the following headings:

4.1 Growth and yield contributing parameters

4.1.1 Plant height

4.1.1.1 Effect of variety

Different Mungbean variety exhibited non-significant influence on plant height (Table 1 and Appendix V). But results indicated that the variety V_2 (BARI Mung-5) showed the highest plant height (42.35 cm) where the lowest plant height (41.85 cn) was obtained from the variety V_1 (BARI Mung-4). Bhowal and Bhowmick (2014), Verma *et al*. (2011) and Katiyar *et al*. (2008) found significant variation in plant height among different Mungbean varieties which is not supported with the present study.

4.1.1.2 Effect of Zn

The data on plant height (cm) of Mungbean at harvest as influenced by Zn was significant (Table1 and Appendix V). Results revealed that the highest plant height (43.96 cm) was obtained from Zn_1 (2.0 Kg Zn ha^{-1}) where the lowest plant height (40.02 cm) was obtained from control treatment (Zn_0). Similar results was also observed by Rahman *et al*. (2015), Malik *et al*. (2015) and Ram and Katiyar (2013). Rahman *et al*. (2015) found that with an experiment that maximum significant plant height (52.05 cm) was obtained with the treatment of Zn_2 (3 kg Zn ha^{-1}).

4.1.1.3 Combined effect of variety and Zn

Significant variation was found on plant height of Mungbean influenced by combined effect of variety and Zn application levels (Table 1 and Appendix IV). It seems from the results that combination of V_2Zn_1 showed the highest plant height (45.53 cm) which was statistically similar with V_1Zn_1. The lowest plant height (38.17 cm) was obtained from the treatment combination of V_1Zn_0which was significantly different from all other treatment combinations followed by V_2Zn_0 and V_3Zn_0.

4.1.2 Number of pods plant^{-1}

4.1.2.1 Effect of variety

Number of pods plant^{-1} was significantly influenced by different variety of Mungbean (Table 1 and Appendix V). Results signified that the highest number of pods plant^{-1} (27.33) was obtained from the variety V_3 (BARI Mung-6) followed by the variety V_1 (BARI Mung-4) and V_5 (BARI Mung-8). The lowest number of pods plant^{-1} (25.67) was obtained from the variety V_4 (BARI Mung-7) followed by V_2 (BARI Mung-5). Bhowal and Bhowmick (2014) and Verma *et al*. (2011) also found significant variation on number of pods plant^{-1} due to different varietal performance.

4.1.2.2 Effect of Zn

Number of pods plant^{-1} of Mungbean was significantly influenced by different levels of Zn application (Table 1 and Appendix V). Results exposed that the highest number of pods plant^{-1} (27.80) was obtained from Zn_1 (2.0 Kg Zn ha^{-1}) where the lowest number of pods plant^{-1} (25.73) was obtained from control treatment (Zn_0). Islam *et al*. (2017), Rahman *et al*. (2015) and Karmakar *et al*.

(2015) found similar results from different experiments and observed that that maximum number of pods plant^{-1} of Mungbean was obtained from the treatment of Zn_2 (3 kg Zn ha^{-1}).

4.1.2.3 Combined effect of variety and Zn

Significant variation was observed on number of pods plant^{-1} influenced by combined effect of variety and Zn (Table 1 and Appendix V). Results showed that the highest number of pods plant^{-1} (29.00) was obtained from the treatment combination of V_3Zn_1which was significantly identical with V_2Zn_1.The lowest number of pods plant^{-1} (24.67) was obtained from the treatment combination of V_4Zn_0which was significantly different from all other treatment combinations followed by V_1Zn_0 and V_2Zn_0.

4.1.3 Pod length

4.1.2.1 Effect of variety

Pod length was significantly influenced by different variety of Mungbean (Table 1 and Appendix V). Results signified that the highest pod length (9.40 cm) was obtained from the variety V_3 (BARI Mung-6) followed by the variety V_2 (BARI Mung-5). The lowest pod length (6.97 cm) was obtained from the variety V_1 (BARI Mung-4) which was statistically identical with V_4 (BARI Mung-7). Significant variation on pod length of Mungbean among different varieties was also found by Verma *et al*. (2011) and Malik *et al*. (2008) which was similar result with the present study.

4.1.2.2 Effect of Zn

Pod length of Mungbean was significantly influenced by different Zn levels (Table 1 and Appendix V). Results exposed that the highest pod length (8.04

cm) was obtained from Zn_1 (2.0 Kg Zn ha^{-1}) where the lowest pod length (7.79 cm) was obtained from control treatment (Zn_0). Islam *et al*. (2017) and Bharti *et al.* (2002) also reported similar result and found that pod length increased when Zn application was increased.

4.1.2.3 Combined effect of variety and Zn

Significant variation was observed on pod length of Mungbean influenced by combined effect of variety and Zn (Table 1 and Appendix V). Results showed that the highest pod length (9.50 cm) was obtained from the treatment combination of V_3Zn_1 which was statistically similar with V_2Zn_1. The lowest pod length (6.87 cm) was obtained from the treatment combination of V_1Zn_0 which was statistically identical with V_4Zn_0 and statistically similar with V_1Zn_1.

4.1.4 Number of seeds pod^{-1}

4.1.3.1 Effect of variety

Different Mungbean variety had significant influence on number of seeds pod^{-1} (Table 1 and Appendix V). Results signified that the highest number of seeds pod^{-1}(12.12) was obtained from the variety V_1 (BARI Mung-4) which was significantly different from other varieties of Mungbean followed by the variety V_5 (BARI Mung-8). The lowest number of seeds pod^{-1}(10.23) was obtained from the variety V_2 (BARI Mung-5) which was statistically identical with V_3 (BARI Mung-6). Bhowal and Bhowmick (2014), Verma *et al*. (2011) and Sadeghipour, Omid (2008) also found similar result on number of seeds pod^{-1} with the present study.

4.1.3.2 Effect of Zn

Significant variation was found for number of seeds pod^{-1} of Mungbean due to application of different doses of Zn (Table 1 and Appendix X). Results verified that the highest number of seeds pod^{-1}(11.10) was obtained from Zn_1 (2.0 Kg Zn ha^{-1}) where the lowest number of seeds pod^{-1}(10.73) was obtained from control treatment (Zn_0). Similar result was also observed by Islam *et al*. (2017), Karmakar *et al*. (2015) and Ram and Katiyar (2013).

4.1.3.3 Combined effect of variety and Zn

Combined effect of variety and Zn showed significant variation on number of seeds pod^{-1} of Mungbean (Table 1 and Appendix V). Results showed that the highest number of seeds pod^{-1}(12.20) was obtained from the treatment combination of V_1Zn_1which was statistically identical with V_5Zn_1. The lowest number of seeds pod^{-1}(10.03) was obtained from the treatment combination of V_2Zn_0which was statistically identical with V_3Zn_0.

4.1.5 Weight of 100 seeds

4.1.4.1 Effect of variety

Significant influence was found on 100 seed weight affected by different varieties of Mungbean (Table 1 and Appendix V). Results signified that the highest 100 seed weight (4.88 g) was obtained from the variety V_3 (BARI Mung-6) which was statistically identical with the variety V_4 (BARI Mung-7). The lowest 100 seed weight (3.19 g) was obtained from the variety V_5 (BARI Mung-8) which was statistically identical with V_1 (BARI Mung-4). Similar result was also observed by Verma *et al*. (2011), Katiyar *et al*. (2008) and Malik *et al*. (2008).

4.1.4.2 Effect of Zn

Weight of 100 seeds of Mungbean was significant due to different doses of Zn (Table 1 and Appendix X). It was observed that the highest 100 seed weight (4.21 g) was achieved from Zn_1 (2.0 Kg Zn ha^{-1}) where the lowest weight of

100 seeds(3.93 g) was obtained from control treatment (Zn_0). Similar results also observed by Islam *et al*. (2017), Rahman *et al*. (2015), Malik *et al*. (2015) and Abdo (2001). Rahman *et al*. (2015) found that the maximum significant weight of 1000-seeds (45.11 g) was obtained from Zn_2 (3 kg Zn ha^{-1}).

4.1.4.3 Combined effect of variety and Zn

Significant variation was observed on 100 seed weight influenced by combined effect of variety and Zn (Table 1 and Appendix V). Results showed that the highest 100 seed weight (5.06 g) was obtained from the treatment combination of V_3Zn_1 which was significantly identical with V_4Zn_1. The lowest 100 seed weight (3.08 g) was obtained from the treatment combination of V_5Zn_0 which was statistically similar with V_1Zn_0.

Table 1. Varietal performance on growth and yield contributing parameters influenced by Zinc

Treatments	Growth and yield contributing parameters at harvest				
	Plant height (cm)	Number of pods plant^{-1}	Pod length (cm)	Number of seeds pod^{-1}	100 seed weight (g)
Effect of variety					
V_1	41.85	27.00 b	6.97 d	12.12 a	3.21 c
V_2	42.35	26.83 c	8.87 b	10.23 d	4.24 b
V_3	41.93	27.33 a	9.40 a	10.41 d	4.88 a
V_4	41.95	25.67 d	7.05 d	10.74 c	4.84 a
V_5	41.87	27.00 b	7.28 c	11.08 b	3.19 c
$LSD_{0.05}$	1.05^{NS}	0.1272	0.188	0.2544	0.038
CV(%)	7.11	9.58	5.21	6.47	4.36
Effect of Zn					
Zn_0	40.02 b	25.73 b	7.79 b	10.73 b	3.93 b
Zn_1	43.96 a	27.80 a	8.04 a	11.10 a	4.21 a
$LSD_{0.05}$	1.023	0.714	0.411	0.376	0.256
CV(%)	7.11	9.58	5.21	6.47	4.36
Combined effect of variety and Zn					
V_1Zn_0	38.17 f	26.00 e	6.87 f	11.50 b	3.12 ef
V_1Zn_1	44.93 ab	28.00 b	7.07 ef	12.20 a	3.29 e
V_2Zn_0	39.77 e	25.33 e	8.67 c	10.03 e	4.12 d
V_2Zn_1	45.53 a	28.67 a	9.29 ab	10.43 d	4.35 c
V_3Zn_0	39.67 e	26.00 de	9.07 b	10.09 e	4.69 b
V_3Zn_1	44.20 b	29.00 a	9.50 a	10.73 c	5.06 a
V_4Zn_0	41.40 cd	24.67 f	6.90 f	10.67 cd	4.62 b
V_4Zn_1	42.50 c	26.00 de	7.20 de	10.82 c	5.03 a
V_5Zn_0	41.10 d	26.67 d	7.20 de	10.67 cd	3.08 f
V_5Zn_1	42.63 c	27.33 c	7.37 d	12.03 a	3.29 e
$LSD_{0.05}$	1.241	0.6441	0.266	0.2301	0.163
CV(%)	7.11	9.58	5.21	6.47	4.36

Means followed by same letter are not significantly different at 5% level by DMRT

V_1 = BARI Mung-4, V_2 = BARI Mung-5, V_3 = BARI Mung-6, V_4 = BARI Mung-7, V_5 = BARI Mung-8

(Zn_0 = 0 Kg Zn ha$^{-1,}$ Zn_1 = 2.0 Kg Zn ha^{-1})

NS= Not significant

4.2 Yield parameters

4.2.1 Seed yield ha^{-1}

4.2.1.1 Effect of variety

Different Mungbean variety had significant influence on seed yield ha^{-1} (Table 2 and Appendix VI). Results signified that the highest seed yield ha^{-1} (988.80 kg) was obtained from the variety V_3 (BARI Mung-6) which was significantly different from other varieties of Mungbean followed by the variety V_2 (BARI Mung-5). The lowest seed yield ha^{-1} (781.80 kg) was obtained from the variety V_5 (BARI Mung-8) followed by the variety V_1 (BARI Mung-4).The results on seed yield found from the present study was conformity with the findings of Lema *et al*. (2014), Singh and Sharma (2014) and Bhowal and Bhowmick (2014).

4.2.1.2 Effect of Zn

Significant variation was found for seed yield ha^{-1}affected by different doses of Zn (Table 2 and Appendix VI). Results signified that the highest seed yield ha^{-1} (941.40 kg) was from Zn_1 (2.0 Kg Zn ha^{-1}) where the lowest seed yield ha^{-1} (813.90 kg) was achieved from control treatment (Zn_0). The results on seed yield found from the present study was conformity with the findings of Ahmad *et al*. (2018), Islam *et al*. (2017), Rahman *et al*. (2015), Karmakar *et al*. (2015) and Ram and Katiyar (2013).

4.2.1.3 Combined effect of variety and Zn

Significant variation was observed on seed yield ha^{-1} of Mungbean influenced by combined effect of variety and Zn (Table 2 and Appendix V). Results showed that the highest seed yield ha^{-1} (1044.00 kg) was obtained from the treatment combination of V_3Zn_1 which was significantly different from all other treatment combinations. The lowest seed yield ha^{-1} (740.70 kg) was obtained from the treatment combination of V_5Zn_0 which was also significantly different from all other treatment combinations.

4.2.2 Stover yield ha^{-1}

4.2.2.1 Effect of variety

Different Mungbean variety had significant effect on stover yield ha^{-1} (Table 2 and Appendix VI). Results revealed that the highest stover yield ha^{-1} (2361.70 kg) was obtained from the variety V_3 (BARI Mung-6) which was significantly different from other varieties of Mungbean followed by the variety V_1 (BARI Mung-4). The lowest stover yield ha^{-1} (1805.00 kg) was obtained from the variety V_2 (BARI Mung-5) which was significantly different from other treatment combinations. Similar result was also observed by Varma and Garg (2003) and Reddy *et al*. (2003).

4.2.2.2 Effect of Zn

Different doses of Zn had significant variation on stover yield ha^{-1} of Mungbean (Table 2 and Appendix VI). It was examined that the Zn level Zn_1 (2.0 Kg Zn ha^{-1}) gave highest stover yield ha^{-1}(2288 kg) where the lowest stover yield ha^{-1} (2149 kg) was obtained from control treatment (Zn_0). The results on stover yield obtained by Ahmad *et al*. (2018), Islam *et al*. (2017), Rahman *et al*. (2015) and Karmakar *et al*. (2015) was similar with the present study.

4.2.2.3 Combined effect of variety and Zn

Significant variation was observed on stover yield ha^{-1} of Mungbean influenced by combined effect of variety and Zn (Table 2 and Appendix VI). Results showed that the highest stover yield ha^{-1}(2483.30 kg) was obtained from the treatment combination of V_3Zn_1 which was significantly different from other treatment combinations. The lowest stover yield ha^{-1}(1710.00 kg) was obtained from the treatment combination of V_2Zn_0 which was also significantly different from other treatment combinations followed byV_2Zn_1.

4.2.3 Biological yield ha^{-1}

4.2.3.1 Effect of variety

Different Mungbean variety had significant influence on biological yield ha^{-1} (Table 2 and Appendix VI). Results signified that the highest biological yield ha^{-1} (3350.50 kg) was obtained from the variety V_3 (BARI Mung-6) which was significantly different from other varieties of Mungbean followed by the variety V_1 (BARI Mung-4). The lowest biological yield ha^{-1} (2704.00 kg) was obtained from the variety V_2 (BARI Mung-5) which was also significantly different from other treatment combinations. Varma and Garg (2003) and Reddy *et al*. (2003) also found similar results with present study.

4.2.3.2 Effect of Zn

Significant difference was recorded for different doses of Zn on biological yield ha^{-1} of Mungbean (Table 2 and Appendix VI). It was found that the highest biological yield ha^{-1} (3229.40 kg) was obtained from Zn_1 (2.0 Kg Zn ha^{-1}) where the lowest biological yield ha^{-1} (2963.20 kg) was obtained from control treatment (Zn_0).

4.2.3.3 Combined effect of variety and Zn

Significant variation was observed on biological yield ha^{-1} of Mungbean affected by combined effect of variety and Zn (Table 2 and Appendix VI). Results showed that the highest biological yield ha^{-1} (3527.30 kg) was obtained from the treatment combination of V_3Zn_1 which was significantly different from other treatment combinations followed by V_1Zn_1. The lowest biological yield ha^{-1} (2549.00 kg) was obtained from the treatment combination of V_2Zn_0 which was also significantly different from other treatment combinations followed by V_2Zn_1.

Table 2. Yield parameters of Mungbean influenced by variety and zinc and their combination

Treatments	Yield parameters		
	Seed yield ha^{-1} (kg)	Stover yield ha^{-1} (kg)	Biological yield ha^{-1} (kg)
Effect of variety			
V_1	851.30 d	2350.00 b	3201.30 b
V_2	899.00 b	1805.00 d	2704.00 e
V_3	988.80 a	2361.70 a	3350.50 a
V_4	867.20 c	2291.70 c	3158.90 c
V_5	781.80 e	2285.00 c	3066.80 d
$LSD_{0.05}$	4.391	7.148	10.95
CV(%)	9.59	11.62	12.79
Effect of Zn			
Zn_0	813.90 b	2149.30 b	2963.20 b
Zn_1	941.40 a	2288.00 a	3229.40 a
$LSD_{0.05}$	8.714	9.163	12.48
CV(%)	9.59	11.62	12.79
Combined effect of variety and Zn			
V_1Zn_0	763.00 h	2216.70 g	2979.70 f
V_1Zn_1	939.70 c	2406.70 b	3346.40 b
V_2Zn_0	839.00 e	1710.00 i	2549.00 h
V_2Zn_1	959.00 b	1900.00 h	2859.00 g
V_3Zn_0	933.30 d	2314.70 d	3248.00 c
V_3Zn_1	1044.00 a	2483.30 a	3527.30 a
V_4Zn_0	793.30 g	2266.70 e	3060.00 e
V_4Zn_1	941.00 c	2316.70 d	3257.70 c
V_5Zn_0	740.70 i	2236.70 f	2977.40 f
V_5Zn_1	823.00 f	2333.30 c	3156.30 d
$LSD_{0.05}$	5.968	8.477	9.433
CV(%)	9.59	11.62	12.79

Means followed by same letter are not significantly different at 5% level by DMRT

V_1 = BARI Mung-4, V_2 = BARI Mung-5, V_3 = BARI Mung-6, V_4 = BARI Mung-7, V_5 = BARI Mung-8

(Zn_0 = 0 Kg Zn $ha^{-1,}$ Zn_1 = 2.0 Kg Zn ha^{-1})

NS=Not significant

4.3 Quality parameters

4.3.1 Nutrient concentration in seed

4.3.1.1 Nitrogen (N) concentration in seed

4.3.1.1.1 Effect of variety

Different Mungbean variety had significant effect on N concentration in Mungbean seed (Table 3 and Appendix VII). The highest N concentration in seed (3.75%) was obtained from the variety V_1 (BARI Mung-4) followed byV_3 (BARI Mung-6) where the lowest N concentration in seed (3.22%) was obtained from the variety V_4 (BARI Mung-7).

4.3.1.1.2 Effect of Zn

Different doses of Zn had significant variation on N concentration in Mungbean seed (Table 3 and Appendix VII). It was examined that the highest N concentration in seed (3.51%) was obtained from the treatment Zn_1 (2.0 Kg Zn ha^{-1}) where the lowest N concentration in seed (3.31%) was found from control treatment (Zn_0).

4.3.1.1.3 Combined effect of variety and Zn

Combined effect of variety and Zn had significant influence on N concentration in Mungbean seed (Table 3 and Appendix VII). Results showed that the highest N concentration in seed (3.84%) was obtained from the treatment combination of V_1Zn_1which was significantly different from other treatment combinations. The lowest N concentration in seed (3.13%) was obtained from the treatment combination of V_4Zn_0 followed by V_2Zn_0 and V_5Zn_0.

4.3.1.2Phosphorus (P) concentration in seed

4.3.1.2.1 Effect of variety

P concentration in Mungbean seed was not significantly influenced by different Mungbean varieties (Table 3 and Appendix VII). But the highest P concentration in seed (0.342%) was obtained from the variety V_3 (BARI Mung-6) where the lowest P concentration in seed (0.31%) was obtained from the variety V_5 (BARI Mung-8).

4.3.1.2.2 Effect of Zn

Different doses of Zn had no significant variation on P concentration in Mungbean seed (Table 3 and Appendix VII). But the highest P concentration in seed (0.338%) was obtained from the control treatment Zn_0 (0 Kg Zn ha^{-1}) where the lowest P concentration in seed (0.331%) was found from the treatment Zn_1 (2.0 Kg Zn ha^{-1}).Ahmed et al. (1986) observed that P content were decreased with Zn application. Sigma et al. (2001) reported that higher phosphorous and Zinc refers exhibited an antagonistics effect and also reduced P and Zn uptake by Mungbean and vice -versa

4.3.1.2.3 Combined effect of variety and Zn

Combined effect of variety and Zn had significant influence on P concentration in Mungbean seed (Table 3 and Appendix VII). But it was found that the highest P concentration in seed (0.357%) was in the treatment combination of $V_4Zn_0$and the lowest P concentration in seed (0.293%) was obtained from the treatment combination of V_5Zn_1.

4.3.1.3 Potassium (K) concentration in seed

4.3.1.3.1 Effect of variety

Different Mungbean variety had significant effect on K concentration in Mungbean seed (Table 3 and Appendix VII). The highest K concentration in seed (1.50%) was obtained from the variety V_3 (BARI Mung-6) which was significantly different from other varieties where the lowest K concentration in seed (1.337%) was obtained from the variety V_1 (BARI Mung-4).

4.3.1.3.2 Effect of Zn

Different doses of Zn had non-significant effect on K concentration in Mungbean seed (Table 3 and Appendix VII). But the highest K concentration in seed (1.433%) was obtained from the treatment Zn_1 (2.0 Kg Zn ha^{-1}) where the lowest K concentration in seed (1.339%) was found from control treatment (Zn_0).Prasad and Ram (1991) form no significant effect of Zn on K uptake by Mungbean at harvest.

4.3.1.3.3 Combined effect of variety and Zn

Combined effect of variety and Zn had significant influence on K concentration in Mungbean seed (Table 3 and Appendix VII). Results showed that the highest K concentration in seed (1.557%) was obtained from the treatment combination of V_3Zn_1which was significantly different from other treatment combinations followed byV_2Zn_1. The lowest K concentration in seed (1.293%) was obtained from the treatment combination of V_1Zn_0 which was significantly same with the treatment combination of V_4Zn_0 and significantly similar with V_2Zn_0 and V_5Zn_0.

4.3.1.4 Sulphur (S) concentration in seed

4.3.1.4.1 Effect of variety

There was no significant influence on S concentration in Mungbean seed affected by different Mungbean varieties (Table 3 and Appendix VII). But the highest S concentration in seed (0.235%) was obtained from the variety V_3 (BARI Mung-6) where the lowest S concentration in seed (0.195%) was obtained from the variety V_1 (BARI Mung-4).

4.3.1.4.2 Effect of Zn

Different doses of Zn had no significant variation on S concentration in Mungbean seed (Table 3 and Appendix VII). But the highest S concentration in seed (0.213%) was found from the control Zn_1 (2.0 Kg Zn ha^{-1}) where the lowest S concentration in seed (0.203%) was found from the treatment Zn_0 (0 Kg Zn ha^{-1}).

4.3.1.4.3 Combined effect of variety and Zn

Combined effect of variety and Zn had significant influence on S concentration in Mungbean seed (Table 3 and Appendix VII). But it was found that the highest S concentration in seed (0.243%) was in the treatment combination of $V_3Zn_1$and the lowest S concentration in seed (0.190%) was obtained from the treatment combination of V_1Zn_0.

4.3.1.5 Zinc (Zn) concentration in seed

4.3.1.5.1 Effect of variety

Different Mungbean variety had significant effect on Zn concentration in Mungbean seed (Table 3 and Appendix VII). The highest Zn concentration in seed (26.67ppm) was obtained from the variety V_3 (BARI Mung-6) which was significantly different from other varieties where the lowest Zn concentration in seed (23.33ppm) was obtained from the variety V_5 (BARI Mung-8).

4.3.1.5.2 Effect of Zn

Different doses of Zn had significant variation on Zn concentration in Mungbean seed (Table 3 and Appendix VII). It was examined that the highest Zn concentration in seed (26.80ppm) was obtained from the treatment Zn_1 (2.0 Kg Zn ha^{-1}) where the lowest Zn concentration in seed (23.07ppm) was found from control treatment (Zn_0). Zaghloecl et al. (2000). Reported that the zinc had a significant effect on Zn uptake of Mungbean .

4.3.1.5.3 Combined effect of variety and Zn

Combined effect of variety and Zn had significant influence on Zn concentration in Mungbean seed (Table 3 and Appendix VII). Results showed that the highest Zn concentration in seed (28.33ppm) was obtained from the treatment combination of V_3Zn_1 which was significantly similar with the treatment combination of V_2Zn_1. The lowest Zn concentration in seed (21.00ppm) was obtained from the treatment combination of V_5Zn_0 which was statistically identical with the treatment combination of V_4Zn_0.

4.3.1.6 Boron (B) concentration in seed

4.3.1.6.1 Effect of variety

Different Mungbean variety had significant effect on B concentration in Mungbean seed (Table 3 and Appendix VII). The highest B concentration in seed (24.64 ppm) was obtained from the variety V_3 (BARI Mung-6) which was significantly different from other varieties where the lowest B concentration in seed (22.46 ppm) was obtained from the variety V_5 (BARI Mung-8).

4.3.1.6.2 Effect of Zn

Different doses of Zn had significant variation on B concentration in Mungbean seed (Table 3 and Appendix VII). It was examined that the highest B concentration in seed (25.02ppm) was obtained from the treatment Zn_1 (2.0 Kg Zn ha^{-1}) where the lowest B concentration in seed (21.71 ppm) was found from control treatment (Zn_0).

4.3.1.6.3 Combined effect of variety and Zn

Combined effect of variety and Zn had significant influence on B concentration in Mungbean seed (Table 3 and Appendix VII). Results showed that the highest B concentration in seed (26.00 ppm) was obtained from the treatment combination of V_3Zn_1 which was significantly same with the treatment combination of V_2Zn_1. The lowest B concentration in seed (20.80 ppm) was obtained from the treatment combination of V_5Zn_0 which was statistically similar with the treatment combination of V_1Zn_0 and V_2Zn_0.

Table 3. Effect of variety and zinc and also their combination on nutrient concentration (N, P, K, S, Zn and B) in Mungbean seed

Treatments	Quality parameters - nutrient concentration in seed					
	N (%)	P (%)	K (%)	S (%)	Zn (ppm)	B ppm)
Effect of variety						
V_1	3.75 a	0.340	1.337 c	0.195	25.00 c	22.81 c
V_2	3.33 c	0.338	1.392 b	0.196	26.00 b	23.56 b
V_3	3.44 b	0.342	1.500 a	0.235	26.67 a	24.64 a
V_4	3.22 d	0.341	1.345 c	0.207	23.67 d	23.36 b
V_5	3.31 c	0.310	1.357 bc	0.207	23.33 d	22.46 c
$LSD_{0.05}$	0.039	0.041^{NS}	0.036	0.038^{NS}	0.386	0.462
CV(%)	1.79	1.35	5.46	4.59	5.02	5.32
Effect of Zn						
Zn_0	3.31 b	0.338	1.339	0.203	23.07 b	21.71 b
Zn_1	3.51 a	0.331	1.433	0.213	26.80 a	25.02 a
$LSD_{0.05}$	0.05	0.107^{NS}	0.112^{NS}	0.108^{NS}	1.052	1.133
CV(%)	1.79	1.35	5.46	4.59	5.02	5.32
Combined effect of variety and Zn						
V_1Zn_0	3.66 b	0.340	1.293 f	0.190	23.00 e	21.12 ef
V_1Zn_1	3.84 a	0.340	1.380 de	0.200	27.00 b	24.81 b
V_2Zn_0	3.24 ef	0.343	1.327 ef	0.191	24.00 de	21.18 ef
V_2Zn_1	3.42 d	0.333	1.457 b	0.200	28.00 ab	25.97 a
V_3Zn_0	3.29 e	0.347	1.443 bc	0.227	25.00 cd	23.30 d
V_3Zn_1	3.58 c	0.337	1.557 a	0.243	28.33 a	26.00 a
V_4Zn_0	3.13 g	0.357	1.303 f	0.203	21.67 f	22.16 e
V_4Zn_1	3.30 e	0.327	1.387 cd	0.210	25.67 cd	24.56 bc
V_5Zn_0	3.21 f	0.327	1.327 ef	0.203	21.00 f	20.80 f
V_5Zn_1	3.42 d	0.293	1.387 d	0.210	25.67 c	23.75 cd
$LSD_{0.05}$	0.054	0.094^{NS}	0.051	0.055^{NS}	1.039	1.008
CV(%)	1.79	1.35	5.46	4.59	5.02	5.32

Means followed by same letter are not significantly different at 5% level by DMRT

V_1 = BARI Mung-4, V_2 = BARI Mung-5, V_3 = BARI Mung-6, V_4 = BARI Mung-7, V_5 = BARI Mung-8

(Zn_0 = 0 Kg Zn $ha^{-1,}$ Zn_1 = 2.0 Kg Zn ha^{-1})

NS= Not significant

4.3.2 Nutrient concentration in stover

4.3.2.1 Nitrogen (N) concentration in stover

4.3.2.1.1 Effect of variety

Different Mungbean variety had no significant effect on N concentration in Mungbean stover (Table 4 and Appendix VIII). But the highest N concentration in stover (1.92%) was obtained from the variety V_3 (BARI Mung-6) where the lowest N concentration in stover (1.77%) was obtained from the variety V_1 (BARI Mung-4).

4.3.2.1.2 Effect of Zn

Different doses of Zn had significant variation on N concentration in Mungbean stover (Table 4 and Appendix VIII). It was examined that the highest N concentration in stover (2.08%) was obtained from the treatment Zn_1 (2.0 Kg Zn ha^{-1}) where the lowest N concentration in stover (1.58%) was found from control treatment (Zn_0).

4.3.2.1.3 Combined effect of variety and Zn

Combined effect of variety and Zn had significant influence on N concentration in Mungbean stover (Table 4 and Appendix VIII). Results showed that the highest N concentration in stover (2.20%) was obtained from the treatment combination of V_3Zn_1 which was significantly different from other treatment combinations. The lowest N concentration in stover (1.53%) was obtained from the treatment combination of V_1Zn_0 which was significantly same with the combination of V_5Zn_0 and significantly similar with the treatment combination of V_2Zn_0 and V_4Zn_0.

4.3.2.2 Phosphorus (P) concentration in stover

4.3.2.2.1 Effect of variety

P concentration in Mungbean stover was not significantly influenced by different Mungbean varieties (Table 4 and Appendix VIII). But the highest P concentration in stover (0.187%) was obtained from the variety V_3 (BARI Mung-6) where the lowest P concentration in stover (0.181%) was obtained from the variety V_2 (BARI Mung-5).

4.3.2.2.2 Effect of Zn

Different doses of Zn had no significant variation on P concentration in Mungbean stover (Table 4 and Appendix VIII). But the highest P concentration in stover (0.188%) was obtained from the control treatment Zn_0 (0 Kg Zn ha^{-1}) where the lowest P concentration in stover (0.178%) was found from the treatment Zn_1 (2.0 Kg Zn ha^{-1}).

4.3.2.2.3 Combined effect of variety and Zn

Combined effect of variety and Zn had significant influence on P concentration in Mungbean stover (Table 4 and Appendix VIII). But it was found that the highest P concentration in stover (0.199%) was obtained from the treatment combination of $V_3Zn_0$and the lowest P concentration in stover (0.173%) was obtained from the treatment combination of V_2Zn_1.

4.3.2.3 Potassium (K) concentration in stover

4.3.2.3.1 Effect of variety

Different Mungbean variety had significant effect on K concentration in Mungbean stover (Table 4 and Appendix VIII). The highest K concentration in stover (1.843%) was obtained from the variety V_3 (BARI Mung-6) which was significantly different from other varieties where the lowest K concentration in stover (1.642%) was obtained from the variety V_1 (BARI Mung-4).

4.3.2.3.2 Effect of Zn

Different doses of Zn had significant variation on K concentration in Mungbean stover (Table 4 and Appendix VIII). It was examined that the highest K concentration in stover (1.873%) was obtained from the treatment Zn_1 (2.0 Kg Zn ha^{-1}) where the lowest K concentration in stover (1.603%) was found from control treatment (Zn_0).

4.3.2.3.3 Combined effect of variety and Zn

Combined effect of variety and Zn had significant influence on K concentration in Mungbean stover (Table 4 and Appendix VIII). Results showed that the highest K concentration in stover (1.99%) was obtained from the treatment combination of V_3Zn_1which was significantly same with the treatment combination of V_5Zn_1. The lowest K concentration in stover (1.47%) was obtained from the treatment combination of V_1Zn_0 followed by V_2Zn_0 and V_5Zn_0.

4.3.2.4 Sulphur (S) concentration in stover

4.3.2.4.1 Effect of variety

There was no significant influence on S concentration in Mungbean stover affected by different Mungbean varieties (Table 4 and Appendix VIII). But the highest S concentration in stover (0.199%) was obtained from the variety V_3 (BARI Mung-6) where the lowest S concentration in stover (0.171%) was obtained from the variety V_5 (BARI Mung-8).

4.3.2.4.2 Effect of Zn

Different doses of Zn had no significant variation on S concentration in Mungbean stover (Table 4 and Appendix VIII). But the highest S concentration in stover (0.188%) was found from the control treatment Zn_0 (0 Kg Zn ha^{-1}) where the lowest S concentration in stover (0.171%) was found from the treatment Zn_1 (2.0 Kg Zn ha^{-1}).

4.3.2.4.3 Combined effect of variety and Zn

Combined effect of variety and Zn had significant influence on S concentration in Mungbean stover (Table 4 and Appendix VIII). But it was found that the highest S concentration in stover (0.205%) was in the treatment combination of $V_3Zn_0$and the lowest S concentration in stover (0.173%) was obtained from the treatment combination of V_5Zn_1.

4.3.2.5 Zinc (Zn) concentration in stover

4.3.2.5.1 Effect of variety

Different Mungbean variety had significant effect on Zn concentration in Mungbean stover (Table 4 and Appendix VIII). The highest Zn concentration in stover (22.08 ppm) was obtained from the variety V_3 (BARI Mung-6) which was significantly same with the variety V_4 (BARI Mung-7) where the lowest Zn concentration in stover (18.73 ppm) was obtained from the variety V_5 (BARI Mung-8).

4.3.2.5.2 Effect of Zn

Different doses of Zn had significant variation on Zn concentration in Mungbean stover (Table 4 and Appendix VIII). It was examined that the highest Zn concentration in stover (25.55 ppm) was obtained from the treatment Zn_1 (2.0 Kg Zn ha^{-1}) where the lowest Zn concentration in stover (16.06 ppm) was found from control treatment (Zn_0).

4.3.2.5.3 Combined effect of variety and Zn

Combined effect of variety and Zn had significant influence on Zn concentration in Mungbean stover (Table 4 and Appendix VIII). Results showed that the highest Zn concentration in stover (27.45 ppm) was obtained from the treatment combination of V_3Zn_1which was significantly same with the treatment combination of V_4Zn_1. The lowest Zn concentration in stover (15.53 ppm) was obtained from the treatment combination of V_5Zn_0 which was statistically identical with the treatment combination of V_1Zn_0 and significantly similar with the treatment combination of V_2Zn_0 and V_4Zn_0.

4.3.2.6 Boron (B) concentration in stover

4.3.2.6.1 Effect of variety

Different Mungbean variety had significant effect on B concentration in Mungbean stover (Table 4 and Appendix VIII). The highest B concentration in stover (31.66 ppm) was obtained from the variety V_3 (BARI Mung-6) which was significantly same with the variety V_4 (BARI Mung-7) where the lowest B concentration in stover (27.84 ppm) was obtained from the variety V_5 (BARI Mung-8).

4.3.2.6.2 Effect of Zn

Different doses of Zn had significant variation on B concentration in Mungbean stover (Table 4 and Appendix VIII). It was examined that the highest B concentration in stover (35.58 ppm) was obtained from the treatment Zn_1 (2.0 Kg Zn ha^{-1}) where the lowest B concentration in stover (24.26 ppm) was found from control treatment (Zn_0).

4.3.2.6.3 Combined effect of variety and Zn

Combined effect of variety and Zn had significant influence on B concentration in Mungbean stover (Table 4 and Appendix VIII). Results showed that the highest B concentration in stover (37.68 ppm) was obtained from the treatment combination of V_3Zn_1 which was significantly same with the treatment combination of V_4Zn_1. The lowest B concentration in stover (21.79 ppm) was obtained from the treatment combination of V_5Zn_0 which was statistically identical with the treatment combination of V_1Zn_0 followed by the treatment combination of V_2Zn_0.

Table 4. Effect of variety and zinc and also their combination on nutrient concentration (N, P, K, S, Zn and B) in Mungbean stover

Treatments	Quality parameters - nutrient concentration in stover					
	N (%)	P (%)	K (%)	S (%)	Zn (ppm)	B ppm)
Effect of variety						
V_1	1.77	0.183	1.642 c	0.180	20.38 c	29.24 b
V_2	1.84	0.181	1.732 b	0.191	21.13 b	29.86 b
V_3	1.92	0.187	1.843 a	0.199	22.08 a	31.66 a
V_4	1.84	0.185	1.760 b	0.189	21.67 a	30.99 a
V_5	1.78	0.182	1.715 b	0.171	18.73 d	27.84 c
$LSD_{0.05}$	0.039^{NS}	0.038^{NS}	0.066	0.038^{NS}	0.4603	0.7458
CV(%)	4.17	4.44	3.24	2.63	8.39	6.67
Effect of Zn						
Zn_0	1.58 b	0.188	1.603 b	0.188	16.06 b	24.26 b
Zn_1	2.08 a	0.178	1.873 a	0.171	25.55 a	35.58 a
$LSD_{0.05}$	0.341	0.103^{NS}	0.105	0.108^{NS}	2.539	3.804
CV(%)	4.17	4.44	3.24	2.63	8.39	6.67
Combined effect of variety and Zn						
V_1Zn_0	1.53 e	0.188	1.47 e	0.180	15.67 f	24.01 d
V_1Zn_1	2.00 c	0.178	1.71 c	0.179	25.23 c	34.48 b
V_2Zn_0	1.58 de	0.188	1.60 d	0.189	16.13 ef	24.69 cd
V_2Zn_1	2.10 b	0.173	1.87 b	0.193	26.13 b	35.04 b
V_3Zn_0	1.64 d	0.199	1.70 c	0.205	16.72 e	25.65 c
V_3Zn_1	2.20 a	0.193	1.99 a	0.195	27.45 a	37.68 a
V_4Zn_0	1.61 de	0.174	1.68 c	0.182	16.23 ef	25.14 cd
V_4Zn_1	2.06 bc	0.176	1.84 b	0.195	27.12 a	36.84 a
V_5Zn_0	1.54 e	0.174	1.57 d	0.168	15.53 f	21.79 e
V_5Zn_1	2.02 c	0.190	1.96 a	0.173	21.80 d	33.88 b
$LSD_{0.05}$	0.050	0.051^{NS}	0.054	0.055^{NS}	0.8473	1.186
CV(%)	4.17	4.44	3.24	2.63	8.39	6.67

Means followed by same letter are not significantly different at 5% level by DMRT

V_1 = BARI Mung-4, V_2 = BARI Mung-5, V_3 = BARI Mung-6, V_4 = BARI Mung-7, V_5 = BARI Mung-8

(Zn_0 = 0 Kg Zn $ha^{-1,}$ Zn_1 = 2.0 Kg Zn ha^{-1})

NS= Not significant

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted in the experimental central BARI Farm during the period from March to June 2018 to find out the response of different popular varieties of Mungbean to zinc fertilization. The experiment consisted of two factors: Factor A: Five varieties of Mungbean *viz*. V_1 = BARI Mung-4, V_2 = BARI Mung-5, V_3 = BARI Mung-6, V_4 = BARI Mung-7 and V_5 = BARI Mung-8 and Factor B: Zinc (Zn) fertilization (two levels) *viz*.Zn_0 = 0 Kg Zn ha^{-1} andZn_1 = 2.0 Kg Zn ha^{-1}. The two factors experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data on different growth, yield contributing parameters and yield were recorded.

Considering varietal performance, plant height was not significant at the time of harvest. But the variety V_2 (BARI Mung-5) showed the highest plant height (42.35 cm) where the lowest (41.85 cm) was obtained from V_1 (BARI Mung-4).Number of pods $plant^{-1}$, Pod length, Number of seeds pod^{-1}, 100 seed weight, Seed yield ha^{-1}, Stover yield $ha^{-1}$and Biological yield ha^{-1} were significantly influenced by different varieties of Mungbean. The highest number of pods $plant^{-1}$ (27.33), pod length (9.40 cm) and 100 seed weight (4.88 g) were obtained from the variety V_3 (BARI Mung-6) but the highest number of seeds pod^{-1} (12.12) was obtained from the variety V_1 (BARI Mung-4).The lowest number of pods $plant^{-1}$ (25.67), pod length (6.97 cm), number of seeds pod^{-1} (10.23) and 100 seed weight (3.19 g) were obtained from variety V_4 (BARI Mung-7), V_1 (BARI Mung-4), V_2 (BARI Mung-5) and V_5 (BARI Mung-8), respectively. Again, the highest seed yield ha^{-1} (988.80 kg), stover yield ha^{-1} (2361.70 kg) and biological yield ha^{-1} (3350.50 kg) were also obtained from the variety V_3 (BARI Mung-6). The lowest seed yield ha^{-1} (781.80 kg) was obtained from the variety V_5 (BARI Mung-8) but the lowest stover yield ha^{-1} (1805.00 kg) and biological yield ha^{-1} (2704.00 kg) were obtained from the variety V_2 (BARI Mung-5).

Regarding zinc (Zn) application, the highest plant height (43.96 cm), number of pods plant^{-1} (27.80), pod length (8.04 cm), number of seeds pod^{-1} (11.10), 100 seed weight(4.21 g), seed yield ha^{-1} (941.40 kg), stover yield ha^{-1} (2288 kg) and biological yield ha^{-1} (3229.40 kg) were obtained from Zn_1 (2.0 Kg Zn ha^{-1}) where the lowest plant height (40.02 cm), number of pods plant^{-1} (25.73), pod length (7.79 cm), number of seeds pod^{-1} (10.73), 100 seeds(3.93 g), seed yield ha^{-1} (813.90 kg), stover yield ha^{-1} (2149 kg) and biological yield ha^{-1} (2963.20 kg) were obtained from control treatment (Zn_0).

In respect of combined effect of variety and Zn application, the treatment combination of V_2Zn_1showed the highest plant height (45.53 cm) but the highest number of pods plant^{-1} (29.00), pod length (9.50 cm), 100 seed weight (5.06 g), seed yield ha^{-1} (1044.00 kg), stover yield ha^{-1} (2483.30 kg) and biological yield ha^{-1} (3527.30 kg) were obtained from the treatment combination of V_3Zn_1 where the highest number of seeds pod^{-1} (12.20) was obtained from the treatment combination of V_1Zn_1.Similarly, the lowest plant height (38.17 cm) and pod length (6.87 cm) were obtained from the treatment combination of V_1Zn_0 where the lowest number of pods plant^{-1} (24.67) was obtained from the treatment combination of V_4Zn_0. The lowest 100 seed weight (3.08 g) and seed yield ha^{-1} (740.70 kg) were obtained from the treatment combination of V_5Zn_0but the lowest number of seeds pod^{-1} (10.03), lowest stover yield ha^{-1} (1710.00 kg) and lowest biological yield ha^{-1} (2549.00 kg) were obtained from the treatment combination of V_2Zn_0.

In terms of nutrient concentration in seed, different Mungbean varieties had no significant effect on P and S concentration but N, K, Zn and B were significantly influenced. The highest N concentration in seed (3.75%) was obtained from the variety V_1 (BARI Mung-4) but the highest P concentration (0.342%), K concentration (1.50%), S concentration (0.235%), Zn concentration (26.67 ppm) and B concentration in seed (24.64 ppm) were obtained from the variety V_3 (BARI Mung-6).The lowest N concentration in seed (3.22%) was obtained from the variety V_4 (BARI Mung-7) but the lowest K concentration (1.337%) and S concentration in seed (0.195%) were obtained from the variety V_1 (BARI Mung-4) where the lowest P concentration (0.31%), Zn concentration (23.33 ppm) and B concentration (22.46 ppm) in seed were obtained from the variety V_5 (BARI Mung-8)

In case of Zn application at different rates, significant difference was not found on P, K and S concentration in seed but significant difference was found on N, Zn and B concentration in seed. The highest N concentration (3.51%),K concentration (1.433%),S concentration (0.213%),Zn concentration (26.80 ppm) and B concentration (25.02 ppm) in seed were obtained from the treatment Zn_1 (2.0 Kg Zn ha^{-1}) but the highest P concentration (0.338%) in seed was obtained from the control treatment Zn_0 (0 Kg Zn ha^{-1}). The lowest N concentration (3.31%), K concentration (1.339%), S concentration (0.203%), Zn concentration (23.07 ppm) and B concentration (21.71 ppm) in seed were found from control treatment (Zn_0) but the lowest P concentration (0.331%) in seed was found from the treatment Zn_1 (2.0 Kg Zn ha^{-1}).

Regarding combined effect of variety and Zn, non-significant variation was found for P and S concentration in seed but N, K, Zn and B were significantly influenced. The highest N concentration (3.84%) in seed was obtained from the treatment combination of $V_1Zn_1$where the highest P concentration (0.357%) in seed was in the treatment combination of V_4Zn_0but the highest K concentration (1.557%), S concentration (0.243%), Zn concentration (28.33 ppm) and B concentration (26.00 ppm) in seed were obtained from the treatment combination of V_3Zn_1. The lowest N concentration (3.13%) was obtained from the treatment combination of V_4Zn_0 where the lowest P concentration (0.293%) in seed was obtained from the treatment combination of V_5Zn_1. Again, the lowest K concentration (1.293%) and S concentration (0.190%) in seed were obtained from the treatment combination of V_1Zn_0 but the lowest Zn concentration (21.00 ppm) and B concentration (20.80 ppm) in seed were obtained from the treatment combination of V_5Zn_0.

In terms of nutrient concentration in stover, different Mungbean varieties had no significant effect on N, P and S concentration but K, Zn and B were significantly influenced. The highest N concentration (1.92%), P concentration (0.187%), K concentration (1.843%), S concentration (0.199%), Zn concentration (22.08 ppm) and B concentration (31.66 ppm) in stover were obtained from the variety V_3 (BARI Mung-6). The lowest N concentration (1.77%) and K concentration (1.642%) in stover were obtained from the variety V_1 (BARI Mung-4) but the lowest P concentration (0.181%) in stover was obtained from the variety V_2 (BARI Mung-5). Again, the lowest S concentration (0.171%), Zn concentration (18.73 ppm) and B concentration (27.84 ppm) in stover were obtained from the variety V_5 (BARI Mung-8).

In case of Zn application at different rates, significant difference was not found on P and S concentration in stover but significant difference was found on N, K, Zn and B concentration in stover. The highest N concentration (2.08%),K concentration (1.873%),Zn concentration (25.55 ppm) and B concentration (35.58 ppm) in stover were obtained from the treatment Zn_1 (2.0 Kg Zn ha^{-1}) but the highest P concentration (0.188%) and S concentration (0.188%) in stover were found from the control treatment Zn_0 (0 Kg Zn ha^{-1}). The lowest N concentration (1.58%), K concentration (1.603%),Zn concentration (16.06 ppm) and B concentration (24.26 ppm) in stover were found from control treatment (Zn_0) where the lowest P concentration in stover (0.178%) and S concentration (0.171%) in stover were found from the treatment Zn_1 (2.0 Kg Zn ha^{-1}).

Regarding combined effect of variety and Zn, non-significant variation was found for P and S concentration in stover but N, K, Zn and B were significantly influenced. The highest N concentration (2.20%), K concentration (1.99%), Zn concentration (27.45 ppm) and B concentration (37.68 ppm) in stover were obtained from the treatment combination of V_3Zn_1 whereas the highest P concentration (0.199%) and S concentration (0.205%) in stover were in the treatment combination of V_3Zn_0. The lowest N concentration (1.53%) and K concentration (1.47%) in stover were obtained from the treatment combination of V_1Zn_0 but the lowest Zn concentration (15.53 ppm) and B concentration (21.79 ppm) in stover were obtained from the treatment combination of V_5Zn_0. Again, the lowest P concentration (0.173%) in stover was obtained from the treatment combination of V_2Zn_1 and the lowest S concentration (0.173%) in stover was obtained from the treatment combination of V_5Zn_1.

Conclusion

From the above results it might be concluded that among the combination of different varieties of Mungbean and application of Zn, the treatment combination of V_3Zn_1 (BARI Mung-6 × 2.0 Kg Zn ha^{-1}) induced superior yield contributing characters and yield of Mungbean as well as nutrient concentration in seed and stover.

Recommendations

1. Such study is needed in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability and other performance
2. Another doses of Zn may be included in the future program
3. Other cultivars may be included in the further program.

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APPENDICES

Appendix I. Agro-Ecological Zone of Bangladesh showing the experimental location

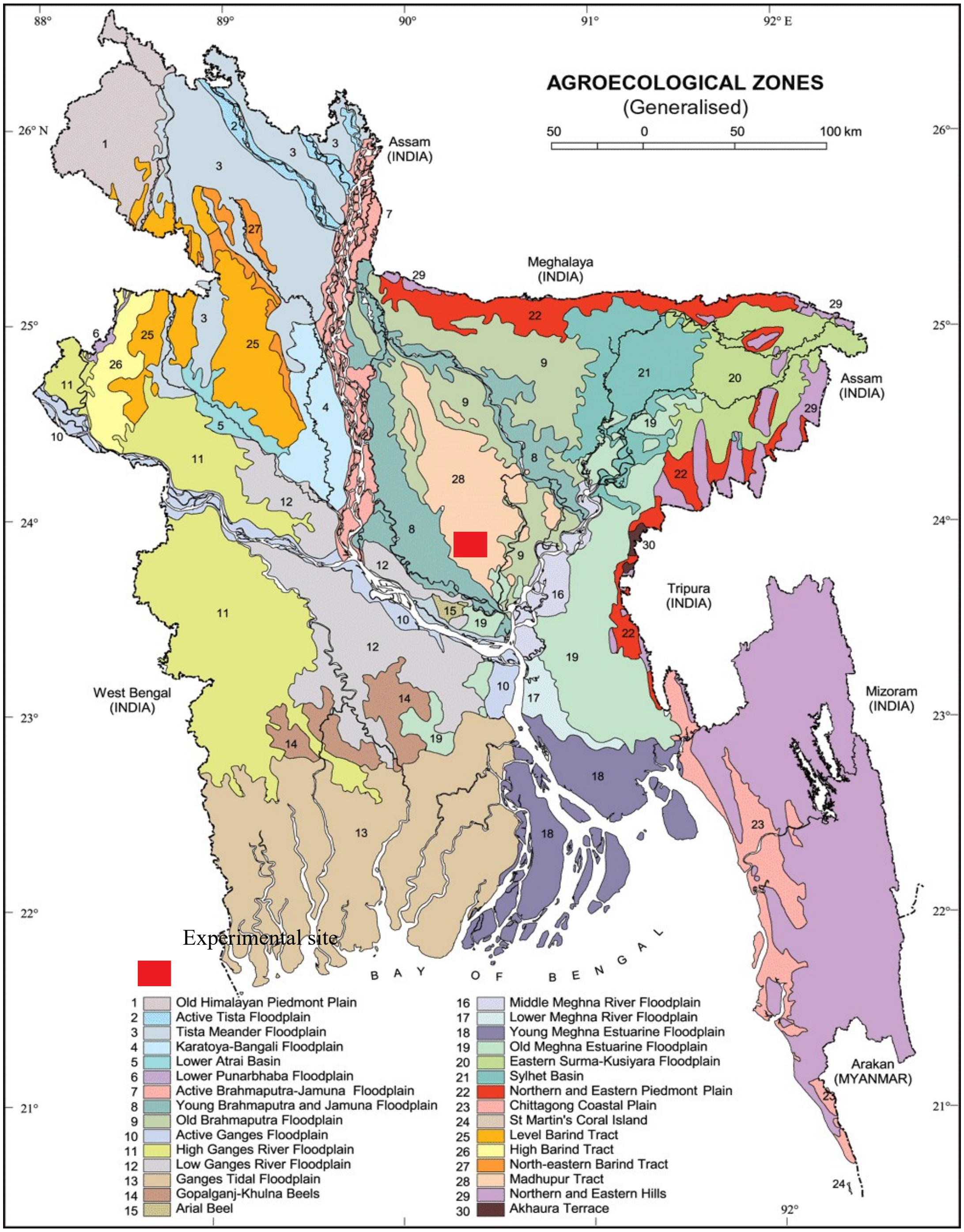

Fig. 1. Experimental site

Appendix II. Monthly records of air temperature, relative humidity and rainfall during the period from Marchto June 2017.

Year	Month	Air temperature (°C)			Relative humidity (%)	Rainfall (mm)
		Max	*Min*	*Mean*		
2017	March	35.20	21.00	28.10	52.44	20.4
2017	April	34.70	24.60	29.65	65.40	165.0
2017	May	32.64	23.85	28.25	68.30	182.2
2017	June	27.40	23.44	25.42	71.28	190

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1212.

Appendix III. Characteristics of experimental soil analyzed at Soil Resources Development Institute (SRDI), Farmgate, Dhaka.

A. Morphological characteristics of the experimental field

Morphological features	**Characteristics**
Location	Agronomy Farm, SAU, Dhaka
AEZ	Modhupur 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	Not Applicable

Source: Soil Resource Development Institute (SRDI)

B. Physical and chemical properties of the initial soil

Characteristics	**Value**
Partical size analysis % Sand	27
%Silt	43
% Clay	30
Textural class	Silty Clay Loam (ISSS)
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20
Exchangeable K (me/100 g soil)	0.1
Available S (ppm)	45

Source: Soil Resource Development Institute (SRDI)

Appendix IV. Layout of the experiment field

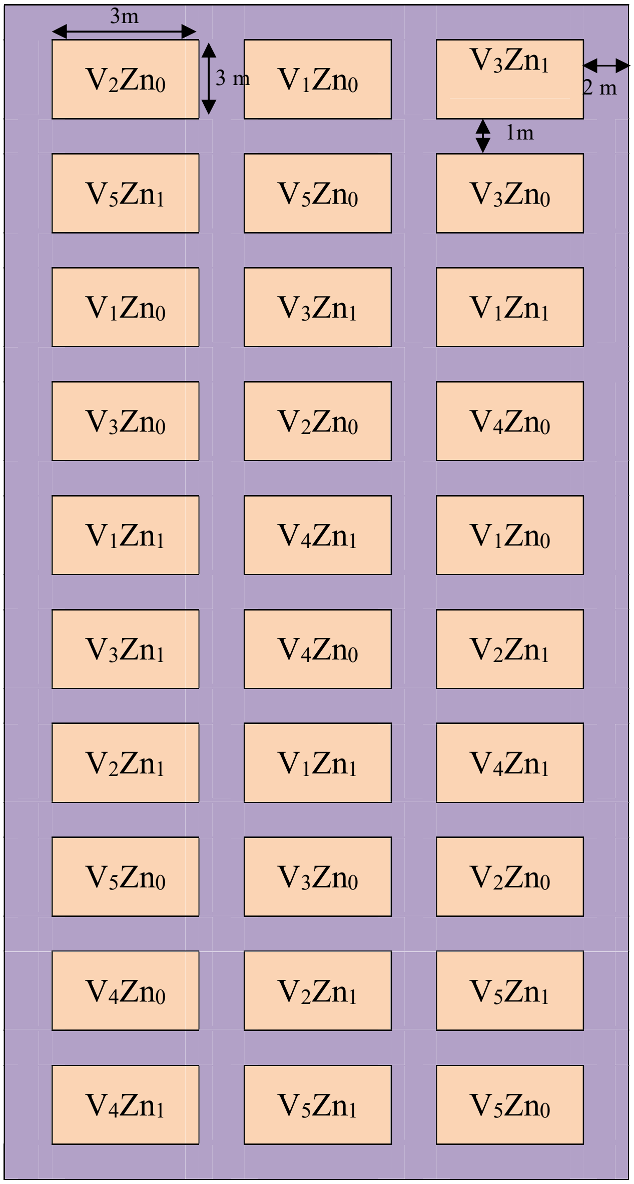

Fig. 2. Layout of the experimental plot

Appendix V. Varietal performance on growth and yield contributing parameters influenced by Zinc

Sources of variation	Degrees of freedom	Growth and yield contributing parameters				
		Plant height (cm)	Number of pods plant^{-1}	Pod length (cm)	Number of seeds pod^{-1}	100 seed weight (g)
Replication	2	1.063	0.433	0.127	0.791	0.002
Factor A	4	0.254^{NS}	2.467*	7.721*	3.327*	4.183*
Factor B	1	116.43**	32.03*	0.486**	1.038*	0.596*
AB	4	10.296*	3.533*	0.014*	0.234*	0.019*
Error	18	8.923	6.581	0.064	0.144	0.009

Appendix VI. Yield parameters of Mungbean influenced by variety and zinc and their combination

Sources of variation	Degrees of freedom	Yield parameters		
		Seed yield ha^{-1} (kg)	Stover yield ha^{-1} (kg)	Biological yield ha^{-1} (kg)
Replication	2	9.733	15.333	13.273
Factor A	4	342.283*	378.000*	482.634*
Factor B	1	985.633*	1442.333*	1638.271*
AB	4	147.217*	163.000*	201.932*
Error	18	8.104	14.815	16.837

Appendix VII. Effect of variety and zinc and also their combination on nutrient concentration (N, P, K, S, Zn and B) in Mungbean seed

Sources of variation	Degrees of freedom	Quality parameters - nutrient concentration in seed					
		N (%)	P (%)	K (%)	S (%)	Zn (ppm)	B ppm)
Replication	2	0.021	0.001	0.006	0.001	0.233	1.708
Factor A	4	0.256*	0.024 NS	0.027*	0.012^{NS}	12.467*	4.171*
Factor B	1	0.324*	0.046 NS	0.067 ^{NS}	0.024 NS	104.533*	81.939*
AB	4	0.004**	0.011 NS	0.001**	0.006 NS	0.200**	1.780*
Error	18	0.004	0.002	0.006	0.001	1.567	4.745

Appendix VIII. Effect of variety and zinc and also their combination on nutrient concentration (N, P, K, S, Zn and B) in Mungbean stover

Sources of variation	Degrees of freedom	Quality parameters - nutrient concentration in stover					
		N (%)	P (%)	K (%)	S (%)	Zn (ppm)	B ppm)
Replication	2	0.008	0.007	0.293	0.001	3.118	1.898
Factor A	4	0.023^{NS}	0.021 NS	0.032*	0.011 NS	10.466*	13.475*
Factor B	1	1.845*	0.032 NS	0.547*	0.018 NS	75.261*	62.314*
AB	4	0.002**	0.011 NS	0.028**	0.007 NS	5.643*	1.085*
Error	18	0.006	0.003	0.020	0.001	3.044	3.978