# EFFECT OF POTASSIUM AND ZINC ON THE GROWTH AND YIELD OF MUNGBEAN (BARI MUNG-6)


**By**

**MAMINUL ISLAM**

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**Approved by**

| | |
|---|---|
| **(Prof. Dr. Md. Nurul Islam)** | **(Assoc. Prof. A. T. M. Shamsuddoha)** |
| Supervisor | Co-supervisor |

**Associate Prof. Dr. Asaduzzaman Khan**
Chairman
Examination Committee

**Sher-e-Bangla Agricultural University**
**Sher-e-Bangla Nagar, Dhaka-1207**

PABX: +88029144270-9
Fax: +88029112649
www.sau.edu.bd

*Ref:*

*Date:* ...................

# *CERTIFICATE*

This is to certify that thesis entitled, *"EFFECT OF POTASSIUM AND ZINC ON THE GROWTH AND YIELD OF MUNGBEAN ( BARI MUNG-6 )"* submitted to the *DEPARTMENT OF SOIL SCIENCE*, Sher-e-Bangla Agricultural University, Dhaka in partial fulfilment of the requirements for the degree of *MASTER OF SCIENCE (M.S.)* in *SOIL SCIENCE* embodies the result of a piece of ***bona fide*** research work carried out by *MAMINUL ISLAM* Registration No. ***07-00949*** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

**Dated:**.....................

**Place: Dhaka, Bangladesh**

..........................................

**Prof. Dr. Md. Nurul Islam**

**Supervisor**

Dedicated to

My

Beloved Mother

&

Father

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*Dated: June, 2009*

*Place: Dhaka, Bangladesh.*

***The Author***

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| ABBREVIATION | FULL WORD |
|---|---|
| AEZ | Agro-ecological zone |
| @ | At the rate of |
| cm | Centimeter |
| $CuSO_4.5H_2O$ | Hydrated copper sulphate |
| CV% | Percentage of coefficient of variance |
| DAS | Days after sowing |
| DMRT | Duncan's multiple range test |
| e.g. | As for example |
| *et al* | and others |
| g | Gram |
| i.e. | That is |
| K | Potassium |
| kg | Kilogram |
| kg $ha^{-1}$ | Kg per hectare |
| LSD | Least significant difference |
| S | Sulphur |
| TSP | Triple super phosphate |
| m | Meter |
| MP | Muriate of potash |
| N | Nitrogen |
| NaOH | Sodium hydroxide |
| P | Phosphorus |
| ppm | Parts per million |
| NS | Not significant |
| OM | Organic matter |
| pH | Hydrogen ion concentration |
| $^0C$ | Degree Celsius |
| % | Percent |
| RCBD | Randomized Complete Block Design |
| SAU | Sher-e-Bangla Agricultural University |
| t $ha^{-1}$ | Ton per hectare |
| Zn | Zinc |

# EFFECT OF POTASSIUM AND ZINC ON THE GROWTH AND YIELD OF MUNGBEAN ( BARI MUNG-6 )

## ABSTRACT

A field experiment was conducted at the Sher-e-Bangla Agricultural University Farm, Dhaka-1207 during the *Kharif* season of 2008 to study the effect of Potassium and Zinc fertilizers on the growth and yield of mungbean. The experimental soil was silty clay loam in texture having pH of 6.4. Four levels of potassium (0,10,20 and 30 kg K $ha^{-1}$) and three levels of zinc (0,1.5 and 3.0 kg Zn $ha^{-1}$ ) were used in the study. Levels of these two nutrient elements making 12 treatment combinations. The experiment was carried out in Randomized complete block design with three replications. Results revealed that grain and stover yield of mungbean increased with increasing the levels of potassium and zinc. The maximum significant grain and straw yields were obtained with the treatment combinations $K_2Zn_2$ ( 20 kg K $ha^{-1}$ + 3 kg Zn $ha^{-1}$ ) and gave the highest seed yield, plant height, pods $plant^{-1}$, seeds $pod^{-1}$, 1000-seed weight. The N, P and K concentration of mungbean plant increased significantly at maturity stage with the highest doses of Potassium and Zinc fertilizers. Application of Potassium and Zinc fertilizers increased organic carbon, N, P and K status of postharvest soil significantly.

# CHAPTER I

# INTRODUCTION

# CHAPTER 1

# INTRODUCTION

Mungbean (*Vigna radiata* L.) is one of the most important pulses in Bangladesh. It belongs to the family Leguminosae. It is originated in South and Southeast Asia (India, Myanmar, Thailand etc.). Now it is widely grown in India, Pakistan, Bangladesh, Burma, Thailand, Philipines, China and Indonesia. It is also grown in parts of east and central Africa, West Indies, USA and Australia. BARIMUNG-6 a high yielding variety fits well in crop rotation between two cereal crops and breaks the build up of disease, insect and weed syndrome. It fixes nitrogen in symbiosis with *Rhizobia* and enriches the soil. Its root breaks the ploughpan of puddled rice fields and goes deep in search of water and nutrients.

Mungbean grows well in all over Bangladesh except the district of Rangamati (BBS 2001). In Bangladesh more than 75% cultivated area is covered by rice where as the pulses occupy only 2.8% of the total area. The production trend of mungbean in Bangladesh from the year 2001-2002 to 2005-06 was 31,30,30,18 and 17 thousand tons respectively. During these period mungbean production has decreased by 3-40% (BBS 2006). In Bangladesh the majority portion of mungbean is being produced in southern part of the country. At present the average yield of mungbean grain in our country is about 1.2 ton $ha^{-1}$. In Bangladesh, daily consumption of pulses is only 13.29 g $capita^{-1}$ (BBS, 2001), while World Health Organization (WHO) suggested 45 g $capita^{-1}$ for a balanced diet. Approximately, 108,000 m ton pulses are imported in Bangladesh in each year (BBS, 2001). But to provide the above-mentioned requirement of 45 g $capita^{-1}$ $day^{-1}$, the production is to be increased even more than three folds (BBS, 1999).

Mungbean is used as whole or split seeds as Dal (Soup) but in other countries sprouted seeds are widely used as vegetables. It is considered as poor man's meat containing almost triple amount of protein as compared to rice. It has good digestibility and flavour. Mungbean contains 51% carbohydrate, 26% protein, 10% moisture, 4% mineral and 3% vitamin. The green plants are used as animal feed and the residues as manure. The crop is potentially useful in improving cropping systems as catch crop due to its rapid growth and early maturing characteristics. Hence, on the nutritional point of view, mungbean is perhaps the best of all other pulses (Khan, 1981 and Kaul, 1982). As a whole, mungbean could be considered as an inevitable component of sustainable agriculture.

Mungbean cultivation covers an area of 60,000 acres producing about 18,000 metric tons (BBS, 2005). In general mungbean is grown in marginal lands of poor fertility and low moisture status and under poor management conditions. Inspite of the many advantages of mungbean, the area coverage and the production are in declining trend (BBS, 1999). This trend is mainly due to the fact that pulses can not compete with HYV cereals in terms of production and economic return and are thus being pushed to marginal lands where nutrient deficiencies are severe. Therefore, to meet the situation it is necessary to boostup the production through varietal development and proper management practices as well as summer mungbean cultivation.

Mungbean has special importance in intensive cropping systems of the country for its short growing period. The agro-ecological conditions of Bangladesh are favourable for growing this crop. It can be cultivated both in summer and winter seasons in the country. Mungbean can tolerate a high temperature not exceeding $40^{\circ}C$ and grows well in the temperature range of $30\text{-}35^{\circ}C$. It is drought tolerant and can be cultivated in areas of low rainfall. The crop is usually grown with residual moisture under rainfed condition in Bangladesh. The possibilities of growing mungbean in summer are being experimented and some successes have already been made in Bangladesh. Bangladesh Agricultural Research Institute (BARI) and Bangladesh Institute of Nuclear Agriculture (BINA) have developed a number of cultivars of mungbean.

Potassium plays a remarkable role in plant physiological processes. It is an essential constituent of different plant substances. Potassium deficiency causes yield reduction by limiting plant growth. It influences nutrient uptake by promoting root growth and nodulation. Mungbean is highly responsive to fertilizers and has considerable response to potassium. Our soils are not rich in all essential nutrient elements and organic matter content. The farmers of Bangladesh generally grow mungbean with almost no fertilizers. So, there is an ample scope of increasing the yield of mungbean $unit^{-1}$ area by using balanced fertilizers including potassium fertilizer. Sangakara (1990) carried out a field experiment to study the effects of 0-120 kg $K_2O$ $ha^{-1}$ on growth, yield parameters and seed quality of mungbean and reported that K application increased plant growth rate, flowers $plant^{-1}$, percent pod set, seeds $pod^{-1}$, 100-seed weight and yield $plant^{-1}$.

Zinc plays essential metabolic roles in plant, of which the most significant is, its activity as a component of a variety of enzymes, such as dehydrogenases, proteinases and peptidases. The basic functions in plants are related to metabolism of carbohydrates, proteins and phosphate and also to auxins, RNA and ribosome. Patil and Somawanshi (1982) reported that application of Zn significantly increased the grain and straw yields of mungbean.

In Bangladesh, many studies have been conducted on nutrient requirements of mungbean but reports are very few on the potassium and zinc fertilizer requirement and on the combined effects of these elements on mungbean. Considering the above facts the present study is aimed at:

i. To determine the effects of potassium fertilizer on the growth and yield of mungbean.

ii. To observe the effectiveness of zinc fertilizer on growth and yield of mungbean.

iii. To study the interaction effect of potassium and zinc fertilizer on growth and yield of mungbean.

# CHAPTER II

# REVIEW OF LITERATURE

# CHAPTER 2

# REVIEW OF LITERATURE

A good number of research works on mungbean have been performed extensively in several countries especially in the South East Asian countries for its improvement of yield and quality. In Bangladesh, little attention has so far been given for the improvement of mungbean variety or its cultural management. Currently the Bangladesh Agricultural Research Institute (BARI) and the Bangladesh Institute of Nuclear Agriculture (BINA) have started extensive research on varietal development and improvement of this crop. Findings of various experiments related to the present study in home and abroad have been reviewed and discussed in this chapter.

## 2.1 Effect of potassium on yield and yield contributing characters of mungbean

Sardana and Verma (1987) made a field trial in Delhi, India with combined application of aldicarb (for the control of various insect pests) with nitrogen, phosphorus and potassium fertilizers and reported that plant height, leaf surface area, number and length of pods, 100-grain weight and yield of green gram were significantly increased.

Maiti *et al.* (1988) reported that 60 or 100 kg $ha^{-1}$ each of $P_20_5$ and $K_20$ increased seed yield in *Vigna radiata* and lentils.

Sangakara (1990) carried out a field experiment to study the effects of 0-120 kg $K_20$ $ha^{-1}$ on growth, yield parameters and seed quality of mungbean and reported that K application increased plant growth rate, flowers plant$^{-1}$, percentage pod set , seeds pod$^{-1}$, 100-seed weight and yield plant$^{-1}$.

Danita *et al.* (1992) studied the effect of 0, 12.5, 25, 37.5, 50 and 75 kg $K_20$ ha$^{-1}$ and reported that application of potassium significantly increased all the yield attributing characters, grain yield and dry matter of mungbean with increasing levels of potassium.

Singh *et al.* (1993) conducted a field experiment to study the response of greengram to nitrogen, phosphorus and potassium. They reported that application of N, P and K improved plant productivity and enhanced the grain yield of greengram significantly. They also reported that response to $K_20$ was recorded up to 40 kg ha$^{-1}$.

Mishra and Ahmed (1994) conducted a potassium experiment with superphosphate, potassium chloride or NPK (14:35:14) and reported that P and K at low concentration (0.1%) increased nodulation and root dry weight. They also reported that plant dry weight and nodulation increased significantly with up to 0.5% NPK.

Luo and Chen (1995) conducted a field experiment on green gram and stated that the proportions of nutrients returned from straw were 43.6-55.7% of N, 41.8-50.3% of $P_2O_5$ and 55.7-61.0% of $K_2O$ and concluded that it was a K-enriched plant.

Asghar *et al.* (1996) conducted a field experiment to study the influence of various doses of potassium on yield and quality of mungbean. They reported that the number of pods plant$^{-1}$, number of seeds pod$^{-1}$, seed yield ha$^{-1}$ and seed protein contents were influenced significantly by potassium application and the heighest seed yield (1.67 t ha $^{-1}$) was obtained with application of 75 kg $K_20$ ha $^{-1}$.

Chatterjee and Mandal (1996) carried out a field experiment on integrated fertilizer management with or without application of potassium and organic matter or manure. They observed that maximum crop productivity was achieved using 150% of the recommended doses of N, P and K in rice-potato-sesame, rice-potato-mungbean and rice-potato-groundnut systems and the available K status was improved in 0-15 cm soil depth.

Kaushik *et al.*(1996) observed that in a greenhouse experiment, *Vigna radiata* cv. CS-94 was given 0-120 mg S ha$^{-1}$ as pyrite or elemental S ( 3 weeks of sowing ) or gypsum or $K_2SO_4$ ( at sowing ). They observed that leaf and stem dry matter, yield and N and P contents increased with upto 40 mg S irrespective of source, where as K content increased with upto 80 mg S.

Sushil *et al.* (1997) conducted an experiment to study the effect of sulphur, potassium and phosphorus supply (0, 25, 50 and 100 mM) on seed protein of *Vigna radiata.* They reported that the amount of globulin and albumin were increased with increasing concentrations of K. Tryptophan in all the protein fractions also increased with higher K levels.

Abd-El-Lateef *et al. (1998)* carried out a field experiment with 0, 15.5 or 31 kg $P_20_5$ and 0 or 24 kg $K_20$ feddan$^{-1}$ and observed that seed yield increased by the application of K and the lower rates of P ( 1 feddan = 0.42 ha).

Reddy *et al.* (1998) carried out a field trial during *kharif* of 1995 at Attibele, Karnataka, India, on peas *cv. Selection FC-1* with 0, 50 or 100% of the recommended rates of NPK (37.5 : 60 : 50 kg $ha^{-1}$), and 0, 5 or 10 t farmyard manure and/or vermicompost $ha^{-1}$. Plant height at harvest, days to initial flowering, number of branches per plant, number of pods per plant, number of seeds per pod and yield were highest with 10 t vermicompost + 100% recommended NPK.

Chaudhury and Mahmood (1999) laid out a field experiment to study the effect of optimum potassium levels on growth, yield and quality of mungbean and reported that 50 kg $K_20$ gave the highest seed yield (832 kg $ha^{-1}$) and also reported that the optimum level of $K_2O$ was between 50 to 100 kg per hectare.

Prasad *et al.* (2000) conducted a pot experiment to study the effects of potassium on yield, water use efficiency and K-uptake by summer mungbean. They observed that total biomass production, grain yield, the water usce efficiency and potassium uptake significantly increased with 20 and 30 kg K as compared to other levels of potassium.

Gobindar and Thirumurugan (2000) conducted an experiment and observed that 1.0% KCl + 1.0% $KN0_3$ gave the highest values for plant height at harvest (48.6 cm), leaf area index at 60 DAS (6.83), number of branches $plant^{-1}$ (2.89), number of pods $plant^{-1}$ (20.6), pod length (8.12cm), number of grains $pod^{-1}$ (10.77), 100-grain weight (4.0 g), grain yield (777 kg $ha^{-1}$), dry matter production at harvest (2783 kg $ha^{-1}$) and benefit : cost (2.53).

Ram and Dixit (2000) conducted a field experiment on summer greengram cv. *K-851* and revealed that nodulation, N, P and K uptake and yield increased with increasing P rate.

Singh and Humuman (2001) studied in an experiment on mungbean and revealed that maximum dry biomass/plant (24.8 g $plant^{-1}$) was recorded from 60 kg $P_2O_5$ $ha^{-1}$. Grain yield was maximum when plants were treated with 30 kg $P_2O_5$ $ha^{-1}$ and 30 mg $kg^{-1}$ Zn (4.3 g $plant^{-1}$). Maximum P content were recorded from 30 kg $P_2O_5ha^{-1}$ and Zn 15 mg $kg^{-1}$ (0.63%).

Sangakara *et al.* (2001) carried out a field experiment to determine the benefits of potassium in overcoming water stress in mungbean. They found that potassium increased shoot growth, root growth and as a significant factor in overcoming soil moisture stress in tropical cropping systems.

Nita *et al.* (2002) carried out a field experiment in West Bengal, India during the summer of 1998-99 to study the effect of K and S at 0, 20 and 40 kg $ha^{-1}$, applied singly or in combination on the growth and productive attributes of mungbean. They reported that leaf area index, plant height, nodules $plant^{-1}$, nodule dry weight, pods $plant^{-1}$, 1000-seed yield, grain yield, harvest index and N, P, K and S contents in seeds and stover of mungbean are increased with increasing rates of K and S.

Chanda, *et al.* (2002) carried out a field experiment on mungbean and showed that seed yield, protein content and net production value increased with increasing rates of K and S. Similarly, the status of N and P in soil decreased with increasing rates of K and S.

Das *et al.* (2002) studied the effects of vermicompost and chemical fertilizer application on the growth and yield of green gram (*V. radiata cv. Sujata*). The dry matter and pod yield of green gram were increased with the application of vermicompost applied in integrated form. The yield was highest with 100% enriched vermicompost compared to sole organic manure. Greater dry matter content, pod yield, nutrient uptake (N, P and K), plant height, leaf area, root volume, number of nodules and fresh weight of nodules were obtained with treatments containing vermicompost. Flowering was earlier by 7 days in vermicompost-treated plants compared with the control.

Abraham and Lal (2003) conducted field experiments from 1997 to 1999 to investigate the effects of NPK fertilizer, organic manures (farm compost + vermicompost and farm compost + poultry manure) and biofertilizers on the productivity of black gram-wheat-greengram cropping system. Pod counts for black gram and green gram and grain yield for wheat were highest with farm compost + poultry manure, but the highest seed yield was recorded with farm compost + vermicompost in black gram in the first year. The treatment biofertilizers + cow's urine recorded higher values of pod count in the first year and weight and seed yield in the second year in green gram.

Ahmad, *et al.* (2003) conducted an experiment on mungbean with N P K at 50 : 0 : 0 ($F_1$), 50 : 100 : 0 ($F_2$) and 50 : 100 : 50 kg $ha^{-1}$ ($F_3$) and revealed that no significant differences in the number of pods per plant, number of grains per plant, grain yield and straw yield were observed in plants under $F_2$ and $F_3$. $F_3$ resulted in the highest grain yield value and costs, and lowest net field benefit.

Oad *et al.* (2003) conducted a field experiment on the growth and yield performance of mungbean (*Vigna radiata*) and showed that mungbean varieties were significantly influenced by phosphorus and potassium fertilizers except pod number, seed weight per plant and seed index were non-significant. However, 100 kg P and 100 kg K $ha^{-1}$ showed an increase in the yield of the crop.

Dey and Basu (2004) conducted a study on green gram and showed that plant height and dry matter accumulation in aerial plant parts were the highest with 40 kg K $ha^{-1}$ along with 40 kg S $ha^{-1}$.

Duary *et al.* (2004) conducted a study on green gram and showed that *Rhizobium,* 10 kg N $ha^{-1}$, 30 kg P $ha^{-1}$, 30 kg K $ha^{-1}$, 20 kg S $ha^{-1}$ produced the significantly highest seed yield.

Oad and Buriro (2005) laid out a field experiment to determine the effect of different NPK levels on the growth and yield of mung bean cv. *AEM 96* and showed that the 10-30-30 kg N-P-K $ha^{-1}$ was the best treatment, recording plant height of 56.25 cm, pod length of 5.02 cm, seed weight per plant of 10.53 g and the highest seed yield of 1205.2 kg $ha^{-1}$.

Asghar *et el.* (2006) laid out a field experiment to determine the effect of different levels of potassium (0, 25, 50, 75 and 100 kg $ha^{-1}$) on growth, yield and quality of two mungbean genotypes (NM-92 and NM-98) was studied in the Department of Agronomy, University of Agriculture, Faisalabad during 2003. Different potassium levels significantly affected the seed yield and protein contents. Maximum seed yield (1458.46 kg $ha^{-1}$) with 25.31 percent protein contents was obtained with 100 kg K per hectare. Genotype NM-98 produced higher seed yield than NM-92.

Naeem *et el.* (2006). carried out a field experiment to determine the effect of organic manures and inorganic fertilizers on growth and yield of mungbean (*Vigna radiata* L.). Experiment comprised of two varieties (NM-98 & M-1) and four fertility levels as N P K @ 25 -50 - 50 kg $ha^{-1}$, poultry manure @ 3.5 t $ha^{-1}$, FYM @ 5 t $ha^{-1}$ and Bio-fertilizer @ 8 g $kg^{-1}$ seed. N P K fertilizers and organic manures were applied at the time of seed bed preparation. Wheat grain yield was recorded highest (1104 kg $ha^{-1}$) with the application of the inorganic fertilizers (N P K @ 25 - 50 - 50 kg $ha^{-1}$). Among organic nutrient a source, poultry manure @ 3.5 t $ha^{-1}$ was found the best followed by FYM @ 5 t $ha^{-1}$. Both varieties were equal in grain yield. Numbers of pods, number of seeds per pod, 1000 grain weight were also almost higher in inorganic fertilizer treatment. The economic analysis revealed maximum net benefit from the treatment, where poultry manure was applied.

Tawfik *et el.* (2008). conducted a pot experiment to study the effect of extension of irrigation interval (2, 5, and 10 days) on growth, yield and metabolic changes in mungbean (Vigna radiata L.) var. VC 1000 in addition to potassiomag application. Generally, fresh, dry weights and yield were significantly reduced under water stress condition. Treatment with K biofertilizer to some extent mitigated the effect of drought stress. The greatest vegetative growth was obtained in plants irrigated every two days and treated with potassiomag, while the greatest seed yield was obtained from plants irrigated every five days and treated with potassiomag. Osmoprotectants such as total soluble sugars, proline and glycine betaine increased in plants subjected to water stress. It could be concluded that to maximize mungbean yield, irrigation should be extended through all phenological stages, specially in flowering and pod-filling stages.

## 2.2 Effect of Zn on yield and yield attributing characters of mungbean

Prasad and Ram (1982) reported that application of Zn at 5 to 10 kg $ha^{-1}$ increased the yield and protein contents of mungbean.

Singh and Bajpai (1982) conducted an experiment in Rajastan with 4 levels of P (0, 20, 40 and 60 kg P $ha^{-1}$) and three levels of Zn (0, 5 and 10 kg $ZnSO_4$ $ha^{-1}$). They found that P and Zn significantly improved the branches and number of pods plant, grain and straw yields of chickpea.

Patil and Somawanshi (1982) reported that application of P and Zn significantly increased the grain and straw yields of greengram. Plants supplied with P alone contained significantly lower Zn than control plants, whereas increasing incorporation of Zn with P substantially increased Zn concentration but reduced P concentration.

Prasad and Ram (1986) stated that two levels of applied *Zn (2.5* and 5.0 $\mu g\ g^{-1}$) increased the concentration of P in mungbean and grain yield.

Ahmed *et al.* (1986) studied that P-Zn interaction significantly increased plant height, number of pods $plant^{-1}$, grain and straw yields of mungbean, Phosphorus contents decreased on application of Zn and vice-versa. They further stated that P application increased protein but Zn application increased protein only at low doses.

Pal (1986) noted that application of Zn, B and a mixture of 6 trace elements to peanut increased yield by 41.9, 34.3 and 80.5%, respectively.

Gangwar and Singh(1988) conducted an experiment using ZnO @ 0.10 and 0.20 μg $g^{-1}$ to study the effect of Zn on yield and quality of lentil. They reported that significantly higher protein content in seed was recorded in all the treatments of Zn application over control.

Islam *et al.* (1989) stated that seed yield ranged from 554 kg $ha^{-1}$ with dipping seeds in 0.1% ZnO solution to 781 kg ha $^{-1}$ with dipping seed in 0.2% ZnO solution. Yield, plant height, branches $plant^{-1}$, pods $plant^{-1}$, seeds $pod^{-1}$, pod length, 1000-seed weight, grain yield and stover yield were significantly affected by Zn rate or application method.

Dwivedi *et al.* (1990) conducted a experiment and observed that micronutrients (Cu, Zn, B and their mixture) either alone or in mixture significantly increased the yield of soybean.

Saxena S. C (1990) conducted a laboratory experiment with chickpeas in salinized sand (EC.34 $dSm^{-1}$) treated with 0, 5 or 10 μg $g^{-1}$ Zn and reported that application of 5 μg $g^{-1}$ Zn increased the number of nodule .

Singh *et al.* (1993) carried out an experiment on mung bean and revealed that K (30, 60 or 90 kg $K_2O$ $ha^{-1}$) and Zn (5, 10 or 15 ppm) application increased the seed protein, N and P contents, but decreased the Mg and Ca contents.

Das (1994) reported that Zn and B increased vegetative growth of groundnut. Mo increased nodule number $plant^{-1}$.

Singha *et al.* (1994) fertilized lentil cv. B-77 with 0.6 or 1.2 kg B $ha^{-1}$ as borax,4.4 kg Zn ha $^{-1}$ as Zn sulphate or in various combinations and observed that B + Zn produced the highest seed yield of (2.29 t $ha^{-1}$) as well as the highest net return.

Saha *et al.*(1996) conducted a field trial in *pre-kharif* season of 1993-94 at Pundibari, India yellow sarson *(Brassica campestris)* was given 0, 2.5 or 5 kg borax applied, at soil, 66% soil + 33% foliar application and the residual effects were studied on summer mungbean.. In both years, green gram seed yield was highest with a combination of 5 kg borax + 2 kg sodium molybdate. Soil application gave higher yields than foliar or soil + foliar application.

Singh *et al.* (1997) conducted a field experiment to study the effect of S and Zn on summer green gram *(Vigna radiata).* They reported that application of 30 kg S and 5 kg Zn $ha^{-1}$ were optimum for plant height, dry matter accumulation, seed protein, yield and S and Zn uptake. Summer Mungbean *(Vigna radiata) was* grown in the field for two years with the application of elemental S (0, 15, 30 and. 45 kg $ha^{-1}$) in an Inceptisol. Sulphur application significantly improved plant biomass, nodule number and seed weight of mungbean optimum being 30 kg $ha^{-1}$.

Tripathi *et al.* (1997) conducted a field experiment consisting of 4 levels of S and Zn. They reported that application of S and Zn had conspicuous and significant effect on yield attributes i.e. number of seeds $plant^{-1}$, 1000-grain weight, grain and straw yield.of greengram. These characters increased significantly with an increase in S and Zn doses upto 40 kg S $ha^{-1}$ and 5 kg Zn $ha^{-1}$ ) and thereafter decreased at 60 kg S $ha^{-1}$.

Rizk, W. M., and Abdo, F. A. (2001) carried out two field experiments at Giza Experimental Station, ARC, Egypt during 1998 and 1999 seasons to investigate the response of mungbean to treatments with some micronutrients. Two cultivars of mungbean (V-2010 and VC-1000) were used in this investigation. Zn (0.2 or 0.4 g $l^{-1}$), Mn (1.5 or 2.0 g $l^{-1}$), B (3.0 or 5.0 g $l^{-1}$l) and a mixture of Zn, Mn, and B (0.2, 1.5 and 3.0 g $l^{-1}$, respectively), in addition to distilled water as control were sprayed once at 35 days after sowing (DAS). The obtained results could be summarized in the following: Generally, cultivar VC-1000 surpassed cultivar V-2010 in yield and its components as well as in the chemical composition of seeds with exception in 100-seed weight and phosphorus percentage in seeds. All treatments increased yield significantly and its components especially Zn (0.2 g $l^{-1}$) which showed a highly significant increase in all characters under investigation compared to the control. All adopted treatments increased significantly protein percentage in seeds of the two mungbean cultivars in both seasons.

Bandopadhyay *et al.* (2002) reported that the number of pod $plant^{-1}$, kernel, oil yield of groundnut increased due to application of S with P, K, Zn and B.

Hossain *et al.* 2008. laid out a field experiment over 3 years to find out an optimum rate of Zn application for the maize–mungbean–rice cropping system in a calcareous soil of Bangladesh. Zinc application was made at 0, 2 and 4 kg $ha^{-1}$ for maize (cv. Pacific 984, Thai hybrid) and at 0, 1 and 2 kg $ha^{-1}$ for rice (cv. BRRI dhan33), with no Zn application for mungbean (cv. BARI mung5). Effect of Zn was evaluated in terms of yield and mineral nutrients contents (N, P, S and Zn). All the three crops responded significantly to Zn application. The optimum rate of Zn for the maize–mungbean–rice cropping system was found to be 4–0–2 kg $ha^{-1}$ for the first year and 2–0–2 kg $ha^{-1}$ for subsequent years particularly when mungbean residue was removed and such rates for mungbean residue incorporation being 4–0–1 and 2–0–1 kg $ha^{-1}$, respectively. For all crops, the Zn and N concentrations of grain were significantly increased with Zn application. For the case of grain-S, the concentration was significantly increased for maize and mungbean, but it remained unchanged incase of rice. The grain-P concentration on the other hand tended to decrease with Zn application. For maize, the grain-Zn concentration increased to 27.0 μg $g^{-1}$ due to 2 kg Zn $ha^{-1}$ from 16.5 μg $g^{-1}$ for Zn control plot and at higher Zn rate (4 kg Zn $ha^{-1}$) the increment was very minimum. Another field experiment was performed over 3 years on the same soil to screen out maize varieties for Zn efficiency. Of the eight varieties tested, the BARI maize 6 and BARI hybrid maize 3 were found Zn inresponsive (Zn efficient) and the others Zn responsive (Zn-inefficient).

Salah Uddin *et al.* (2009) carried out an experiment to investigate the interaction effect of variety and fertilizers on the growth and yield of summer Mungbean during the summer season of 2007. Five levels of fertilizer viz. control, N + P +K, Biofertilizer, Biofertilizer + N + P + K and Bio-fertilizer + P + K. and three varieties BARI mung 5, BARI mung 6 and BINA mung 5 were also used as experimental variables. Results showed that most of the growth and yield component of mungbean viz. plant height, branch $plant^{-1}$, number of nodules $plant^{-1}$, total dry matter $plant^{-1}$, pods $plant^{-1}$, seed $plant^{-1}$, seed $pod^{-1}$, weight of 1000-seeds, seed yield and straw yield were significantly influence by the bio-fertilizer (Bradyrhyzobium inoculums) treatment except number of leaves and dry weight of nodule. These are influenced by chemical fertilizer and biofertilizer also. All the parameters performed better in case of Bradyrhyzobium inoculums. BARI mung 6 obtained highest number of nodule $plant^{-1}$ and higher dry weight of nodule. It also obtained highest number of pod $plant^{-1}$, seed $plant^{-1}$, 1000 seed weight and seed yield. Interaction effect of variety and bio-fertilizer (Bradyrhyzobium) inoculation was significant of all the parameters. BARI mung 6 with Bradyrhyzobium inoculums produced the highest number of nodule and pod $plant^{-1}$. It also showed the highest seed yield, Stover yield and 1000-seed weight.

Henselova and Slovakova (2010) carried out an experiment to investigate the effect of the foliar fertilizer Campofort Special-Zn (CSZn) and the plant growth regulator Rastim 30 DKV (RM) on growth, yield parameters and seed protein content in mungbean [*Vigna radiata* (L.) Wilczek] Plants grown under greenhouse and field conditions. CSZn at a dose of 10 L $ha^{-1}$, and RM at doses of 3, 30 and 60 g $ha^{-1}$ were applied alone or in combination (before flowering and 14 days after first application). The initiation of flowering and ripening processes and the chlorophyll content were evaluated. At harvest, total yield and yield components (number of pods $plant^{-1}$, seed number $pod^{-1}$, single pod mass, seed mass $pod^{-1}$), germination of seeds and seed protein content were determined. RM applied alone induced intensive flowering, increased the number of pods and yield components plant$^{-1}$, accelerated the ripening of the pods and delayed senescence in treated plants. The mixture of RM with CSZn and RM alone at a dose of 60 g ha$^{-1}$ had a retarding and morphogenic effect on the growth of treated plants and also decreased the protein content and germination of the seeds.

## 2.3 Interaction effect of K and Zn on yield and yield attributing characters of mungbean

Singh *et al.* (1993) carried out an experiment on mung bean and revealed that K (30, 60 or 90 kg $K_2O$ $ha^{-1}$) and Zn (5, 10 or 15 ppm) application increased the plant height, branches $plant^{-1}$, pods $plant^{-1}$, seeds $pod^{-1}$, pod length, 1000-seed weight, grain yield, stover yield, seed protein, N P and K contents and increase the abailability of N P K in soil, but decreased the Mg and Ca contents.

Singh and Humuman (2001) studied in an experiment on mungbean and revealed that maximum dry biomass $plant^{-1}$ (24.8 g $plant^{-1}$) was recorded from 60 kg $K_2O$ $ha^{-1}$. Grain yield and grain yield was maximum when plants were treated with 30 kg $K_2O$ $ha^{-1}$ and 30 mg $kg^{-1}$ Zn (4.3 g $plant^{-1}$). Maximum P content in seeds and stover were recorded from 30 kg $K_2O$ $ha^{-1}$ and Zn 15 mg $kg^{-1}$ (0.63%).

Thalooth *et el.* (2006) carried out two field experiments at the Agriculniral Experimental Station of National Research Centre, at Shalakan. Kalubia Governorate during the summer seasons of 2002 and 2003 to study the effect of foliar application of zinc, potassium or magnesium on growth, yield and yield components and some chemical constituents of mungbean plants grown under water stress conditions (missing one irrigation at vegetative, flowering and pod formation growth stages). The results revealed that missing one irrigation at any of the three studied stages significantly reduced all the tested growth parameters, yield and yield components as well as photosynthetic pigments content as compared with unstressed plants (control). However, subjecting mungbean plants to moisture stress at vegetative stage had the most negative effect on growth parameters. Meanwhile, stress at a pod formation stage produced the least yield and yield components' values. On the other hand, water stress had a stimulating effect on proline and crude protein contents. The present study also indicate that foliar application of Zn. K or Mg had a positive effect on growth parameters, yield and yield components but K application surpassed the two other nutrients.

# CHAPTER III

# MATERIALS AND METHODS

# CHAPTER 3

# MATERIALS AND METHODS

This chapter includes a brief description of the experimental soil, mungbean variety, land preparation, experimental design, treatments, cultural operations, collection of soil and plant samples etc. and analytical methods followed in the experiment to study the effect of potassium and zinc on the yield of mungbean.

## 3.1 Experimental site

The research work relating to the study of the effect of potassium and zinc on the yield of mungbean was conducted at the Sher-e-Bangla Agricultural University Farm, Dhaka- 1207 during the *Kharif* season of 2008. The map (Appendix -Figure 1) shows the specific location of experimental site.

## 3.2 Description of soil

The soil of the experimental field belongs to the Tejgaon series under the Agroecological Zone, Madhupur Tract (AEZ- 28) and the General Soil Type is Deep Red Brown Terrace Soils in Table 1.

**Table 1. Morphological Characteristics of experimental field**

| Morphological Features | Characteristics |
|---|---|
| Location | Sher-e-Bangla Agricultural University Farm, Dhaka |
| AEZ No. and name | AEZ-28, Modhupur Tract |
| General Soil Type | Deep Red Brown Terrace Soil |
| Soil Series | Tejgaon |
| Topography | Fairly leveled |
| Depth of inundation | Above flood level |
| Drainage condition | Well drained |
| Land type | High land |

**Table 2. Initial physical and chemical properties of the experimental soil**

| Soil properties | Value |
|---|---|
| **A. Physical properties** | |
| 1. Particle size analysis of soil. | |
| % Sand | 29.04 |
| % Silt | 41.80 |
| % Clay | 29.16 |
| 2. Soil texture | Clay loam |
| **B. Chemical properties** | |
| 1. Soil pH | 6.14 |
| 2. Organic carbon (%) | 0.68 |
| 3. Organic matter (%) | 1.17 |
| 4. Total N (%) | 0.08 |
| 5. C : N ratio | 9.75 : 1 |
| 6. Available P (ppm) | 13.42 |
| 7. Available K (ppm) | 45 |
| 8. Available S (ppm) | 23.74 |
| 9. Available Zn (ppm) | 0.42 |

### 3.3 Description of the mungbean variety

BARIMUNG-6, a high yielding variety of mungbean was released by Bangladesh Agricultural Research Institute, Joydebpur, Gazipur in 2003.It is photo insensitive, semi synchronous maturity, short lifepan 60 to 65 days and bold seeded crop. Its yield potentiality is more than 2 t $ha^{-1}$. This variety is resistant to diseases, insects and pest attack.

### 3.4 Climate

The experimental area has sub-tropical climate characterized by heavy rainfall during May to September and scanty rainfall during rest of the year. The annual precipitation of the site is 2152 mm and potential evapotranspiration is 1297 mm, the average maximum temperature is $30.34^{0}$C and average minimum temperature is $21.21^{0}$C. The average mean temperature is $25.17^{0}$C. The experiment was carried out during *kharif* season, 2008. The monthly average temperature, humidity and rainfall of the site during the experimental period are enclosed in appendix 1.

### 3.5 Preparation of the field

The plot selected for the experiment was opened by power tiller driven rotovator on the $5^{th}$ March 2008; afterwards the land was ploughed and cross-ploughed several times followed by laddering to obtain a good tilth. Weeds and stubbles were removed and the large clods were broken into smaller pieces to obtain a desirable tilth of soil for sowing of seeds. Finally, the land was leveled and the experimental plot was partitioned into the unit plots in accordance with the experimental design mentioned in the following section.



### 3.6 Layout of the experiment

The experiment was laid out in a Randomized Complete Block Design with three replications. The total number of plots was 36, each measuring 2 m × 2 m (4 $m^2$). The treatment combination of the experiment was assigned at random into 12 plots of each at 3 replications. The distance maintained between two plots was 75 cm and between blocks was 100 cm. The layout of the experiment is presented in Figure 2.

### 3.7 Treatments

The experiment consists of 2 Factors i.e. potassium and zinc fertilizers. Details of factors and their combinations are presented below:

**Factor A: Potassium(K)**

1. $K_0$ = 0 kg K $ha^{-1}$

2. $K_1$ = 10 kg K $ha^{-1}$

3. $K_2$ = 20 kg K $ha^{-1}$

4. $K_3$ = 30 kg K $ha^{-1}$

**Factor B: Zinc(Zn)**

1. $Zn_0$= 0 kg Zn $ha^{-1}$

2. **$Zn_1$= 1.5 kg Zn $ha^{-1}$**

3. **$Zn_2$= 3 kg Zn $ha^{-1}$**

**Treatment Combinations**

1. $K_0Zn_0$= Control (No K and Zn)

2. $K_0Zn_1$ = 0 kg K $ha^{-1}$ + 1.5 kg Zn $ha^{-1}$

3. $K_0Zn_2$ = 0 kg K $ha^{-1}$ + 3 kg Zn $ha^{-1}$

4. $K_1Zn_0$= 10 kg K $ha^{-1}$ + 0 kg Zn $ha^{-1}$

5. $K_1Zn_1$= 10 kg K $ha^{-1}$ + 1.5 kg Zn $ha^{-1}$

6. $K_1$Zn2= 10 kg K $ha^{-1}$ + 3 kg Zn $ha^{-1}$

7. $K_2Zn_0$= 20 kg K $ha^{-1}$ + 0 kg Zn $ha^{-1}$

8. $K_2Zn_1$= 20 kg K $ha^{-1}$ + 1.5 kg Zn $ha^{-1}$

9. $K_2Zn_2$ =20 kg K $ha^{-1}$ + 3 kg Zn $ha^{-1}$

10. $K_3Zn_0$ = 30 kg K $ha^{-1}$ + 0 kg Zn $ha^{-1}$

11. $K_3$Zn1= 30 kg K $ha^{-1}$ + 1.5 kg Zn $ha^{-1}$

12. $K_3Zn_2$= 30 kg K $ha^{-1}$ + 3 kg Zn $ha^{-1}$

### 3.8 Application of fertilizers

The required amounts of K and Zn fertilizers from Muriate of Potash and Zinc sulphate were applied at the time of final land preparation **as per treatment combinations and design of the experiment. The recommended basal doses of N, P and S were applied in each plot from Urea, TSP and gypsum.**

### 3.9 Seed sowing

Mungbean seeds were sown on the 5$^{th}$ March 2008 in lines following the recommended line to line distance of 30 cm and plant to plant distance of 10 cm.

### 3.10 Cultural and management practices

Various intercultural operations such as thinning of plants, weeding and spraying of insecticides were accomplished whenever required to keep the plants healthy and the field weed free. At the very early growth stage (after 10 days of emergence of seedlings) the plants were attacked by Cutworm, which was removed by applying Malathion. Special care was taken to protect the crop from birds especially after sowing and germination stages. The field was irrigated twice- one at 15 days and the other one at 30 days after sowing.

### 3.11 Harvesting

The crop was harvested at maturity on 10$^{th}$ May 2008. The harvested crop of each plot was bundled separately. Grain and straw yields were recorded plot wise and the yields were expressed in t $ha^{-1}$.

### 3.12 Collection of samples

#### 3.12.1 Soil Sample

The initial soil samples were collected randomly from different spots of the field selected for the experiment at 0-15 cm depth before the land preparation and mixed thoroughly to make a composite sample for analysis. Post harvest soil samples were collected from each plot at 0-15 cm depth on $15^{th}$ May 2008. The samples were air -dried, grounded and sieved through a 2 mm (10 meshes) sieve and preserved for analysis.

#### 3.12.2 Plant sample

Plant samples were collected from every individual plot for laboratory analysis at maturity stage of the crop. The samples were collected by avoiding the border area of the plots. The plant samples were dried in the electric oven at $70^0$ C for 48 hours. After that the samples were grounded in an electric grinding machine and stored for chemical analysis.

### 3.13 Collection of experimental data

Ten (10) plants from each plot were selected as random and were tagged for the data collection. Data were collected at harvesting stage. The sample plants were cut down to ground level prior to harvest and dried properly in the sun. The seed yield and stover yield per plot were recorded after cleaning and drying those properly in the sun. Data were collected on the following parameters:

1. Plant height (cm)
2. Number of branches plant$^{-1}$

3. Number of pods plant$^{-1}$
4. Pod length (cm)
5. Number of seeds pod$^{-1}$
6. Weight of 1000-seeds (g)
7. Grain yield (t ha$^{-1}$)
8. Stover yield (t ha$^{-1}$)
9. N, P, K, S and Zn content of plant
10. N, P, K, S and Zn contents in seed
11. N, P, K, S and Zn contents in postharvest soil

### 3.13.1 Plant height

The plant height was measured from the ground level to the top of the canopy of 10 randomly selected plants from each plot and averaged. It was done at the maturity stage of the crop.

### 3.13.2 Number of branches plant $^{-1}$

No. of branches were counted from 10 randomly selected plants at maturity stage from each plot and averaged.

### 3.13.3Number of pods plant $^{-1}$

Pods of 10 randomly selected plants were counted at maturity stage from each plot and averaged.

### 3.13.4 Pod length (cm)

Pod length was measured at maturity stage for 10 pods randomly collected from each plot and averaged.

### 3.13.5 Number of seeds pod$^{-1}$

The number of seeds from 10 randomly selected pods from each plot were counted and averaged.

### 3.13.6 Thousand seed weight

Thousand seeds of mungbean were counted randomly and then weighed plot wise.

### 3.13.7 Grain yield

Grains obtained from 1 $m^2$ area from the center of each individual plot was dried, weighed carefully and then converted into t $ha^{-1}$ as yield.

### 3.13.8 Stover yield

Stover obtained from 1 $m^2$ area from the center of each individual plot was dried, weighed carefully and expressed in t $ha^{-1}$.

## 3.14 Chemical analysis of the plant and soil samples

### 3.14.1 Plant sample analysis

The grounded plant samples were digested with conc. $HNO_3$ and $HClO_4$ mixture for the determination of P, K, S and Zn.

#### 3.14.1. a Nitrogen

Plant samples were digested with 30% $H_2O_2$, conc. $H_2SO_4$ and a catalyst mixture ($K_2SO_4$ : $CuSO_4.5H_2O$ : Selenium powder in the ratio 100 : 10 : 1, respectively) for the determination of total nitrogen by Micro-Kjeldal method. Nitrogen in the digests were determined by distillation with 40% NaOH followed by titration of the distillate absorbed in $H_3BO_3$ with 0.01N $H_2SO_4$ (Jackson, 1973).

#### 3.14.1. b Phosphorous

Phosphorous in the digest was determined by ascorbic acid blue color method (Murphy and Riley, 1962) with the help of a Spectrophotometer.

### 3.14.1. c Potassium

The exchangeable potassium content in plant samples were determined by flame photometer (Black, 1965).

### 3.14.1. d Sulphur

Sulphur content in the digests were determined by turbidimetric method as described by Hunt (1980) using a Spectrophotometer (LKB Novaspac, 4049).

### 3.14.1. e Zinc

The zinc content in plant samples were determined directly by Atomic Absorption Spectrophotometer. ( Page *et al.* , 1982 ).

### 3.14.2 Soil sample analysis

### 3.14.2. a Total nitrogen

Total nitrogen of soil samples were estimated by Micro-Kjeldahl method where soils were digested with 30% $H_2O_2$ conc. $H_2SO_4$ and catalyst mixture ($K_2SO_4$: $CuSO_4$. 5 $H_2O$ : Selenium powder in the ratio 100 : 10 : 1 respectively). Nitrogen in the digests were determined by distillation with 40% NaOH followed by titration of the distillate absorbed in $H_3BO_3$ with 0.01N $H_2SO_4$ (Jackson, 1973).

### 3.14.2. b Available Phosphorous

Available phosphorous was extracted from the soil by Bray-1 method (Bray and Kurtz, 1945). Phosphorous in the extract was determined by ascorbic acid blue color method (Murphy and Riley, 1962) with the help of a Spectrophotometer.

### 3.14.2. c Available potassium

Available potassium was extracted from soil by 1N ammonium acetate. The exchangeable potassium content in plant samples were determined by flame photometer (Black, 1965).

### 3.14.2. d Available sulphur

Available sulphur was extracted from the soil with Ca $(H_2PO_4)_2$. $H_2O$ (Fox, *et. al.*, 1964). Sulphur in the extract was determined by the turbidimetric method as described by Hunt (1980) using a Spectrophotometer (LKB Novaspec, 4049). The intensity of turbid was measured by spectrophotometer at 420 nm wavelength.

### 3.14.2. e Zinc

Zinc content in the digests were extracted by 0.05N HCl solution and determined directly by Atomic Absorption Spectrophotometer. ( Page *et al.* , 1982 ).

### 3.14.3 Statistical analysis

The data were analyzed statistically to find out the significance of the difference among the treatments. The mean values of all the characters were evaluated and analysis of variance was performed by the 'F' (variance ratio) test. The significance of the differences among pairs of treatment means was estimated by the Least Significant Difference (LSD) test at 5% and 1% level of probability (Gomez and Gomez, 1984).

# CHAPTER IV

# RESULTS AND DISCUSSION

# CHAPTER 4

# RESULTS AND DISCUSSION

The results on different yield attributes, yield and nutrient concentrations in the plants and grains and availability of different nutrients in the soil after harvest of mungbean are presented in this chapter.

## 4.1 Plant height

### 4.1.1 Effect of potassium on plant height

The effects of potassium on the plant height of mungbean are presented in (Table 4.1). Significant variation was observed on plant height when the plot was fertilized with different doses of potassium. Plant height was increased with K levels from 0-20 Kg $ha^{-1}$ then declined. The highest plant height (43.29 cm) was obtained with 20Kg K $ha^{-1}$ which was followed by $K_3$ (30 Kg K $ha^{-1}$) treatment. On the other hand, the lowest plant height (35.72 cm) was observed in the $K_0$ treatment where no potassium was applied. The result is agreed with the findings of Nita *et al.* (2002) who observed significant increase in plant height of mungbean due to the application of increasing level of K fertilizer.

### 4.1.2 Effect of zinc on plant height

Mungbean plants showed significant variation in respect of plant height when zinc fertilizers in different doses were applied (Table 4.2). Among the different fertilizer doses, $Zn_2$ (3 Kg Zn $ha^{-1}$) showed the highest plant height (40.96 cm). On the contrary, the lowest plant height (38.50 cm) was observed in the treatment where no zinc was applied. Islam *et al.* (1989) found significant increase in plant height of mungbean due to the application of 0.1% - 0.2% ZnO solution.

**Table 4.1 Effect of potassium on growth parameters**

| Levels of K (Kg $ha^{-1}$) | Plant height (cm) | No. of branches $plant^{-1}$ | No. of pods $plant^{-1}$ | No. of seeds $pod^{-1}$ |
|---|---|---|---|---|
| $K_0$ | 35.72 c | 1.73 b | 14.42 d | 9.239 d |
| $K_1$ | 39.77 b | 2.63 a | 16.05 b | 10.81 b |
| $K_2$ | 43.29 a | 2.74 a | 18.05 a | 11.32 a |
| $K_3$ | 40.17 b | 2.54 a | 15.67 c | 10.10 c |
| **LSD** | **0.661** | **0.324** | **0.324** | 0.281 |
| **Significance level** | **5%** | **5%** | **5%** | **5%** |

$K_0$ = 0 Kg K $ha^{-1}$, $K_1$ =10 Kg K $ha^{-1}$, $K_2$ = 20 Kg K $ha^{-1}$, $K_3$ = 30 Kg K $ha^{-1}$

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly.

### 4.1.3 Interaction effect of potassium and zinc on plant height

Combined application of different doses of potassium and zinc fertilizers showed significant effect on the plant height of mungbean (Table 4.3). The lowest plant height (33.78 cm) was observed in the treatment combination of $K_0Zn_0$ (No potassium and No zinc). On the other hand the highest plant height (44.03 cm) was recorded with $K_2Zn_2$ (20 kg K $ha^{-1}$ + 3 kg Zn $ha^{-1}$). Singh *et al.* (1993) found significant increase in plant height of mungbean due to the application of increasing level of K fertilizer.

### 4.2 Number of branches plant$^{-1}$

#### 4.2.1 Effect of potassium on number of branches plant$^{-1}$

Significant variation was observed in number of branches plant$^{-1}$ of mungbean when different doses of potassium were applied (Table 4.1). The highest number of branches plant$^{-1}$ (2.74) was recorded in $K_2$ (20 kg K ha$^{-1}$). The lowest number of branches plant$^{-1}$ (1.73) was recorded in the K control plot. Gobindar and Thirumurugan (2000) found significant increase in number of branches of mungbean due to the application of 1.0% KCl + 1.0% $KNO_3$.

**Table 4.2 Effect of zinc on growth parameters**

| Treatments | Plant height (cm) | No. of branches plant$^{-1}$ | No. of pods plant$^{-1}$ | No. of seeds pod$^{-1}$ |
|---|---|---|---|---|
| $Zn_0$ | 38.50 c | 2.68 b | 16.00 | 10.38 |
| $Zn_1$ | 39.75 b | 2.80 a | 15.96 | 10.39 |
| $Zn_2$ | 40.96 a | 2.75ab | 16.16 | 10.37 |
| **LSD** | **0.573** | **0.088** | ------------- | ------------- |
| **Significance level** | **5%** | **5%** | **NS** | **NS** |

$Zn_0$ = 0 Kg Zn ha$^{-1}$, $Zn_1$ =1.5 Kg Zn ha$^{-1}$, $Zn_2$ = 3 Kg Zn ha$^{-1}$

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly.
NS= Non significant

#### 4.2.2 Effect of zinc on number of branches plant$^{-1}$

Different doses of zinc fertilizers showed significant variations in respect of number of branches plant$^{-1}$ (Table 4.2). Among the different doses of fertilizers, $Zn_1$ (1.5 kg Zn ha$^{-1}$) showed the highest number of branches plant$^{-1}$ (2.80) which was statistically similar to $Zn_2$ (3 Kg Zn ha$^{-1}$) treatment. On the contrary, the lowest number of branches plant$^{-1}$ (2.68) was observed with $Zn_0$, where no zinc fertilizer was applied. The result accords with the findings of Islam *et al.* (1989) who observed significant increase in number of branches plant$^{-1}$ of mungbean due to the application of 0.1% - 0.2% Zn0 solution.

### 4.2.3 Interaction effect of potassium and zinc on number of branches plant$^{-1}$

The combined effect of different doses of K and Zn fertilizers on the number of branches plant$^{-1}$ of mungbean was statistically significant (Table 4.3). The highest number of branches plant$^{-1}$ (2.82) was recorded with the treatment combination of $K_2Zn_2$ (20 kg K ha$^{-1}$ + 3 kg Zn ha$^{-1}$). On the other, hand the lowest number of branches plant$^{-1}$ (1.48) was found in control treatment (No K and No Zn). Singh *et al.* (1993) found significant increase in number of branches plant$^{-1}$ of mungbean due to the application of increasing level of K fertilizer.

## 4.3 Number of pods plant$^{-1}$

### 4.3.1 Effect of potassium on number of pods plant$^{-1}$

Different doses of potassium showed Significant variation was in respect of number of pods plant$^{-1}$ of mungbean when different doses of potassium were applied (Table 4.1). The highest number of pods plant$^{-1}$ (18.05) was recorded in $K_2$ (20 kg K ha$^{-1}$) .The lowest number of pods plant$^{-1}$ (14.42) was recorded in the $K_0$ treatment where no potassium was applied. Asghar *et al.* (1996) found significant increase in number of pods plant$^{-1}$ of mungbean due to the application of 75 kg $K_20$ ha$^{-1}$.

**Table 4.3 Interaction effect of potassium and zinc on growth parameters**

| Treatments | Plant height (cm) | No. of branches plant$^{-1}$ | No. of pods plant$^{-1}$ | No. of seeds pod$^{-1}$ |
|---|---|---|---|---|
| $K_0Zn_0$ | 33.78 g | 1.48 f | 14.22 f | 9.04 f |
| $K_0 Zn_1$ | 35.76 f | 1.65 f | 14.38 f | 9.33 ef |
| $K_0 Zn_2$ | 37.61 e | 2.06 e | 14.66 ef | 9.33 ef |
| $K_1 Zn_0$ | 38.24 e | 2.59 bcd | 15.54 d | 10.84 bc |
| $K_1 Zn_1$ | 40.14 cd | 2.66 abcd | 16.29 c | 10.84 bc |
| $K_1 Zn_2$ | 40.92 c | 2.65 abcd | 16.32 c | 10.75 bc |
| $K_2 Zn_0$ | 41.40 c | 2.68 abc | 17.81 b | 11.20 ab |
| $K_2 Zn_1$ | 43.45 b | 2.74 ab | 17.77 b | 11.21 ab |
| $K_2 Zn_2$ | 45.03 a | 2.82 a | 18.47 a | 11.56 a |
| $K_3 Zn_0$ | 40.59 cd | 2.68 abc | 16.44 c | 10.50 cd |
| $K_3 Zn_1$ | 39.66 d | 2.48 cd | 15.41 d | 10.16 d |
| $K_3 Zn_2$ | 40.27 cd | 2.47 d | 15.17 de | 9.62 e |
| **LSD** | **1.146** | **0.177** | **0.561** | **0.487** |
| **Significance level** | **5%** | **5%** | **5%*** | **5%** |

$K_0$ = 0 Kg K ha$^{-1}$, $K_1$ =10 Kg K ha$^{-1}$, $K_2$ = 20 Kg K ha$^{-1}$, $K_3$ = 30 Kg K ha$^{-1}$
$Zn_0$ = 0 Kg Zn ha$^{-1}$, $Zn_1$ =1.5 Kg Zn ha$^{-1}$, $Zn_2$ = 3 Kg Zn ha$^{-1}$

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly.

### 4.3.2 Effect of zinc fertilizers on number of pods plant$^{-1}$

Different doses of zinc fertilizers showed insignificant variations in respect of number of pods plant$^{-1}$ (Table 4.2). Among the different doses of fertilizers, $Zn_2$ (3 kg Zn ha$^{-1}$) produced the highest number of pods plant$^{-1}$ (16.16). On the contrary, the lowest number of pods plant$^{-1}$ (15.96) was observed with $Zn_1$ where (1.5 kg Zn ha$^{-1}$) zinc fertilizer was applied. This findings is in conformity with the results of Islam *et al.* (1989) who found significant increase in number of pods plant$^{-1}$ of mungbean due to the application of 0.1% - 0.2% Zn0 solution.

### 4.3.3 Interaction effect of potassium and zinc on number of pods plant$^{-1}$

The combined effect of different doses of K and Zn fertilizer on number of pods plant$^{-1}$ of mungbean was significant (Table 4.3). The highest number of pods plant$^{-1}$ (18.47) was found with the treatment combination of $K_2Zn_2$ (20 kg K ha$^{-1}$ + 3 kg Zn ha$^{-1}$). On the other hand, the lowest number of pods plant$^{-1}$ (14.22) was found in $K_0Zn_0$ (0 kg K ha$^{-1}$ + 0 kg Zn ha$^{-1}$).



## 4.4 Number of seeds pod$^{-1}$

### 4.4.1 Effect of potassium on number of seeds pod$^{-1}$

Potassium had Significant variation on number of seeds pod$^{-1}$ of mungbean when different doses of potassium were applied (Table 4.1). The highest number of seeds pod$^{-1}$ (11.32) was recorded in $K_2$ (20 kg K ha$^{-1}$). The lowest number of seeds pod$^{-1}$ (9.23) was recorded in the $K_0$ treatment where no potassium was applied. Asghar *et al.* (1996) found significant increase in number of seeds plant$^{-1}$ of mungbean due to the application of 75 kg $K_2$ ha$^{-1}$.

### 4.4.2 Effect of zinc on number of seeds pod$^{-1}$

There was no significant variation in respect of number of seeds pod$^{-1}$ due to the application of Zn (Table 4.2). Among the different doses of fertilizers $Zn_1$ showed the highest number of seeds pod$^{-1}$ (10.39) which was statistically similar with the other doses of zinc fertilizer applied.

### 4.4.3 Combined effect of potassium and zinc on number of seeds $pod^{-1}$

The combined effect of different doses of K and Zn fertilizers on number of seeds $pod^{-1}$ of mungbean was statistically significant (Table 4.3). The highest number of seeds $pod^{-1}$ (11.56) was recorded with the treatment combination of $K_2Zn_2$ (20 kg K $ha^{-1}$ + 3 kg Zn $ha^{-1}$). On the other hand, the lowest number of seeds $pod^{-1}$ (9.04) was found in $K_0Zn_0$ treatment (No K and No Zn). Bandopadhyay *et al.* (2002) found significant increase in number of seeds $pod^{-1}$ of groundnut due to the application of K and Zn.

## 4.5 Pod length

### 4.5.1 Effect of potassium on pod length

Pod length as affected by different doses of potassium showed a statistically significant variation (Table 4.4). Among the different doses of K the highest pod length (9.10cm) was observed in $K_2$ (20 kg K $ha^{-1}$). The lowest pod length (7.34 cm) was recorded in the $K_0$ treatment where no K was applied. Gobindar and Thirumurugan (2000) observed significant increase in number of pod length of mungbean due to the application of 1.0% KCl and 1.0% $KNO_3$.

### 4.5.2 Effect of zinc on pod length

Application of Zn fertilizers at different doses showed a significant variation on the pod length of mungbean (Table 4.5). Among the different Zn fertilizer doses, $Zn_2$ (3 kg Zn $ha^{-1}$) showed the highest pod length (10.95cm). On the other hand, the lowest pod length (7.17 cm) was recorded with $Zn_0$ treatment where no Zn was applied. Islam *et al.* (1986) found significant increase in pod length of mungbean due to the application of of 0.1% - 0.2% Zn0 solution.

### 4.5.3 Interaction effect of potassium and zinc on pod length

Combined effects of K and Zn fertilizers produced significant variation on pod length (Table 4.6). The highest pod length (9.14 cm) was recorded in the treatment combination of $K_2Zn_2$ (20 kg K $ha^{-1}$ + 3 kg Zn $ha^{-1}$). On the other hand, the lowest pod length (7.03 cm) was found in $K_0Zn_0$. Singh *et al.* (1993) found significant increase in pod length of mungbean due to the application of increasing level of K fertilizer.

## 4.6 Weight of 1000-seed

### 4.6.1 Effect of potassium on weight of 1000-seed

Significant variation was observed on the weight of 1000-seed of mungbean when different doses of K were applied (Table 4.4). The maximum weight of 1000-seed (43.81 g) was found in $K_2$ (20 kg K $ha^{-1}$). The lowest weight of 1000-seed (38.70 g) was recorded in the $K_0$ treatment where no K was applied. Sangakara (1990) found significant increase in weight of 1000-seed of mungbean due to the application of 0-120 kg $K_20$ $ha^{-1}$.

### 4.6.2 Effect of zinc on weight of 1000-seed

Different doses of Zn fertilizers showed significant variations in respect of the weight of 1000-seed (Table 4.5). Zinc fertilization at $Zn_2$ (3 kg Zn $ha^{-1}$) produced the highest weight of 1000-seed (43.64g). On the contrary, the lowest weight of 1000-seed (41.36 g) was observed with $Zn_0$ where no Zn fertilizer was applied. Islam *et al.* (1989) found significant increase in weight of 1000-seed of mungbean due to the application of 0.1% - 0.2% Zinc oxide solution.

**Table 4.4 Effect of potassium on yield and yield contributing characters**

| Treatments | Pod length (cm) | 1000-seed wt. (g) | Grain yield (t $ha^{-1}$) | Stover yield (t $ha^{-1}$) |
|---|---|---|---|---|
| $K_0$ | 7.34 c | 38.70 c | 1.22 d | 2.02 b |
| $K_1$ | 8.03 b | 41.89 b | 1.27 c | 2.44 a |
| $K_2$ | 9.10 a | 43.81 a | 1.42 a | 2.54 a |
| $K_3$ | 7.69 bc | 41.56 b | 1.34 b | 2.43 a |
| **LSD** | **0.349** | **0.652** | **0.053** | **0.193** |
| **Significance level** | **5%** | **5%** | **5%** | **5%** |

$K_0$ = 0 Kg K $ha^{-1}$, $K_1$ =10 Kg K $ha^{-1}$, $K_2$ = 20 Kg K $ha^{-1}$, $K_3$ = 30 Kg K $ha^{-1}$

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly.

### 4.6.3 Interaction effect of potassium and zinc on weight of 1000-seed

The combined effect of different doses of K and Zn fertilizers on the weight of 1000-seed of mungbean was statistically significant (Table 4.6). The highest weight of 1000-seed (44.21 g) was recorded with the treatment combination of $K_2Zn_2$ (20 kg K $ha^{-1}$ + 3 kg Zn $ha^{-1}$). On the other hand, the lowest weight of 1000-seed (38.36 g) was found in $K_0Zn_1$ (0 kg K $ha^{-1}$ + 1.5 kg Zn $ha^{-1}$).

### 4.7 Grain yield of mungbean

#### 4.7.1 Effect of K on grain yield

Significant variation was observed on the grain yield of mungbean when different doses of K were applied (Table 4.4). The highest grain yield of mungbean (1.42 t $ha^{-1}$) was recorded in $K_2$ (20 kg K $ha^{-1}$). The lowest grain yield of mungbean (1.22 t $ha^{-1}$) was recorded in the $K_0$ treatment where no K was applied. These findings are similar with some other researchers findings, Asghar *et al.* (1996)who obtained highest mungbean grain yield due to the application of 75 kg $K_20$ $ha^{-1}$.

**Table 4.5 Effect of zinc fertilizer on yield and yield contributing characters and the yield**

| Treatments | Pod length (cm) | 1000-seed wt. (g) | Grain yield (t $ha^{-1}$) | Stover yield (t $ha^{-1}$) |
|---|---|---|---|---|
| $Zn_0$ | 7.17 c | 41.36 ab | 1.31 ab | 2.29 b |
| $Zn_1$ | 8.00 b | 41.47 ab | 1.29 b | 2.30 b |
| $Zn_2$ | 10.95 a | 43.64 a | 1.34 a | 2.45 a |
| LSD | **0.302** | **0.565** | **0.046** | **0.167** |
| **Significance level** | **5%** | **5%** | **5%** | **5%** |

$Zn_0$ = 0 Kg Zn $ha^{-1}$ , $Zn_1$ =1.5 Kg Zn $ha^{-1}$ , $Zn_2$ = 3 Kg Zn $ha^{-1}$

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly.

#### 4.7.2 Effect of Zn on grain yield

Different doses of Zn fertilizers showed significant variations in respect of grain yield of mungbean (Table 4.5). Among the different doses of Zn fertilizers, $Zn_2$ (3 kg Zn $ha^{-1}$) produced the highest grain yield of mungbean (1.34 t $ha^{-1}$). On the contrary, the lowest grain yield of mungbean (1.29 t $ha^{-1}$) was found in $Zn_0$ where no Zn fertilizer was applied.

**Table 4.6 Interaction effect of potassium and zinc on yield and yield contributing characters**

| Treatments | Pod length (cm) | 1000-seed wt. (g) | Grain yield (t $ha^{-1}$) | Stover yield (t $ha^{-1}$) |
|---|---|---|---|---|
| $K_0Zn_0$ | 7.32 cd | 38.36 g | 1.16 f | 1.97 c |
| $K_0 Zn_1$ | 7.17 d | 38.11 g | 1.24 ef | 1.90 c |
| $K_0 Zn_2$ | 7.54 cd | 39.62 f | 1.25 ef | 1.19 d |
| $K_1 Zn_0$ | 7.90 bc | 41.31 de | 1.31 bcd | 2.24 b |
| $K_1 Zn_1$ | 8.27 b | 42.59 bc | 1.25 ef | 2.66 a |
| $K_1 Zn_2$ | 7.93 bc | 41.78 cde | 1.26 def | 2.44 ab |
| $K_2 Zn_0$ | 9.11 a | 43.42 ab | 1.36 bcd | 2.48 ab |
| $K_2 Zn_1$ | 9.06 a | 43.81 a | 1.41 b | 2.50 ab |
| $K_2 Zn_2$ | 9.14 a | 44.21 a | 1.51 a | 2.64 a |
| $K_3 Zn_0$ | 8.35 b | 42.34 bcd | 1.40 b | 2.49 ab |
| $K_3 Zn_1$ | 7.43 cd | 41.38 cde | 1.26 cdef | 2.43 ab |
| $K_3 Zn_2$ | 7.28 cd | 40.95 e | 1.36 bc | 2.38 ab |
| **LSD** | **0.605** | **1.131** | **0.092** | **0.334** |
| **Significance level** | **5%** | **5%** | **5%** | **5%** |

$K_0$ = 0 Kg K $ha^{-1}$, $K_1$ =10 Kg K $ha^{-1}$, $K_2$ = 20 Kg K $ha^{-1}$, $K_3$ = 30 Kg K $ha^{-1}$
$Zn_0$ = 0 Kg Zn $ha^{-1}$, $Zn_1$ =1.5 Kg Zn $ha^{-1}$, $Zn_2$ = 3 Kg Zn $ha^{-1}$

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly.

### 4.7.3 Interaction effect of K and Zn fertilizers on grain yield

The combined effect of different doses of K and Zn fertilizers on the grain yield of mungbean was significant (Table 4.6). The highest grain yield of mungbean (1.51 t $ha^{-1}$) was recorded with the treatment combination of $K_2Zn_2$ (20 kg K $ha^{-1}$ + 3 kg Zn $ha^{-1}$). On the other hand, the lowest grain yield of mungbean (1.16 t $ha^{-1}$) was found in $K_0Zn_0$ treatment (No K and No Zn). Singh and Humuman (2001) found significant increase in grain yield of mungbean due to the application of 30 kg $K_20$ $ha^{-1}$ and 15 mg Zn $kg^{-1}$.

## 4.8 Stover yield of mungbean

### 4.8.1 Effect of K on stover yield

Significant variation was observed on the stover yield of mungbean when different doses of K were applied (Table 4.4). The highest stover yield of mungbean (2.54 t $ha^{-1}$) was recorded in $K_2$ (20 kg K $ha^{-1}$). The lowest stover yield (2.02 t $ha^{-1}$) was recorded in the $K_0$ treatment where no K was applied. Danita *et al.* (1992) found significant increase in stover yield of mungbean due to the application of increasing level of K fertilizer.

### 4.8.2 Effect of Zn on stover yield

Different doses of Zn fertilizers showed significant variations in respect of stover yield of mungbean (Table 4.5). Application of Zn at 3 kg Zn $ha^{-1}$produced the highest stover yield (2.45 t $ha^{-1}$). On the contrary, the lowest stover yield (2.29 t $ha^{-1}$) was observed with $Zn_{0,}$ where no Zn fertilizer was applied. The results are in agreement with the findings of Ahmed *et al.* (1986)

found significant increase in stover yield of mungbean due to the application of Zn.

### 4.8.3 Interaction effect of K and Zn on stover yield

The combined effect of different doses of K and Zn fertilizers on the stover yield was significant (Table 4.6). The highest stover yield (2.64 t $ha^{-1}$) was recorded with the treatment combination of $K_2Zn_2$ (20 kg K $ha^{-1}$ + 3 kg Zn $ha^{-1}$). On the other hand, the lowest stover yield (1.90 t $ha^{-1}$) was found in treatment $K_0Zn_1$ (0 kg K $ha^{-1}$ + 1.5 kg Zn $ha^{-1}$). Singh and Humuman (2001) found significant increase in stover yield of mungbean due to the application of 30 kg K $ha^{-1}$ and 5 kg Zn $ha^{-1}$.

## 4.9 Total nitrogen concentrations in mungbean stover

### 4.9.1 Effect of K on nitrogen content in mungbean stover

Application of K showed significant variation in the nitrogen concentration in mungbean stover (Table 4.7).The N concentration in mungbean stover increased with increasing level of K fertilizer up to 20 Kg K $ha^{-1}$ The highest nitrogen concentration in stover (0.733%) was recorded in $K_2$ (20 kg K $ha^{-1}$). On the other hand, the lowest nitrogen concentration in stover (0.53%) was recorded in the $K_0$ treatment where no K was applied. Nita *et al.* (2002) found significant increase in nitrogen concentration in stover of mungbean due to the application of 0, 20 and 40 kg K $ha^{-1}$.

### 4.9.2 Effect of Zn on nitrogen content in mungbean Stover

The effect of different doses of zinc showed statistically significant difference in nitrogen concentration in mungbean stover (Table 4.8). The highest nitrogen concentration among the treatments of zinc (0.65%) was observed in $Zn_2$ (3 kg Zn $ha^{-1}$). The lowest nitrogen concentration (0.53%) was observed in $Zn_0$ (control condition) treatment. Singh and Bajpai (1993) found significant increase of nitrogen concentration in mungbean due to the application of 0, 5. 10 kg $ZnSO_4$ $ha^{-1}$.

### 4.9.3 Interaction effect of K and Zn on nitrogen concentrations in mungbean stover

Significant effect of combined application of different doses of K and Zn fertilizers on the nitrogen concentration was observed in the stover of mungbean (Table 4.9). The highest concentration of nitrogen in the stover (0.74%) was recorded with the highest dose of $K_2Zn_2$ (20 kg K $ha^{-1}$ + 3 kg Zn $ha^{-1}$) On the other hand, the lowest nitrogen concentration (0.52%) in stover was found in $K_0Zn_0$ (No K+ No Zn) treatment. Singh *et al.* (1993) found significant increase of nitrogen concentration in mungbean stover due to the application of 60 kg K $ha^{-1}$ and 10 ppm Zn.

## 4.10 Total phosphorus concentrations in mungbean stover

### 4.10. 1 Effect of K on phosphorus content in mungbean stover

Application of K showed significant variation in the phosphorus concentration in mungbean stover (Table 4.7). The highest phosphorus concentration in stover (0.46%) was recorded in $K_2$ (20 kg K $ha^{-1}$). On the other hand, the lowest phosphorus concentration in stover (0.36%) was recorded in the $K_0$ treatment where no K was applied. Nita *et al.* (2002) found significant increase in phosphorus concentration in stover of mungbean due to the application of 0, 20 and 40 kg K $ha^{-1}$.

### 4.10.2 Effect of Zn on phosphorus content in mungbean Stover

The effect of different doses of zinc showed statistically significant difference in phosphorus concentration in mungbean stover (Table 4.8). The highest phosphorus concentration of 0.51% was observed in $Zn_2$ (3 kg Zn $ha^{-1}$) treatment. The lowest phosphorus concentration of 0.41% was observed in $Zn_0$ (control condition) treatment. Singh and Bajpai (1982) found significant increase of phosphorus concentration in mungbean due to the application of 0, 5. 10 kg $ZnSO_4$ $ha^{-1}$.

### 4.10.3 Interaction effect of K and Zn on phosphorus concentrations in mungbean stover

Significant effect of combined application of different doses of K and Zn fertilizers on the phosphorus concentration was observed in the stover of mungbean (Table 4.9). The highest concentration of phosphorus in the stover (0.51%) was recorded with the $K_2Zn_2$ (20 kg K $ha^{-1}$ + 3 kg Zn $ha^{-1}$) treatment combination On the other hand, the lowest phosphorus concentration (0.34%) in stover was found in $K_0Zn_0$ (control treatment). Singh *et al.*(1993) found significant increase of phosphorus concentration in mungbean stover due to the application of 60 kg K $ha^{-1}$ and 10 ppm Zn.

**Table 4.7 Effect of potassium on total N P K S and Zn concentrations in mungbean stover**

| Treatments | Total N % | Total P (%) | Total K (%) | Total S (%) | Total Zn (%) |
|---|---|---|---|---|---|
| $K_0$ | 0.53 d | 0.36 c | 0.73 c | 0.102 | 0.005 |
| $K_1$ | 0.62 c | 0.43 b | 0.87 b | 0.105 | 0.006 |
| $K_2$ | 0.73 a | 0.46 a | 0.98 a | 0.109 | 0.007 |
| $K_3$ | 0.68 b | 0.45 ab | 0.96 a | 0.106 | 0.007 |
| **LSD** | **0.043** | **0.030** | **0.030** | ---------- | ---------- |
| **Significance level** | **5%** | **5%** | **5%** | **NS** | **NS** |

$K_0$= 0 Kg K $ha^{-1}$, $K_1$=10 Kg K $ha^{-1}$, $K_2$= 20 Kg K $ha^{-1}$, $K_3$= 30 Kg K $ha^{-1}$

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly.
NS = Non significant.

### 4.11 Total potassium concentrations in mungbean stover

#### 4.11.1 Effect of K on potassium content in stover

A statistically significant variation was observed in potassium concentration in stover of mungbean with different doses of potassium (Table 4.7). The highest potassium concentration among the different doses of potassium (0.98%) was recorded in $K_2$ (20 kg K $ha^{-1}$). On the other hand, the lowest potassium concentration (0.73 %) was recorded in the $K_0$ treatment where no K was applied. Nita *et al.* (2002) found significant increase in potassium concentration in stover of mungbean due to the application of 0, 20 and 40 kg K $ha^{-1}$.

#### 4.11.2 Effect of Zn on potassium content in mungbean stover

The effect of different doses of Zn fertilizers showed a statistically significant variation in the potassium concentration in mungbean stover (Table 4.8). The accumulation of K increased in higher level of Zn fertilizer application. The highest potassium concentration among the different doses of Zn fertilizers (0.92%) was recorded with $Zn_2$ treatment. The lowest potassium concentration (0.86 %) was observed in the fertilizer combination $Zn_0$ where no Zn fertilizer was applied.

#### 4.11.3 Interaction effect of K and Zn on total potassium content in mungbean stover

Significant effect of combined application of different doses of K and Zn fertilizers on the potassium concentration was observed in stover of mungbean (Table 4.9). The highest concentration of potassium in the stover (1.08 %) was recorded with $K_2Zn_2$ (20 kg K $ha^{-1}$ + 3 kg Zn $ha^{-1}$) treatment. On the other hand, the lowest potassium concentration (0.66 %) was found in $K_0Zn_0$ (No K + No Zn) treatment.

### 4.12 Total sulphur concentrations in mungbean stover

#### 4.12.1 Effect of K on sulphur content in mungbean stover

A statistically insignificant variation was observed in sulphur concentration in stover of mungbean with different doses of K (Table 4.7). Among the different doses of K the highest sulphur concentration in plant (0.109 %) was recorded in $K_2$ (20 kg K $ha^{-1}$) treatment. On the other hand, the lowest sulphur concentration (0.102 %) was recorded in the $K_0$ treatment where no K was applied.

**Table 4.8 Effect of zinc on total N P K S and Zn concentrations in mungbean stover**

| Treatments | Total N % | Total P (%) | Total K (%) | Total S (%) | Total Zn (%) |
|---|---|---|---|---|---|
| $Zn_0$ | 0.53 c | 0.41 c | 0.86 b | 0.105 | 0.006 |
| $Zn_1$ | 0.60 b | 0.46 b | 0.87 b | 0.105 | 0.007 |
| $Zn_2$ | 0.65 a | 0.51 a | 0.92 a | 0.107 | 0.008 |
| **LSD** | **0.037** | **0.026** | **0.026** | **NS** | **NS** |
| **Significance level** | **5%** | **5%** | **5%** | -------- | -------- |

$Zn_0$= 0 Kg Zn $ha^{-1}$ , $Zn_1$=1.5 Kg Zn $ha^{-1}$ , $Zn_2$= 3 Kg Zn $ha^{-1}$

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly.
NS = Non significant.

### 4.12.2 Effect of Zn on sulphur content in mungbean stover

The effect of different doses of Zn fertilizers showed a statistically insignificant variation in the sulphur concentration of stover of mungbean (Table 4.8). The highest sulphur concentration in plant among different doses of Zn fertilizers (0.107 %) was recorded with $Zn_2$ treatment. The lowest sulphur concentration (0.105 %) was observed in the treatment $Zn_0$ where no Zn fertilizer was applied. Singh *et al.* (1997) found significant increase of sulphur concentration in summer green gram due to the application of 5 kg Zn $ha^{-1}$.

### 4.12.3 Interaction effect of K and Zn on sulphur content in mungbean stover

Insignificant effect of combined application of different doses of K and Zn fertilizers on the sulphur concentration was observed in stover of mungbean (Table 4.9). The highest concentration of sulphur in the stover (0.109%) was recorded with the $K_2Zn_2$ treatment (20 kg K $ha^{-1}$ + 3 kg Zn $ha^{-1}$). On the other hand, the lowest sulphur concentration (0.101 %) was found in $K_0$ $Zn_0$ (No K + No Zn) treatment.

## 4.13 Total zinc concentrations in mungbean stover

### 4.13.1 Effect of K on zinc content in mungbean stover

A statistically insignificant variation was observed in zinc concentration in stover of mungbean with different doses of K (Table 4.7). Among the different doses of K the highest zinc concentration in plant (0.007 %) was recorded in $K_3$ (30 kg K $ha^{-1}$) treatment. On the other hand, the lowest zinc concentration (0.005 %) was recorded in the $K_0$ treatment where no K was applied.

### 4.13.2 Effect of Zn on zinc content in mungbean stover

The effect of different doses of Zn fertilizers showed a statistically insignificant variation in the zinc concentration in stover of mungbean (Table 4.8). The highest zinc concentration in stover among different doses of Zn fertilizers (0.008 %) was recorded with $Zn_3$. The lowest zinc concentration (0.006 %) was observed in the treatment $Zn_0$ where no Zn fertilizer was applied. Singh *et al.*

(1997) found significant increase of zinc concentration in summer greengram due to the application of 5 kg Zn $ha^{-1}$.

**Table 4.9 Interaction effect of potassium and zinc on N P K S and Zn concentrations in mungbean stover**

| Treatments | Total nitrogen (%) | Total phosphorus (%) | Total potassium (%) | Total sulphur (%) | Total zinc (%) |
|---|---|---|---|---|---|
| $K_0Zn_0$ | 0.52 | 0.34 c | 0.66 g | 0.101 | 0.005 |
| $K_0 Zn_1$ | 0.55 | 0.36 bc | 0.73 f | 0.102 | 0.006 |
| $K_0 Zn_2$ | 0.53 | 0.39 abc | 0.81 e | 0.105 | 0.006 |
| $K_1 Zn_0$ | 0.58 | 0.42 abc | 0.85 de | 0.104 | 0.006 |
| $K_1 Zn_1$ | 0.61 | 0.44 abc | 0.87 cd | 0.105 | 0.006 |
| $K_1 Zn_2$ | 0.67 | 0.43 abc | 0.89 bcd | 0.105 | 0.006 |
| $K_2 Zn_0$ | 0.72 | 0.43 abc | 0.92 bc | 0.106 | 0.006 |
| $K_2 Zn_1$ | 0.73 | 0.47 ab | 0.93 b | 0.107 | 0.007 |
| $K_2 Zn_2$ | 0.74 | 0.51 a | 1.08 a | 0.109 | 0.007 |
| $K_3 Zn_0$ | 0.71 | 0.48 a | 1.07 a | 0.108 | 0.008 |
| $K_3 Zn_1$ | 0.69 | 0.45 ab | 0.91 bc | 0.106 | 0.007 |
| $K_3 Zn_2$ | 0.64 | 0.43 abc | 0.90 bcd | 0.106 | 0.007 |
| **LSD** | **NS** | **0.092** | **0.053** | **NS** | **NS** |
| **Significance level** | ---------- | **5%** | **5%** | ------------ | ---------- |

$K_0$ = 0 Kg K $ha^{-1}$, $K_1$ =10 Kg K $ha^{-1}$, $K_2$ = 20 Kg K $ha^{-1}$, $K_3$ = 30 Kg K $ha^{-1}$
$Zn_0$ = 0 Kg Zn $ha^{-1}$, $Zn_1$ =1.5 Kg Zn $ha^{-1}$, $Zn_2$ = 3 Kg Zn $ha^{-1}$

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly.
NS = Non significant

### 4.13.3 Interaction effect of K and Zn on zinc content in mungbean stover

Insignificant effect of combined application of different doses of K and Zn fertilizers on the zinc concentration was observed in stover of mungbean (Table

4.9). The highest concentration of zinc in the stover (0.008 %) was recorded with the $K_3Zn_0$ (30 kg K $ha^{-1}$ + 0 kg Zn $ha^{-1}$) treatment combination. On the other hand, the lowest zinc concentration (0.005 %) was found in $K_0Zn_0$ (No K + No Zn) treatment combination.

### 4.14 Total nitrogen concentrations in mungbean seed

#### 4.14.1 Effect of K on nitrogen content in mungbean seed

Application of K showed significant variation in the nitrogen concentration in mungbean seed (Table 4.10). The highest nitrogen concentration in seed (7.07%) was recorded in $K_2$ (20 kg K $ha^{-1}$). On the other hand, the lowest nitrogen concentration in seed (6.15%) was recorded in the $K_0$ treatment where no K was applied. Chanda *et al.* (2002) found significant increase of nitrogen concentration in mungbean seed due to the application of K fertilizer.

#### 4.14.2 Effect of Zn on nitrogen content in mungbean seed

The effect of different doses of zinc showed statistically significant difference in nitrogen concentration in mungbean seed (Table 4.11). The highest nitrogen concentration among the treatments of zinc (6.65%) was observed in $Zn_2$ (3 kg Zn $ha^{-1}$). The lowest nitrogen concentration (6.46%) was observed in $Zn_0$ (control condition) treatment.

#### 4.14.3 Interaction effect of K and Zn on nitrogen concentrations in mungbean seed

Significant effect of combined application of different doses of K and Zn fertilizers on the nitrogen concentration was observed in the seed of mungbean

(Table 4.12). The highest concentration of nitrogen in the seed (7.12%) was recorded with the treatment combination $K_2Zn_2$ (20 kg K $ha^{-1}$ + 3 kg Zn $ha^{-1}$). This may be due to the higher supply and subsequent assimilation of this element in the seed. On the other hand, the lowest nitrogen concentration (5.74%) in seed was found in $K_0Zn_0$ (No K+ No Zn) treatment combination. Singh *et al.* (1993) found significant increase of nitrogen concentration in mungbean due to the application of increasing level of K fertilizer.

**Table 4.10 Effect of potassium on total N P K S and Zn concentrations in mungbean seeds**

| Treatments | Total N (%) | Total P (%) | Total K (%) | Total S (%) | Total Zn (%) |
|---|---|---|---|---|---|
| $K_0$ | 6.15 c | 0.42 c | 1.43 d | 0.31 c | 0.005 |
| $K_1$ | 6.87 b | 0.47 b | 1.85 b | 0.35 bc | 0.006 |
| $K_2$ | 7.07 a | 0.56 a | 2.18 a | 0.42 a | 0.007 |
| $K_3$ | 6.21 c | 0.47 b | 1.61 c | 0.37 b | 0.006 |
| **LSD** | **0.06** | **0.03** | **0.05** | **0.05** | **NS** |
| **Significance level** | **5%** | **5%** | **5%** | **5%** | -------- |

$K_0$ = 0 Kg K $ha^{-1}$, $K_1$ =10 Kg K $ha^{-1}$, $K_2$ = 20 Kg K $ha^{-1}$, $K_3$ = 30 Kg K $ha^{-1}$

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly.
NS = Non significant.

**4.15 Total phosphorus concentrations in mungbean seed**

**4.15. 1 Effect of K on phosphorus content in mungbean seed**

Application of K increased phosphorus concentration in mungbean plant (Table 4.10). The highest phosphorus concentration in seed (0.56%) was recorded in

$K_2$ (20 kg K $ha^{-1}$). On the other hand, the lowest phosphorus concentration in seed (0.42%) was recorded in the $K_0$ treatment where no K was applied. Increased P concentration in mungbean seed was also reported by Kaushik *et al.* (1996) found significant increase of phosphorus concentration in mungbean seed due to the application of $K_2S0_4$ .

### 4.15.2 Effect of Zn on phosphorus content in mungbean seed

Concentration of P in mungbean seed was affected significant due to the application of different doses of zinc (Table 4.11). The highest phosphorus concentration among the treatments of zinc (0.49%) was observed in $Zn_1$ (1.5 kg Zn $ha^{-1}$). The lowest phosphorus concentration (0.47%) was found in plants raised without Zn fertilization. $Zn_0$ (0 kg Zn $ha^{-1}$) treatment. Singh and Humuman (2001) found significant increase of phosphorus concentration in wheat due to the application of Zn at 15 mg Zn $kg^{-1}$.

### 4.15.3 Interaction effect of K and Zn on phosphorus concentrations in mungbean seed.

Significant effect of combined application of different doses of K and Zn fertilizers on the phosphorus concentration was observed in mungbean seed (Table 4.12). The highest concentration of phosphorus in the seed (0.58%) was recorded with the treatment combinations $K_2Zn_3$. This may be due to the higher supply and subsequent assimilation of this element in the seed. On the other hand, the lowest phosphorus concentration (0.41%) in seed was recorded without K and Zn application ($K_0Zn_0$). Singh *et al.* (1993) found significant increase of phosphorus concentration in mungbean due to the application of increasing level of K fertilizer.

### 4.16 Total potassium concentrations in mungbean seed

#### 4.16.1 Effect of K on potassium content in seed

A statistically significant variation was observed in potassium concentration in seed of mungbean with different doses of K (Table 4.10). The highest potassium concentration among the different doses of K (2.18 %) was recorded in $K_2$ (20 kg K $ha^{-1}$) in seed. On the other hand, the lowest potassium concentration in mungbean seed (1.43 %) was recorded in the $K_0$ treatment where no K was applied.

#### 4.16.2 Effect of Zn on potassium content in mungbean seed

The effect of different doses of Zn fertilizers showed a statistically significant variation in the potassium concentration in mungbean seed (Table 4.11). The highest potassium concentration in mungbean seed (1.85 %) was recorded in 3Kg Zn $ha^{-1}$. The lowest potassium concentration (1.70%) in seed was observed in the treatment having no zinc fertilizer was applied.

#### 4.16.3 Interaction effect of K and Zn on potassium content in mungbean seed

Significant effect of combined application of different doses of K and Zn fertilizers on the potassium concentration was observed in seed of mungbean (Table 4.12). The highest concentration of potassium in the seed (2.26%) was recorded with the treatment combination of $K_2Zn_2$ which may be due to the higher supply and subsequent assimilation of this element in the seed. On the other hand, the lowest potassium concentration (1.20 %) in seed was found in $K_0Zn_0$ treatment combination. Singh *et al.* (1993) found significant increase of potassium concentration in mungbean due to the application of K (30, 60, and 90 kg $K_2O$ $ha^{-1}$) and Zn (5, 10 and 15 ppm).

**Table 4.11 Effect of zinc on total N P K S and Zn concentrations in mungbean seeds**

| Treatments | Total N % | Total P (%) | Total K (%) | Total S (%) | Total Zn(%) |
|---|---|---|---|---|---|
| **$Zn_0$** | 6.46 b | 0.47 a | 1.70 c | 0.35 a | 0.006 |
| **$Zn_1$** | 6.60 a | 0.49 a | 1.76 b | 0.36 a | 0.007 |
| **$Zn_2$** | 6.65 a | 0.48 a | 1.85 a | 0.37 a | 0.008 |
| **LSD** | **0.05** | **0.02** | **0.04** | **0.04** | **NS** |
| **Significance level** | **5%** | **5%** | **5%** | **5%** | ——— |

$Zn_0$ = 0 Kg Zn $ha^{-1}$, $Zn_1$ =1.5 Kg Zn $ha^{-1}$, $Zn_2$ = 3 Kg Zn $ha^{-1}$

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly.
NS = Non significant.



### 4.17 Total sulphur concentrations in mungbean seed

#### 4.17.1 Effect of K on sulphur content in mungbean seed

Sulphur concentrations in mungbean seed varied significantly with different doses of K (Table 4.10). Among the K doses the highest sulphur concentration in seed (0.42%) was recorded in $K_2$ (20 kg K $ha^{-1}$) treatment. On the other hand, the lowest sulphur concentration in seed (0.31 %) was obtained from having no potassium recorded in the $K_0$ treatment where no K was applied.

### 4.17.2 Effect of Zn on sulphur content in mungbean seed

The effect of different doses of Zn fertilizers showed significant variation in sulphur concentration in the seed of mungbean (Table 4.11). The highest sulphur concentration (0.37%) in seed among different doses of Zn fertilizer was recorded with $Zn_2$ treatment (3 kg Zn ha$^{-1}$). The lowest sulphur concentration (0.35 %) in seed was observed in the treatment $Zn_0$ where no zinc fertilizer was applied.Application of Zn increased sulphur concentration in summer greengram was observed by Singh *et al.* (1997).

### 4.17.3 Interaction effect of K and Zn on sulphur content in mungbean seed

Combined application of K and Zn fertilizers affected sulphur concentration in mungbean seed (Table 4.12). The highest concentration of sulphur in seed (0.45%) was recorded with the higher dose of K and Zn fertilizers which may be due to the higher supply and subsequent assimilation of these elements in the seed. The lowest sulphur concentration (0.30 %) in seed was found in $K_0Zn_1$ treatment combination.

## 4.18 Total zinc concentrations in mungbean seed

### 4.18.1 Effect of K on zinc content in mungbean seed

Different dosed of Potassium did not influence zinc concentration in seed (Table 4.10). However, the highest zinc concentration in seed (0.007 %) was recorded in $K_2$ (20 kg K $ha^{-1}$) treatment. The lowest zinc concentration in seed (0.005 %) was recorded in the $K_0$ treatment where no K was applied.

### 4.18.2 Effect of Zn on zinc content in mungbean seed

Zinc fertilization had no significant importance on Zn concentration in mungbean seeds (Table 4.11). The highest zinc concentration in seed (0.008 %) was recorded with $Zn_2$ (3 kg Zn $ha^{-1}$) and the lowest zinc concentration (0.006 %) in seed was observed in $Zn_0$ treatment where no Zn fertilizer was applied.

### 4.18.3 Interaction effect of K and Zn on zinc content in mungbean seed

There was no significant effect of combined application of K and Zn fertilizers on the zinc concentration was observed in mungbean seed (Table 4.12). The highest concentration of zinc in the seed (0.008 %) was recorded with the $K_2Zn_2$ (20 kg K $ha^{-1}$ + 3 kg Zn $ha^{-1}$) which may be due to the higher supply and subsequent assimilation of this element in the seed. It was observed that zinc concentration in seed was the lowest (0.004 %) in $K_0Zn_0$ (No K + No Zn) treatment combination.

## 4.19 Effect of potassium on nutrient status of the post harvest soil of mungbean field

### 4.19.1 Effect of potassium on total nitrogen content in the post harvest soil of mungbean field

A statistically insignificant variation was observed in nitrogen concentration in post harvest soil of mungbean field with different doses of K (Table 4.14).

Considering the different doses of K the highest nitrogen concentration in soil (0.084 %) was recorded in $K_2$ (20 kg K $ha^{-1}$). The lowest nitrogen concentration in soil (0.074%) was recorded in the $K_0$ treatment with no K was applied.

**Table 4.12 Interaction effect of potassium and zinc on N P K S and Zn concentrations in mungbean seeds**

| Treatments | Total nitrogen (%) | Total phosphorus (%) | Total potassium (%) | Total sulphur (%) | Total zinc (%) |
|---|---|---|---|---|---|
| $K_0Zn_0$ | 5.74 h | 0.41 d | 1.20 g | 0.31 cd | 0.004 |
| $K_0 Zn_1$ | 6.24 f | 0.42 d | 1.47 f | 0.30 d | 0.005 |
| $K_0 Zn_2$ | 6.46 e | 0.44 cd | 1.62 e | 0.31 cd | 0.005 |
| $K_1 Zn_0$ | 6.78 d | 0.46 cd | 1.92 c | 0.32 cd | 0.006 |
| $K_1 Zn_1$ | 6.83 cd | 0.48 bc | 1.77 d | 0.36 bcd | 0.006 |
| $K_1 Zn_2$ | 6.92 bc | 0.49 bc | 1.87 c | 0.38 abcd | 0.007 |
| $K_2 Zn_0$ | 7.01 ab | 0.53 ab | 2.06 b | 0.40 abc | 0.007 |
| $K_2 Zn_1$ | 7.09 a | 0.56 a | 2.21 a | 0.43 ab | 0.007 |
| $K_2 Zn_2$ | 7.12 a | 0.58 a | 2.26 a | 0.45 a | 0.008 |
| $K_3 Zn_0$ | 6.31 f | 0.49 bc | 1.63 e | 0.39 abc | 0.007 |
| $K_3 Zn_1$ | 6.23 f | 0.48 bc | 1.58 e | 0.36 bcd | 0.006 |
| $K_3 Zn_2$ | 6.10 g | 0.44 cd | 1.63 e | 0.36b cd | 0.005 |
| **LSD** | 0.11 | 0.05 | 0.09 | 0.07 | **NS** |
| **Significance level** | **5%** | **5%** | **5%** | **5%** | ——— |

$K_0$ = 0 Kg K $ha^{-1}$ , $K_1$ =10 Kg K $ha^{-1}$ , $K_2$ = 20 Kg K $ha^{-1}$ , $K_3$ = 30 Kg K $ha^{-1}$
$Zn_0$ = 0 Kg Zn $ha^{-1}$ , $Zn_1$ =1.5 Kg Zn $ha^{-1}$ , $Zn_2$ = 3 Kg Zn $ha^{-1}$

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly.
NS = Non significant.

### 4.19.2 Effect of potassium on available phosphorus content in the post harvest soil of mungbean field

Significant variation was observed in phosphorus concentration in postharvest soil with different doses of K (Table 4.14). Considering the different doses of K the highest phosphorus concentration in soil (19.34 ppm) was recorded in $K_2$ (20 kg K $ha^{-1}$). The lowest phosphorus concentration in soil (15.44 ppm) was found in $K_0$ treatment which was statistically similar to $K_0$ where no K was applied.

### 4.19.3 Effect of potassium on available potassium content in the post harvest soil of mungbean field

Potassium concentration in postharvest soil of mungbean with different doses of K was found significant (Table 4.14). The highest potassium concentration in soil (43.83 ppm) was recorded in $K_2$ (20 kg K $ha^{-1}$ and the lowest potassium concentration in soil (35.17 ppm) potassium concentration was recorded in $K_0$ treatment. Prasad *et al.* (2000) found significant increase of potassium concentration in the post harvest soil of summer mungbean field due to the application of 20- 30 kg K $ha^{-1}$.

### 4.19.4 Effect of potassium on available sulphur content in the post harvest soil of mungbean field

A statistically significant variation was observed in sulphur concentration in the post harvest soil of mungbean with different doses of K (Table 4.14).

Considering the different doses of K the highest sulphur concentration in soil (23.45 ppm) was recorded in $K_2$ (20 kg K $ha^{-1}$) treatment. The lowest sulphur concentration in soil (15.57 ppm) was recorded in the $K_0$ treatment where no K was applied.

**Table 4.13 Effect of potassium on total N, available P, available K, available S and available Zn contents of the post harvest soil of mungbean field**

| Treatments | Total N (%) | Avail. P (ppm) | Avail. K (ppm) | Avail. S (ppm) | Available Zn (ppm) |
|---|---|---|---|---|---|
| $K_0$ | 0.074 | 15.44 c | 35.17 d | 15.57 d | 0.55 c |
| $K_1$ | 0.082 | 15.69 c | 37.33 c | 17.53 c | 0.75 b |
| $K_2$ | 0.084 | 19.34 a | 43.83 a | 23.45 a | 1.06 a |
| $K_3$ | 0.082 | 17.85 b | 42.00b | 22.40 b | 1.05 a |
| **LSD** | **NS** | **0.74** | **0.030** | **0.71** | **0.030** |
| **Significance level** | ------ | **5%** | **5%** | **5%** | **5%** |

$K_0$ = 0 Kg K $ha^{-1}$ , $K_1$ =10 Kg K $ha^{-1}$ , $K_2$ = 20 Kg K $ha^{-1}$ , $K_3$ = 30 Kg K $ha^{-1}$

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly.
NS = Non significant.

### 4.19.5 Effect of potassium on available zinc content in the post harvest soil of mungbean field

A statistically significant variation was observed in zinc concentration in the post harvest soil of mungbean with different doses of K (Table 4.14). Considering the different doses of K the highest zinc concentration in soil (1.06 ppm) was recorded in $K_2$ (20 kg K $ha^{-1}$) treatment. The lowest zinc concentration in soil (0.55 ppm) was recorded in treatment with no K was applied.

## 4.20 Effect of zinc on the nutrient status of the post harvest soil of mungbean field

### 4.20.1 Effect of zinc on total nitrogen content in the post harvest soil of mungbean field

The effect of different doses of zinc fertilizers did not show significant variation in the nitrogen concentration in post harvest soil (Table 4.15). Among the treatments $Zn_1$ (1.5 kg Zn $ha^{-1}$) showed the highest nitrogen concentration (0.084 %) in soil. The lowest nitrogen concentration (0.074 %) in soil was observed in the treatment where no Zn fertilizer, ($Zn_0$).

### 4.20.2 Effect of zinc on available phosphorus content in the post harvest soil of mungbean field

Significant variation in phosphorus concentration in the soil of mungbean field (Table 4.15) was observed due to Zn application. Among the different treatments $Zn_2$ (3 kg Zn $ha^{-1}$) showed the highest phosphorus concentration (18.87 ppm). The lowest phosphorus concentration (14.63 ppm) in soil was observed in the treatment $Zn_0$ where no Zn fertilizer was applied.

### 4.20.3 Effect of zinc on available potassium content in the post harvest soil of mungbean field

The effect of different doses of zinc fertilizers produced significant differences in the potassium concentration in soil of mungbean field (Table 4.15). Among the different doses of Zn fertilizers, $Zn_2$ (3 kg Zn $ha^{-1}$) gave the highest potassium concentration (48.75 ppm) in soil. The lowest potassium concentration (42.50 ppm) in soil was observed in the $Zn_0$ treatment where no Zn fertilizer was applied.

### 4.20.4 Effect of zinc on available sulphur content in the post harvest soil of mungbean field

The effect of different doses of zinc fertilizers showed a statistically significant difference in the sulphur concentration in soil of mungbean field (Table 4.15). Among the different treatments of fertilizer doses, $Zn_1$ (1.5 kg Zn $ha^{-1}$) showed the highest sulphur concentration (25.88 ppm) in soil. The lowest sulphur concentration (15.65 ppm) in soil was observed in the treatment $Zn_0$ where no Zn fertilizer was applied.

**Table 4.14 Effect of zinc on total N, available P, available K, available S and available Zn contents of the post harvest soil of mungbean field**

| Treatments | Total N % | Avail. P (ppm) | Avail. K (ppm) | Avail. S (ppm) | Available Zn (ppm) |
|---|---|---|---|---|---|
| $Zn_0$ | 0.074 | 14.63 c | 42.50 c | 15.65 c | 0.44 c |
| $Zn_1$ | 0.081 | 15.46 b | 43.08 b | 22.33 b | 0.68 b |
| $Zn_2$ | 0.084 | 18.87 a | 48.75 a | 25.88 a | 1.00 a |
| **LSD** | **NS** | **0.64** | **0.02** | **0.74** | **0.02** |
| **Significance level** | -------- | **5%** | **5%** | **5%** | **5%** |

$Zn_0$ = 0 Kg Zn $ha^{-1}$ , $Zn_1$ =1.5 Kg Zn $ha^{-1}$ , $Zn_2$ = 3 Kg Zn $ha^{-1}$

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly.
NS = Non significant

### 4.20.5 Effect of zinc on available zinc content in the post harvest soil of mungbean field

The effect of different doses of zinc fertilizers showed significant variation in the zinc concentration in postharvest soil of mungbean field (Table 4.15). Among the different treatments of fertilizer doses, $Zn_2$ (3 kg Zn $ha^{-1}$) showed the highest zinc concentration (1.00 ppm) in soil, which was statistically different from other treatments. The lowest zinc concentration (0.44 ppm) in soil was observed in the treatment $Zn_0$ where no Zn fertilizer was applied.

### 4.21 Interaction effect of potassium and zinc on nutrient status of the post harvest soil of mungbean field

#### 4.21.1 Interaction effect of potassium and zinc on total nitrogen content of the post harvest soil of mungbean field

There was no significant effect was observed in postharvest soil due to combined application of K and Zn fertilizers (Table 4.16). The highest nitrogen concentration (0.089 %) was recorded in the treatment combination with $K_2Zn_2$ (20 kg K $ha^{-1}$ + 3 kg Zn $ha^{-1}$) treatment. On the other hand, the lowest nitrogen concentration (0.074 %) in soil was found in $k_0Zn_0$ treatment combination. Singh *et al.* (1993) found significant increase of total nitrogen concentration in soil of mungbean field due to the application of K (30, 60, and 90 kg $K_2O$ $ha^{-1}$) and Zn (5, 10 and 15 ppm).

#### 4.21.2 Interaction effect of potassium and zinc on available phosphorus content of the post harvest soil of mungbean field

Significant effect of combined application of different doses of K and Zn fertilizers on the phosphorus concentration was observed in soil of mungbean field (Table 4.16). The highest phosphorus concentration (23.33 ppm) was recorded in the treatment combination of $K_2Zn_2$ (20 kg K $ha^{-1}$ + 3 kg Zn $ha^{-1}$) in the post harvest soil. On the other hand, the lowest phosphorus concentration (12.20 ppm) in soil was found in $K_0$ $Zn_0$ (No K+ No Zn) treatment. Singh *et al.* (1993) found significant increase of phosphorus concentration in soil mungbean field due to the application of K (30, 60, and 90 kg $K_2O$ $ha^{-1}$) and Zn (5, 10 and 15 ppm).

**Table 4.15 Interaction effects of potassium and zinc on total N, available P, available K, available S and available Zn contents in the post harvest soil of mungbean field**

| Treatments | Total nitrogen (% | Available phosphorus (ppm) | Available potassium (ppm) | Available sulphur (ppm) | Availabl e zinc (ppm) |
|---|---|---|---|---|---|
| $K_0Zn_0$ | 0.074 | 12.20 g | 41.00 g | 17.27 g | 0.43 f |
| $K_0 Zn_1$ | 0.085 | 13.45 f | 47.67 d | 17.68 fg | 0.56 e |
| $K_0 Zn_2$ | 0.079 | 19.16 c | 51.00 b | 18.16 fg | 0.60 de |
| $K_1 Zn_0$ | 0.078 | 18.57 cd | 49.00 c | 19.16 ef | 1.17 ab |
| $K_1 Zn_1$ | 0.075 | 16.44 e | 49.00 c | 18.78 f | 0.46 ef |
| $K_1 Zn_2$ | 0.086 | 17.62 de | 51.00 b | 19.33 e | 0.68 de |
| $K_2 Zn_0$ | 0.085 | 19.92 bc | 46.00 e | 21.76 d | 1.03 c |
| $K_2 Zn_1$ | 0.081 | 18.79 cd | 47.33 d | 20.27 de | 1.16 ab |
| $K_2 Zn_2$ | 0.089 | 23.33 a | 55.01 a | 27.14 a | 1.20 a |
| $K_3 Zn_0$ | 0.087 | 17.79 d | 50.00 bc | 23.83 c | 0.85 d |
| $K_3 Zn_1$ | 0.087 | 21.68 b | 44.33 f | 26.19 b | 1.06 bc |
| $K_3 Zn_2$ | 0.063 | 22.54 ab | 50.00 bc | 23.88 c | 1.15 b |
| **LSD** | **NS** | **1.19** | **1.03** | **1.48** | **0.160** |
| **Significance level** | -------- | **5%** | **5%** | **5%** | **5%** |

$K_0$ = 0 Kg K $ha^{-1}$, $K_1$ =10 Kg K $ha^{-1}$, $K_2$ = 20 Kg K $ha^{-1}$, $K_3$ = 30 Kg K $ha^{-1}$
$Zn_0$ = 0 Kg Zn $ha^{-1}$, $Zn_1$ =1.5 Kg Zn $ha^{-1}$, $Zn_2$ = 3 Kg Zn $ha^{-1}$

In a column, figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly.
NS = Non significant

### 4.21.3 Interaction effect of potassium and zinc on available potassium content of the post harvest soil of mungbean field

Significant effect of combined application of different doses of K and Zn fertilizers on the potassium concentration was observed in soil of mungbean field (Table 4.16). The highest potassium concentration (55.01 ppm) was recorded in the treatment combination of $K_2Zn_2$ (20 kg K $ha^{-1}$ + 3 kg Zn $ha^{-1}$). On the other hand, the lowest potassium concentration (41.00 ppm) in the post harvest soil was found in $K_0Zn_0$ (control condition) treatment.

### 4.21.4 Interaction effect of potassium and zinc on available sulphur content of the post harvest soil of mungbean field

Significant effect of combined application of different doses of K and Zn fertilizers on the sulphur concentration was observed in soil of mungbean field (Table 4.16). The highest sulphur concentration (27.14 ppm) was recorded in the treatment combination of $K_2Zn_2$ (20 kg K $ha^{-1}$ + 3 kg Zn $ha^{-1}$).On the other hand, the lowest sulphur concentration (17.27 ppm) in soil sample was found in $K_0Zn_0$ (No K+ No Zn) treatment.

### 4.21.5 Interaction effect of potassium and zinc on available zinc content of the post harvest soil of mungbean field

Significant effect of combined application of different doses of K and Zn fertilizers on the zinc concentration was observed in soil of mungbean field (Table 4.16). The highest zinc concentration (1.20 ppm) was recorded in the treatment combination of $K_2Zn_2$ (20 kg K $ha^{-1}$ + 3 kg Zn $ha^{-1}$). The lowest zinc concentration (0.043 ppm) in soil sample was found in $K_0$ $Zn_0$ treatment.

# CHAPTER V

# SUMMARY AND CONCLUSION

# CHAPTER 5

# SUMMARY AND CONCLUSION

An experiment was conducted at the Sher-e-Bangla Agricultural University Farm Dhaka 1207 (Tejgaon series under AEZ No.28) during the *kharif* season of 2008 to study the " Effect of Potassium and Zinc on the growth and yield of Mungbean". The soil was silty clay loam in texture having pH 6.14 and organic carbon content of 0.68%. Four levels of potassium (0, 10, 20 and 30 kg K $ha^{-1}$) and three levels of zinc (0,1.5 and 3.0 kg Zn $ha^{-1}$ ) were used in the study. Levels of these two nutrient elements making 12 treatment combinations. The experiment was carried out in Randomized complete block design with three replications.



Recommended blanket doses of N, P and Sulphur (20 kg N from urea, 30 kg P from TSP and 15 kg S $ha^{-1}$ from Gypsum, respectively) were applied.

The whole amounts of Urea, TSP, MP fertilizer were applied as basal dose during final land preparation. The required amounts of K (from Muriate of Potash) and Zn (from Zinc sulphate) were applied at a time as per treatment combination after field layout of the experiment and were mixed properly through hand spading.

Mungbean seeds were sown on 5th March 2008 and the crop was harvested on 10th May 2008. The data were collected plot wise for plant height (cm), number of branches $plant^{-1}$, number of pods $plant^{-1}$, number of seeds $pod^{-1}$, pod length (cm), weight of 1000-seed (g), grain yield (t $ha^{-1}$) and stover yield (t $ha^{-1}$).

The plot wise post harvest soil samples from 0-15 cm depth were collected and analyzed for N, P, K, S and Zn contents. Seed and stover samples were also chemically analyzed for total N, P, K, S and Zn contents. All the data were statistically analyzed following F-test and the mean comparison was made by LSD. The results of the experiment are stated below.

Plant height was significantly affected by different levels of K and Zn. Plant height increased with increasing levels of K and Zn individually. The individual application of K @ 20 kg $ha^{-1}$($K_3$) produced the tallest plant (43.29cm), whereas application of Zn @ 3 kg $ha^{-1}$ produced the tallest plant height (40.96 cm) . The tallest plant (44.03 cm) was found in $K_2Zn_3$ treatment combination which was higher over control treatment (33.88 cm).

The individual application of K and Zn showed positive effect on the number of branches per plant, number of pod per plant, number of seeds per pod, weight of 1000 seed, grain yield and stover yield. All the plant characters increased with increasing levels of K and Zn up to higher level.

Like all other plant characters, grain yield of mungbean was influenced significantly due to application of K and Zn. Grain yield increased with increasing levels of K and Zn up to certain level. The highest grain yield (1.42 t $ha^{-1}$) was found in plants receiving K @ 20 kg $ha^{-1}$ and the lowest was recorded in $K_0$ treatment. The individual application of Zn @ 1.5 kg $ha^{-1}$ produced the highest amount of grain yield (1.34 t $ha^{-1}$). The combined application of K and Zn had positive effect on grain yield of mungbean. The highest grain yield of mungbean was recorded in $K_2Zn_2$ treatment which was statistically identical with each other. The lowest yield was recorded in $K_0Zn_0$ treatment. Combined application of K@ 20 kg $ha^{-1}$ and Zn @ 1.5 kg $ha^{-1}$ produced higher grain yield as compared to control treatment significantly.

Nutrient contents (N, P, K, S and Zn) in stover were positively affected due to K and Zn fertilization. The interaction effect of K and Zn was also found remarkable. The N, P, K, S and Zn content in stover varied from 0.52% in $K_0Zn_0$ treatment to 0.74% in $K_2Zn_2$ treatment, 0.36% in $K_0Zn_0$ treatment to 0.50% in $K_2Zn_2$ treatment, 0.66% in $K_0Zn_0$ treatment to 1.08% in $K_2Zn_2$ treatment, 0.101% in $K_0Zn_0$ treatment to 0.112% in $K_3Zn_0$ and 0.005% in $K_0Zn_0$ to 0.008 % in $K_3Zn_0$ treatment, respectively. Nitrogen (N),P, K, S and Zn contents in stover increased with increasing levels of K and Zn up to certain level.

Nutrient contents (N, P, K, S and Zn) in seeds were positively affected due to K and Zn fertilization. The interaction effect of K and Zn was also found remarkable. The N, P, K, S and Zn content in seeds varied from 5.74% in $K_0Zn_0$ treatment to 7.12% in $K_2Zn_2$ treatment, 0.41% in $K_0Zn_0$ treatment to 0.58% in $K_2Zn_2$ treatment, 1.20% in $K_0Zn_0$ treatment to 2.26% in $K_2Zn_2$ treatment, 0.30% in $K_0Zn_1$ treatment to 0.45% in $K_2Zn_2$ and 0.004% in $K_0Zn_0$ to 0.008% in $K_2Zn_2$ treatment, respectively. The N, P, K, S and Zn contents in seeds also increased with increasing level of K and Zn up to certain level.

Nutrient content in post harvest soil was also influenced by different levels of K and Zn application. The total N, available P, available K, available S and available Zn of post harvest soil varied from 0.074 to 0.089%, 12.20 to 23.33 ppm, .41.00 to 55.01 ppm, 12.27 to 27.24 ppm and 0.433 to 1.20 ppm, respectively due to combined application of K and Zn at different levels. The addition of K and Zn not only increased the yield but also protect the soil from total exhaustion of nutrients.

**Considering all the parameters studied the following conclusion may be drawn:-**

- The growth and yield of mungbean responded significantly by the combined application of potassium and Zinc fertilizers @ 20 kg K $ha^{-1}$ and 3 kg Zn $ha^{-1}$ respectively.

**Based on the results of the present study, the following recommendation may be drawn:-**

- Application of Potassium and Zinc fertilizers @ 20 kg K $ha^{-1}$ and 3 kg Zn $ha^{-1}$ may be the best combination for higher yield of mungbean and also to maintain soil fertility and productivity than their individual application in Tejgaon series under AEZ No.28.

Recommendation may vary from soil to soil. However, to reach a specific conclusion and recommendation more research work on mungbean should be done in different Agro-ecological zones of Bangladesh.

# REFERENCES

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# APPENDICES

# APPENDICES

**Appendix 1. Records of meteorological information (monthly) during the period from October, 2007 to February, 2008**

| Month | Air temperature (°C) | | Relative humidity | | Rainfall (mm) |
|---|---|---|---|---|---|
| | Maximum | Minimum | Morning 6am (%) | Evening 6pm (%) | |
| January, 2008 | 24.38 | 13.32 | 88.16 | 72.90 | 2.54 |
| February, 2008 | 24.63 | 13.79 | 88.16 | 62.55 | 3.06 |
| March, 2008 | 32.6 | 19.6 | 93.38 | 72.38 | 6.8 |
| April, 2008 | 33.2 | 23.1 | 95.70 | 72.90 | 7.7 |
| May, 2008 | 32.9 | 24.5 | 94.70 | 62.55 | 7.3 |

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

## Summary of analysis of variance of growth character of mungbean

**Appendix 2. Summary of analysis of variance of yield and yield attributes mungbean as influenced by different level of potassium and zinc**

| Sources of variation | Degrees of freedom | Mean square (MS) | | | | |
|---|---|---|---|---|---|---|
| | | Plant height(cm) | No. of pod $plant^{-1}$ | No.of branch $plant^{-1}$ | No. of Seeds $pod^{-1}$ | Length of pod |
| Replication | 2 | 0.002 | 0.55 | 0.024 | 0.002 | 0.109 |
| Potassium | 3 | 86.95* | 20.02* | 1.94* | 7.375* | 5.22* |
| Zinc | 2 | 18.10* | 0.12NS | 0.072* | 0.022NS | 0.159* |
| Potassium × Zinc | 6 | 3.08* | 0.82* | 0.085* | 0.26* | 0.363* |
| Error | 22 | 0.45 | 0.11 | 0.011 | 0.083 | 0.128 |

* Significant at 5% level of probability

NS= Non significant.

**Appendix 3. Summary of analysis of variance of yield and yield attributes of mungbean as influenced by different level of potassium and zinc**

| Sources of variation | Degrees of freedom | Mean square (MS) | | |
|---|---|---|---|---|
| | | 1000 seed weight(g) | Seed Yield (t $ha^{-1}$) | Stover Yield (t $ha^{-1}$) |
| Replication | 2 | 0.76 | 0.001 | 0.025 |
| Potassium | 3 | 40.06* | 0.070* | 0.487* |
| Zinc | 2 | 0.24* | 0.008* | 0.045* |
| Potassium × Zinc | 6 | 1.65* | 0.011* | 0.063* |
| Error | 22 | 0.44 | 0.003 | 0.039 |

* Significant at 5% level of probability

NS= Non significant.

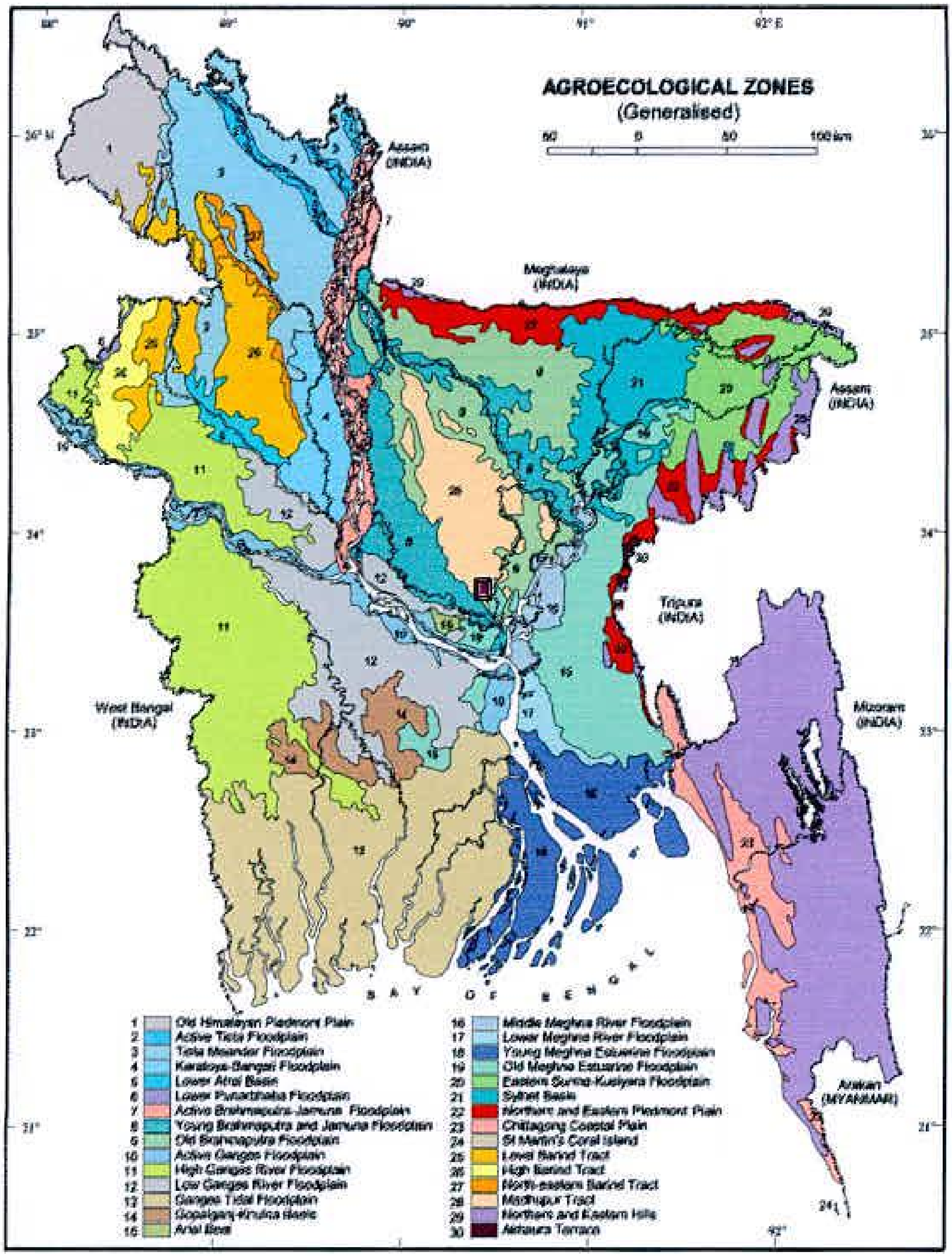


**Figure 1. Map showing the experimental site under study**

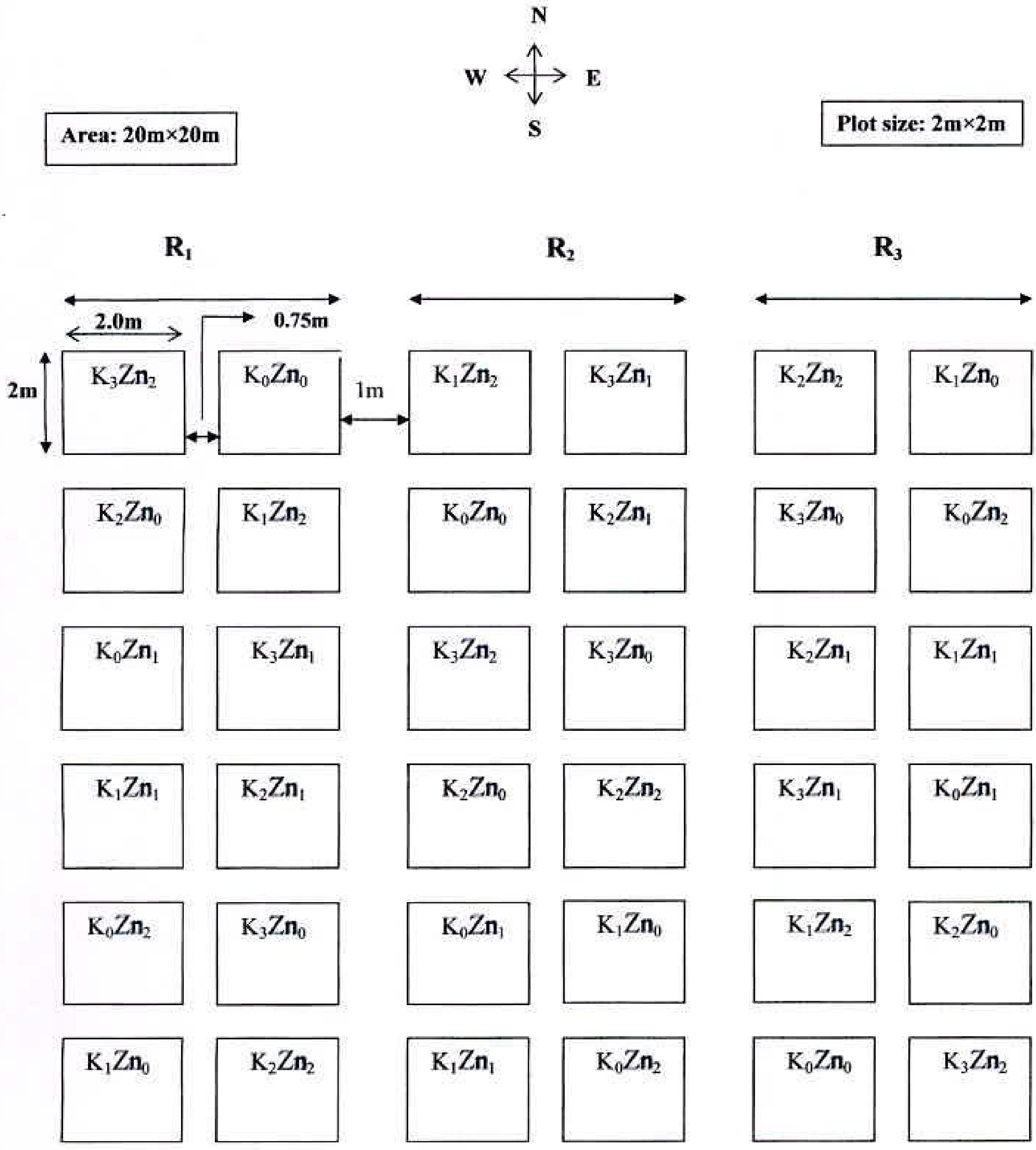


**Figure 2: Layout of the Experiment in RCBD Design**

## Field view of the experiment

**Figure 3.** Field view of experimental plot at 20 DAS.

**Figure 4.** Field view of experimental plot at 50 DAS.

**Figure 5.** Field view of experimental plot at 60 DAS.