INFLUENCE OF DIFFERENT COMBINATIONS OF MICRONUTRIENT AND SULPHUR ON GROWTH AND YIELD OF MAIZE (*Zea mays* L.)

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CERTIFICATE

This is to certify that the thesis entitled ***"INFLUENCE OF DIFFERENT COMBINATIONS OF MICRONUTRIENT AND SULPHUR ON GROWTH AND YIELD OF MAIZE (Zea mays L.)"*** *submitted to the Faculty of Agriculture, Sher-E-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE (MS)*** *in* ***AGRONOMY,*** *embodies the results of a piece of bona fide research work carried out by* ***AFROJA,*** *Registration. No.* **12-04960** *under my supervision and guidance. No part of this 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.

Dated:
Dhaka, Bangladesh

(Prof. Dr. A. K. M. Ruhul Amin)

Supervisor

DEDICATED

TO

MY BELOVED PARENTS

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The Author

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ABSTRACT

The experiment was conducted at Sher-e-Bangla Agricultural University farm to study the effect of micronutrients on the growth and yield of maize (*Zea mays* L.) during rabi season 2017-18. The experiment consisted of two factors: 1) variety viz. i) V_1= white maize (PSC-121) and ii) V_2= yellow maize (BARI hybrid bhutta 7); 2) micronutrient treatment viz. F_0= No Fertilizer, F_1= NPK, F_2= NPK+Zn+B+S+Mn, F_3= NPK+Zn+B+S (no Mn), F_4= NPK+Zn+B+Mn (no S), F_5= NPK+Zn+Mn+S (no B) and F_6= NPK+Mn+S+B (no Zn). All the fertilizers were applied at their recommended doses. The experiment was laid out in Split Plot design with two factors and three replications. The result showed that variety, micronutrients and their interaction had significant effect on growth, yield and yield contributing characters. Combined effect showed that growth parameters viz. plant height, number of leaves plant^{-1}, dry weight plant^{-1} responded positively. The highest grain yield (12.78 t ha^{-1}) was obtained from treatment V_1F_2. This heigher grain yield obtained from V_1F_2 was due to increase grains row^{-1} (32.88), grains cob^{-1} (472.10) and 1000 grain weight plant^{-1} (408.80 g). The present results indicated that the micronutrient like Zn, B and Mn combined with S should be applied along with NPK fertilizers at recommended rate to maximize yield of maize.

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LIST OF ACRONYMS

Acronyms	Full word
AEZ	Agro ecological zone
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
cm	Centimeter
CV	Coefficient of Variation
DAS	Days After Sowing
et al.	And others (*et alibi*)
FAO	Food and Agriculture organization
g	Gram
ha	Hectare
HI	Harvest Index
kg	Kilogram
LAI	Leaf Area Index
LSD	Least Significance Difference
m^2	Square Meter
MP	Muriate of potash
no.	Number
NS	Non-Significant
%	Percent
pH	Hydrogen ion concentration
$plant^{-1}$	per plant
Seed cob^{-1}	Seeds per cob
SAU	Sher-e- Bangla Agricultural University
SRDI	Soil Resources and Development Institute
TSP	Triple Superphosphate
t ha^{-1}	Ton (s) per hectare

CHAPTER I

INTRODUCTION

Maize (*Zea mays* L.) belongs to the family Poaceae is one of the most important cereal crops contributes to the world agricultural economy both as food for human and feed for animals. Maize ranks 1st in respect of yield per unit area, 2nd in respect total production and 3rd after wheat and rice in respect of acreage in cereal crops. It is a high yielder in comparison to rice and wheat occupying first position among the cereals in terms of yield (maize 6.98 t ha^{-1}; wheat 3.085 t ha^{-1}; and rice 3.038 t ha^{-1}) (BBS, 2016). Maize has been called "Queen of cereals" for it's high yield potential. It has attracted the attention in the world due to its importance being used as fodder and human food (Guruprasad *et al.*, 2016; Dogan *et al.*, 2015). In many countries it has been contributing to human food security (Katinila *et al.*, 1998).

Rice has been the traditional source of calories in Bangladesh's rural area but now about 10% of the requirement is being met by wheat. But wheat production area in Bangladesh is being shrunken gradually due to its gradual reduction in its yield and severe disease infestation like Blast. So, it's a major challenge for Bangladesh to meet the demand of cereal production as the population is increasing rapidly but the production is still limited. Bangladesh may also need to double its food production by 2050 for its projected population of over 202 million.

Due to the global climate-change scenario it may be forecasted that the currently cultivated varieties of different crops may not perform well under the adverse situation and from this point of view Bangladesh's food demand might not be met from growing only rice and wheat. So, to meet this challenge, maize (*Zea mays* L.) can be chosen to supplement cereal food deficiency because of its higher yield potential as compared to rice and wheat (Mian *et al*. 2002). Compared to other crops, the acreage of maize has expanded rapidly. A major shift in global cereal demand is underway and, by 2020, demand for maize in developing countries is expected to exceed demand for both wheat and rice (Pingali and Pandey, 2001). Over the past 40 years, the global total area under maize has increased by 40% while production has doubled (Huang *et al.*, 2006). So, it can be inferred that maize is on the way of its increased popularity.

In Bangladesh due to the expansion of poultry industry since 2004 the popularity of growing maize got a momentum and farmers have been raising the acreage of yellow maize from 50 thousand hectares to 307 thousand hectares in 2012-13 growing season with the total production of 2.12 million M tons (BBS, 2016) being which is mostly used as poultry feed. The maize is also consumed as human food throughout the world which is mostly from white-grained type. Bangladesh although produces enough food grains of nearly 38.332 Million tons annually for its 160 million people (BBS, 2016) most of which comes from rice and wheat. However, such amount cannot be guaranteed in all the years especially in the year(s) when natural calamities such as flood, cyclone and drought happen. Moreover, after 2050 when the population has been projected to be 202 million (UN, 2015; Timsina *et al*., 2016) posing an increased demand for foods for Bangladesh leaving an uncertainty in sustaining food security. So, under this assumption a third crop maize, being a C_4 crop and having two to three-fold productivity as compared to that of rice and wheat which has a higher productivity might be considered.

PSC-121 (white maize) is one of the recently developed hybrid white maize varieties with medium duration with a maturity period of 90-100 days. However, the maturity duration may be prolonged in winter growing season. Genetically the variety is a double cross hybrid having bold grain quality which remains green at maturity. This variety is mostly suitable for growing in kharif season planting with an outstanding characteristic of tolerating drought. The crop shows good stand ability**.** And BARI hybrid bhutta 7 (yellow maize) is single cross high yielding hybrid. The variety matures relatively earlier (130-140 days). In Rabi season silk formation time 75-80 days, crop duration in Rabi season 133-141 days, kernels are bold, light yellow color and flint type.

Maize can be grown all over the country especially in hilly areas where other serial production is limited. For the 2002–2004 periods, world average yields of maize and winter wheat were estimated for 4.57 and 2.77 t/ha, respectively (FAO, 2005). Yield of maize crop is alarmingly affected due to deficiency of plant nutrients. The application of essential plant nutrients in optimum quantity and right proportion is a key to enhance and sustain crop productivity. Overall crop nutrition plays a vital role in plant development and it is generally comprised of macronutrients and micronutrients with major role of macro ones, but the micronutrients (Zn, B, Co, Mn, Mo, Cu, Ni and Fe), even being required in smaller amounts are of equally vital for plant growth and development (Alloway, 2004). Micronutrients not only enhance the grain yields but also contribute to the improvement of the quality in terms of grain nutrients as well (Baloch *et al*, 2008). It was further elucidated that micronutrients can increase grain yield up to 50%, as well as increase macronutrients use efficiency (Brown *et al.* 1993). But Most of the times due to their over-mining by the crops and shortage of which often show the deficiency symptoms and yields are reduced. Joshy (1997) reported the critical limit of some micronutrients on maize as sulfur 14 ppm, boron 95 ppm, zinc 82 ppm and for manganese 0 ppm. Micronutrient deficiencies are due to not only to low contents of these elements in the soil but more often to their unavailability to growing plants (Brady and Weil, 2002). So, it is necessary to maintain the optimum availability of micronutrient to maize for higher yield. In this context, this experiment was designed to evaluate their effect on maize production and to recommend the micronutrients that could improve the productivity of maize.

Objectives

1. To find out the effect of variety on growth and yield of maize,
2. To find out the effect of micronutrient on growth and yield of maize, and
3. To find out the interaction effect of variety and micronutrient on growth and yield of maize.

CHAPTER II

REVIEW OF LITERATURE

Maize (*Zea mays* L.) ranks the largest cereal crops after rice and wheat on the basis of acreage covered by it. Its grain is a rich source of many important nutrients and used for multipurpose needed. But yield of maize crop is alarmingly affected due to deficiency of plant nutrients due to excess mining of nutrients from soil. The application of essential plant nutrients in optimum quantity and right proportion is a key to enhance and sustain crop productivity. Overall crop nutrition plays a vital role in plant development and it is generally comprised of macronutrients and micronutrients with major role of macro ones, but the micronutrients, even being required in smaller amounts are of equally vital for plant growth and development.

Effects of Variety

Kabululu (2017) reported that the yield productivity of the modern (hybrids or yielding) varieties of maize are generally higher than the local ones.

Akbar *et al.* (2016) conducted an on-farm experiments in the Bandarban valley during dry season, October 2015 through March, 2016 to investigate the possibility of introducing white maize as human food. Yield response of two maize hybrids (PSC 121 and KS 510) planted in three different row arrangements was evaluated in one experiment. The other experiment determined the optimum fertilizer rate for maize hybrids. Grain yield ranged between 7,103 kg and 10,126 kg per ha across hybrids and planting arrangements. Hybrid PSC 121 recorded 19% more yield than KS 510.

Nuss and Tanumihardjo (2010) reported that modern white maize hybrids with a short growing season produce a softer, smaller kernel that contains about 72% starch, 10% protein, and 4% fat, supplying an energy density of 365 kcal/100g.

Effects of micronutrients

A. Growth contributing characters

Wasaya et al. (2017) conducted a field study to investigate the role of Zn and B application alone and in combination through seed, soil and foliar application methods on growth, yield and net returns of maize grown under rainfed conditions. Results showed that combined application of Zn and B on foliage improved relative water contents, SPAD chlorophyll values, leaf area index (LAI), crop growth rate (CGR), and grain yield due to substantial expansion in entire yield related traits. Combined foliar application of Zn and B harvested 12% and 45% more yield compared with seed priming and control treatments, respectively. The foliar application of Zn and B in combination counteracted the low rainfall effect by producing higher relative water contents that helped in improving SPAD-chlorophyll values, LAI and CGR. Higher net returns and benefit: cost ratio was also obtained by foliar application of Zn and B in combination. In conclusion, combined foliar application of B and Zn improved maize yield due to significant expansion in allometric and yield related traits and thus improved net returns of maize grown under rainfed conditions of Pothwar plateu in Pakistan.

Mona E. El-Azab (2015) reported that among many growth factors zinc was recognized as one of the limiting factors of corn growth and yielding. Corn plants cultivar Giza10 were sprayed with zinc solution at three concentrations (0.0, 1.0, 1.5 and 2 % Zn solution) or foliar application (0.0, 1.0, 1.5 and 2 % Zn) alone or in combination with NPK fertilizer. Results showed that maize with combined application of Zn (1.5%) and NPK fertilizer significantly improved plant height as compared to the treatment fertilized only with NPK. Zinc increased N, P and K uptake and grain yield of maize plants.

Gillani *et al.* (2014) conducted an experiment at Agronomic Research Area, Faisalabad, Pakistan to check the interactive effect of both macronutrients and micronutrients on the yield and quality of forage maize. The experiment comprised two factors i.e. varieties (Pak Afghoi and Syngenta-6621) and nutrients (NP and micronutrients). The application of two foliar sprays of micronutrients at 15 and 30 DAS along with NP applied in soil significantly increased the green forage yield (58.63 t/ha) in Pak Afghoi variety of maize. The quality parameters like crude protein (%), crude fiber percentage and ash contents percentage were also significantly affected by the application of micronutrients. Significant differences were also observed among the cultivars regarding with maximum plant height (maximum plant height 247.3 cm), leaves number per plant (Maximum number of leaves per plant 18.17) and stem girth per plant (maximum stem diameter 1.96 cm).

Salem and Nasser (2012) found that micronutrients fertilization using Zn + Mn +Fe treatment was the most effective treatment of all studied traits of plant height, ear height and chlorophyll units value. Treatments involving application of one of the nutrients singly showed slight and non-significant superiority over than non-fertilized treatment regarding plant height.

Tahir *et al.* (2012) did a field study which was carried out to evaluate the effect of foliar applied boron on growth, yield and quality of maize (*Zea mays* L.). Foliar application of boron was carried out after 20 days of crop emergence at 0, 0.15, 0.30 and 0.45 kg of boron ha^{-1}. Boron application at 0.30 kg/ha increased the plant height, leaf area, stem diameter, cob weight, number of grains per cob, protein and oil contents.

Nadim *et al.* (2012) studied with physiology and yield attributes of wheat variety Gomal-8 using different levels of Zn, Cu, Fe, Mn and B alone and in different combinations. The results revealed that application of boron @ 2 kg ha^{-1} produced higher leaf area index (0.33 and 3.49) and leaf area duration (2.30 and 48.90) at 49 and 98 days after sowing (DAS). The same treatment also enhanced crop growth rate (33.40 g m^{-2} day^{-1}), number of grains (46.50 $spike^{-1}$) and grain yield (3.67 t ha^{-1}) of wheat. However, the use of @ 8 kg ha^{-1} produced the maximum number of tillers (249 m^{-2}) and statistically at par grain yield (3.62 t ha^{-1}) similar to that of boron application. Higher net assimilation rate (3.19 mg m^{-2} day^{-1}) was recorded when copper was applied @ 6 kg ha^{-1}. Among different micronutrients, zinc application produced minimum number of grains (37.7 $spike^{-1}$) while the use of iron did not improve plant growth. The study showed that boron application improved the wheat grains and yield while the use of copper and manganese had also positive effect on wheat productivity.

Safyan *et al.* (2012) showed in an experiment that microelements spraying was effective on plant height, leaf area index, total dry weight, ear diameter, grain weight, grain yield, and grain protein amount but not on harvest index. The highest amounts of mentioned traits were belonged to Fe + Zn treatment except plant height which its highest amount was obtained in Cu + Mn treatment. The highest and the lowest amounts of harvest index were related to Fe + Zn and Cu + Mn but without any significant differences. According to our results, microelements spraying have a great role in yield increasing of grain corn in Iran, especially for iron +zinc and copper + manganese.

A field experiment conducted by Soomro *et al.* (2011) which results revealed that the foliar application of 0.5% boron as a boric acid at early, mid and late whorl stages resulted in taller plants (195.05 cm), thicker stem girth (5.21), more number of green leaves (8.00) plant^{-1}, less number of dry leaves (3.00) plant^{-1}, more fresh (58.04 t ha^{-1}) and dry fodder yield (17.59 t ha^{-1}).

Ghaffari *et al.* (2011) conducted an experiment with following treatments: T_1 (control), T_2 (recommended NPK @ 200-120-125 kg ha^{-1}), T_3 [single spray of multi-nutrient (a solution mixture of micronutrients i.e; Zn = 2%, Fe = 1%, B = 1%, Mn = 1%, Cu = 0.2% and macronutrients N = 1%, K_2O = 2%, S = 2%) @1.25 L ha^{-1}], T_4 (recommended NPK @ 200-120-125 kg ha^{-1} + single spray of multi-nutrient @ 1.25L ha^{-1}), T_5 (recommended NPK @ 200-120-125 kg ha^{-1} + two spray of multi-nutrient @1.25 Lha^{-1}) and T_6 (recommended NPK @ 200-120-125 kg ha^{-1}+ three spray of multi-nutrient @ 1.25 Lha^{-1}). The recommended dose of NPK in addition with single spray of Multi-nutrients substantially improved all growth parameters, ear characteristics and also enhanced macronutrients use efficiency up to 11.5% which induced significant increase in grain yield as compared to control and also in the treatment where recommended dose of NPK was applied alone. The quality parameter of maize (oil contents) significantly improved by foliar application of multi-nutrients solution but recommended dose of fertilizer in addition to single spray of multi-nutrients was economical.

Hossain *et al.* (2011) worked with eight maize varieties viz. four composites (Mohor, Barnali, Khoibhutta, and BARI Maize-6) and four hybrids (BARI Hybrid Maize-1, BARI Hybrid Maize-3, BARI Hybrid Maize Top 1 & Pacific 984), which were tested for their response to zinc fertilization (0 and 3 kg Zn/ha) at the Regional Agricultural Research Station (RARS), Jessore (AEZ-11, High Ganges River Floodplain). The varieties were not equally responsive to Zn addition. Except BARI Hybrid Maize 3, all other hybrids showed higher response to Zn compared to composite varieties. When the growth characters were looked into, it appeared that except the stem breadth, all other growth characters, such as plant height, collar leaf number, leaf area index, dry matter weight were responded positively to Zn.

An experiment was conducted by Panhwar *et al.* (2011) at glasshouse of University Putra Malaysia with boron (B) and zinc (Zn) deficient soil to evaluate the effect of B and Zn on maize crop and the behavior of soil microbial communities with various levels of boron and zinc. Among the six tested soil series, Malawi soil was found the most deficient in boron (0.06 ppm). Four levels of B from Borax as 0, 0.5, 1.0, and 1.5 kg ha^{-1} and two levels of Zn from Zinc Sulphate, 0 and 5 kg ha^{-1} were applied. The highest plant height (109 cm), root length (30.67 cm), leaf area index, chlorophyll content, shoot (5.38 g) and root dry weight (0.23 g) were obtained at B 0.5 + Zn 5.0 kg ha^{-1} treatment. The interaction effect between boron × zinc in the soil was significant.

Galavi *et al.* (2011) conducted field experiment to evaluate the effect of bio-fertilizer, phosphorus and foliar application of micronutrients on dry matter accumulation, yield, and phosphorus and zinc concentration of maize (*Zea mays* L.). The micronutrients foliar application in two levels (foliar application and non-foliar application) were the main plots, and four levels of phosphate (T_1: 0 (no fertilizer), T_2: 100 kg ha^{-1} P_2O_5, T_3: 100g bio-phosphate, T_4:100g bio-phosphate with 50 kg ha^{-1} P_2O_5) as the sub plots. Results showed that micronutrients foliar application and biological and chemical phosphorus fertilizers had a significant influence on dry matter accumulation. The maximum dry matter accumulation was obtained by applying 50 kg ha^{-1} P_2O_5 plus bio-fertilizer. Grain yield, 1000-seed weight and protein content of grain were significantly affected by micronutrients and phosphorus fertilizers treatments. Grain phosphorus and zinc concentration where significantly increased by application of micronutrients and phosphorus fertilizers.

Adhikary *et. al.* (2010) experimented for three years which revealed that the growth of maize was significantly affected by the application of NPK and micronutrients over the non-treated control plot. Maize plant height, ear height, ear length and stover yield were observed significantly affected in all the years. The 1st year result indicated that tallest plant height (183.66 cm) was recorded when the crop was supplied with recommended dose of NPK fertilizers along with micronutrients (B, Mn, S and Zn).

Majlesy *et al.* (2010) worked to study the effect of drought stress, potassium and, soil and foliar application of micronutrient on yield and yield components of hybrid grain–maize S.C.704. Results showed that foliar application of micronutrients increased the whole characteristics except biomass that increased with soil application of micronutrients. Foliar application of micronutrients with potassium in drought stress situation, significantly increased concentration of Fe and Mn in stalk and Zn in grain, leaf and stalk. Foliar application of micronutrients at drought stress without potassium increased concentration of Fe in grain. In normal irrigation form:

Foliar application of micronutrients without using potassium increased concentration of Mn in leaf, but soil application of micronutrients with using potassium increased biomass. It can be concluded that in drought stress, using potassium with micronutrients leads to improvement of growth index.

A pot experiment was done by Adiloglu (2006) with maize plant grown on zinc (Zn) deficient soil was conducted to study the effect of increasing boron (B) and zinc (Zn) application nutritional status and shoot growth under greenhouse conditions. Three levels B (0, 10 and 20 mg kg^{-1}) and two levels Zn (0 and 10 mg kg^{-1}) applied to maize plant. At the end of experiment, shoot dry matter yield of maize plant decreased with B application, while increased with Zn application. Nitrogen, P and K concentrations of plant increased with B and Zn applications. Same way, Cu, Zn and Mn concentrations of maize also increased same treatments, but Fe concentration of maize was adverse affected with Zn application while positive affect B application.

Emami (2005) reported that microelements spraying had a highly significant effect ($p<0.01$) on total dry weight. The highest mean of this trait was belonged to Fe+ Zn (237.26 g/m2) and the lowest to Fe+ Zn+ Cu+ Mn (208.61 g/m^2). Zinc plays an important role in chlorophyll production and base metabolism. Iron is necessary for chlorophyll producing in green plants and increase in chlorophyll will increase LAI and then dry weight. Iron deficit will reduce leaves dry weight, leaf area, Iron concentration and chlorophyll. Then, iron plus zinc treatment are effective on total dry matter accumulation of plant among growth season considering their effect on LAI production, increase in chlorophyll and then more photosynthesis.

B. Yield contributing characters

Rahman *et al.* (2017) studied the requirement of micronutrients for yield maximization of BARI Hybrid Maize 5 under field condition. The highest grain yield of maize of 10.1 t/ha was obtained with the application of Zn along with recommended NPKS. The Zn application alone produces about 50% yield benefits compared to control. The concentration of macronutrients (N, P, K and S) in maize grain and straw remained unaffected while concentration of micronutrients (Zn, B, Cu, Mn and Fe) increased significantly due to their application. The result clearly indicated the necessity of applying 3 kg Zn/ha along with recommended doses of NPKS for yield maximization of BARI Hybrid Maize 5 in Old Brahmaputra Floodplain soil.

Esmaeili *et al.* (2016) experimented with the nitrogen mineral fertilizer in 100, 200 and 300 amounts of kg urea ha^{-1}, Azotobacter (inoculation and non-inoculation) and foliar application of zinc (Zn_1 = 1000 mg l^{-1} zinc sulfate, Zn_2 = 500 mg l^{-1} zinc sulfate and Zn_3 = 0 mg l^{-1}) were considered as the applied treatments. Grain yield, biological yield, dry matter weight, harvest index (%) and total protein content of each treatment were assessed. Results indicated that foliar applications of Zn had a significant effect on all studied traits. The highest grain yield was related to Zn_1 treatment in each urea application and also between biological fertilizer treatments the highest yield was observed in inoculation treatment. Between all studied treatments the maximum grain yield (with 10.23 ton ha^{-1}) was obtained through non-inoculation treatment × Zn_1 for 300 kg urea ha^{-1}.

A field experiment was carried out by Sultana *et al.* (2016) at micronutrient experimental field of Soil Science Division, BARI, Joydebpur, Gazipur to study the effect of foliar application of zinc on yield of wheat (BARI gom-25) grown by skipping irrigation at different growth stages of the crop. Zinc Sulphate Monohydrate ($ZnSO4. H2O$) was used as a source of Zn. The interaction effect of irrigation and foliar application of zinc significantly influenced the yield and yield components of wheat. The highest yield (5.59 t ha-1) was recorded in normal irrigation which was identical with skipping irrigation at flowering and heading stage with 0.06% foliar application of zinc. Skipping irrigation at crown root initiation stage had the most negative effect on growth and yield. Skipping irrigation at flowering and heading stage of wheat with 0.04% foliar application of zinc gave the identical yield in regular irrigation with 0.04% and 0.06% foliar application of zinc. Thus, foliar application of zinc played a major role on yield and yield components of wheat at later stages of growth. The response of foliar application of Zn was positive and quadrate in nature.

Shabaz *et al.* (2015) did study of seed coating of micronutrients on Maize (*Zea mays* L.) was arranged to check the effect of Boron and Zinc Sulphate on germination, growth and yield. Experiment was carried out at Agricultural Research Area and Environment of Multan, Pakistan. It was concluded from prescribed study that application of Boron increased toxicity and inhibit the germination of maize crop. Application of 3.6 g ZnSO4 kg seed with suggested amount of Nitrogen, Phosphorous and Potassium can improve corn production in the field condition greater than the solitary addition of NPK.

Kaur and Nelson (2015) explored that Boron (B) is an essential micronutrient needed for normal plant growth and development. To evaluate the response of corn to foliar B applications at V4–V6 (4–6 leaves with visible collars) and VT (tasseling) growth stages on fine textured soils, a field experiment was conducted in Northeast Missouri. The treatments included a non-treated control; V4–V6 applied B at 0.56, 1.12 and 2.24 $kg{\cdot}ha^{-1}$; and VT applied B at 0.28, 0.56 and 1.12 $kg{\cdot}ha^{-1}$. Foliar B, applied at V4–V6 at 2.24 $kg{\cdot}ha^{-1}$, resulted in higher yields than VT applications. No significant differences in yield were found for B applications at different timings for concentrations of 0.56 and 1.12 $kg{\cdot}ha^{-1}$. Boron applied at V4–V6 and 2.24 $kg{\cdot}ha^{-1}$ increased yield 0.29 $Mg{\cdot}ha^{-1}$ compared to the non-treated control.

Gillani *et al.* (2014) showed in an experiment that the Pak Afghoi, a variety of maize with two foliar sprays of micronutrients applied at 15 and 30 DAS along with NP as soil application produced significantly higher green forage yield (58.63 t/ha) and crude protein (9.55 %). For higher yield and protein content of forage maize, Pak Afghoi variety should be grown with two foliar applications of micronutrients at 15 and 30 DAS along with simultaneous use of NP in soil.

Tariq *et al.* (2014) conducted a field experiment at Agronomic Research Area, University of Agriculture, Faisalabad, Pakistan to evaluate the comparative efficacy of Zn uptake and grain yield in three maize hybrids namely Pioneer-32F 10, Monsanto-6525 and Hycorn-8288 through the application of Zn in the form of ZnSO4. The experimental results showed substantial difference in all physiological and yield parameters except plant height and stem diameter. Statistically maximum grain yield (8.76 t ha^{-1}) was obtained with foliar spray of $ZnSO_4$ at 9 leaf stage in case of Monsanto-6525. As regard to quality parameters, Pioneer-32F 10 and Hycorn-8288 accumulated more zinc contents in grains but Monsanto-6525 attained more zinc concentration in straw.

A pot study was done by Shahin (2014), in which corn plant's nitrogen and boron uptake has been observed using 5 different boron sources in soil that has 7 different properties where the B level in soil and soil characteristics are different, was carried out. In the study, maize variety of Sele (*Zea Mays* L.) was used, applied at the rate of 1.5 kg B ha-1 to pots and as boron source ground colemanite ($2CaO.3B_2O_3.5H_2O$), borax decahidrate ($Na_2B_4O_7.10H_2O$), borax pentahidrate (Granubor) ($Na_2B_4O_7.5H_2O$), sodium metaborate tetrahidrate ($NaBO_2.4H_2O$), boric acid (H_3BO_3) were applied. Until plant's harvest day, NPK nutrient requirements were supplied. When soils' B content was taken into consideration, differences between soils in their boron uptake with additional boron fertilization were noticed. pH, lime and organic matter contents of soil characteristics were determining factors. Plant's N contents differ in accordance with soil types. Significant differences in boron concentration of the plant in terms of applied boron sources were noticed. Results show that in order for plant to benefit from the boron element, it is necessary to apply suitable boron fertilizer considering restrictive factors of the boron level in the soil and soil characteristics.

Sarkar (2014) conducted an experiment with micronutrients at Sher-e-Bangla Agricultural university which results revealed that yield and yield contributing characters were influenced significantly by levels of zinc and boron. The tallest plant (80.26 cm) and the highest grain yield (2.73 t ha^{-1}) were obtained from application of 0.04 % Zn. In contrast, the shortest plant (77.73 cm) and minimum grain yield (2.30 t ha^{-1}) were observed when Zn was not applied. On the other hand, plant height (80.02 cm) and grain yield (2.79 t ha^{-1}) were the highest when 1 kg B ha^{-1} was imposed. The shortest plant height (76.85 cm) and the lowest grain yield (2.35 t ha^{-1}) being recorded from the control (no boron). All the yield and yield contributing characters were significantly affected due to the interaction effects of different levels of Zn and B.

A field study was carried out by Tahir *et al.* (2012) to evaluate the effect of foliar applied boron on growth, yield and quality of maize (*Zea mays* L.). Foliar application of boron was carried out after 20 days of crop emergence at 0, 0.15, 0.30 and 0.45 kg of boron ha^{-1}. The maximum grain yield (7.14 tons ha^{-1}), biological yield (527.4 t ha^{-1}) was recorded in B_2 where application of boron was carried out at 0.30 kg ha^{-1}.

Safyan *et al.* (2012) also revealed that the effect of spraying, was highly significant ($p<0.01$) on grain yield and the highest yield mean was belonged to Fe+Zn treatment (19650 kg ha^{-1}) whereas the copper treatment produced the lowest grain yield (11350 kg ha^{-1}). Total content of grain's carbohydrates, starch, Indole acetic acid (IAA) and protein is increased by using iron and zinc, that this will improve carbohydrate producing and its transferring to grains and finally yield increase. It seems that significant increase of LAI in Fe+ Zn treatment of this study, caused increase in current photosynthesis and more photo assimilate transferring to grains which increased 1000 grains weight and grain yield consequently.

Kumar *et al.* (2010) conducted experiment indicated that application of different sources of zinc significantly increased the stover and grain yield of maize compared to that of absolute control and the treatment which received only NPK fertilizers. However, the treatment, which received zinc through pressmud compost recorded a maximum yield of 5.96 and 6.85 t ha^{-1} of stover and grain respectively. Similarly, zinc uptake by maize significantly increased due to applied zinc sources except zinc oxide.

Further, application of zinc through organic sources was found to increase uptake of in N, P, K, Ca, Mg, S, Cu, Fe, Mn and Zn significantly.

Potarzycki and Grzebisz (2009) found that maize crop responded significantly to zinc foliar application in two of three years of study. The optimal rate of zinc foliar spray for achieving significant grain yield response was in the range from 1.0 to 1.5 kg Zn ha^{-1}. Grain yield increase was circa 18% (mean of three years) as compared to the treatment fertilized only with NPK. Plants fertilized with 1.0 kg Zn ha^{-1} significantly increased both total N uptake and grain yield. Yield forming effect of zinc fertilizer revealed via improvement of yield structure elements. The number of kernels per plant showed the highest response (+17.8% as compared to the NPK plot) and simultaneously the highest dependence on N uptake (R_2 = 0.79). For this particular zinc treatment, however, the length of cob can also be applied as a component of yield structure significantly shaping the final grain yield.

An experiment was conducted by Ziaeyana and Rajaiea (2009) to determine the effect of boron (B) and zinc (Zn) application on yield and yield components of corn (*Zea mays* L.) plants grown in a B and Zn-deficient calcareous soil (fine, carbonatic, thermic, Typic Haploxerepts) of southern Iran Zn and B fertilization significantly increased plant biological yield, grain yield, harvest index (%), thousand grain weight, number of grains per stalk, grain protein content and the concentration of B and Zn in corn tissues. There was a significant B × Zn interaction on corn yield and tissue nutrient concentrations. In general, the effect of B × Zn interaction was synergistic on corn growth and yield. Although B and Zn fertilization made significant changes in some plant nutrients, the changes were slight enough not to affect plant growth and production.

Ziaeyana and Rajaiea (2009) reported that Zn and B fertilization significantly increased plant biological yield, grain yield, thousand grain weight, number of grains per stalk, grain protein content and the concentration of B and Zn in corn tissues by conducting an experiment to determine the effect of boron (B) and zinc (Zn) application on yield and yield components of corn (*Zea mays* L.) plants grown in a B and Zn-deficient calcareous soil of southern Iran. Treatments consisted of five levels of Zn (soil application of zinc sulfate at the rates of 0, 8, 16 and 24 kg ha^{-1} and foliar spray of Zn solutions containing 0.3 weight percent of zinc sulfate) and four levels of B (soil application of boric acid at the rates of 0, 3 and 6 kg ha^{-1} and foliar spray of B solutions containing 0.1 weight percent of boric acid). Zn and B solutions were applied at the rate of 1000L ha^{-1}. There was a significant B × Zn interaction on corn yield and tissue nutrient concentrations. In general, the effect of B × Zn interaction was synergistic on corn growth and yield. Although B and Zn fertilization made significant changes in some plant nutrients, the changes were slight enough not to affect plant growth and production.

Tabrizi *et al.* (2009) conducted an experiment to evaluate effects of micronutrients on some traits of *Zea mays* L. where treatments were six types of micronutrients (control, $ZnSO_4$, $MnSO_4$, H_3BO_3, $FeSO_4$ and complete micronutrients) and three methods of application (soil application, seed coating and foliar application). Applying any microelements in any methods increased net assimilation rate (NAR) and crop growth rate (CGR) of corn. Seed coating was superior to others in early season but nutrient amounts were little, so they were used or fixed by plant or soil, then its effect began to decrease before mid-season. Soil application of any microelement improved NAR and CGR of corn, but fixation of H_3BO_3 and

$ZnSO_4$ at mid-season decreased NAR and CGR. Foliar application of micronutrients covered all needs of corn and led it to have the best action on NAR and CGR. Highest yields (16,040 kg ha^{-1}) were obtained when leaves were sprayed with $ZnSO_4$. The 1000 kernel weight of corn was 374.6 g with foliar application of $ZnSO_4$. Kernel weight increased 35.47% when $ZnSO_4$ was used.

Markhand and Soomro (2008) conducted an experiment to explore the effect of micronutrients on maize. Except plant height, all other plant parameters studied viz. cob height from earth surface, internodes length, cob weight, number of grains cob^{-1}, grain weight cob^{-1}, 1000 grains weight, biological and grain yields and harvest index were significantly affected by application of micronutrients (Copper, Manganese and Zinc). Cob weight, number of grains cob^{-1}, grain weight cob^{-1} and 1000 grains, which are the important yield components of maize, were increased maximally with application of $CuSO_4$ + $MnSO_4$ + $ZnSO_4$ at the rate of 5.00 + 10.00 + 5.00 kg ha^{-1}. The results also indicated the synergetic relationship between copper, manganese and zinc. It is suggested that micronutrients should be applied along with major nutrients to get better yield of maize.

Ranjbar and Bahmaniar (2007) conducted an experiment in order to investigate the role of Zn application (soil + foliar application) on growth traits, yield, its concentration and accumulation in wheat leaves and grains, two common cultivars of wheat namely Tajan and Nye 60 have been selected. It was found that Zn had increasing effects on grain yield, total dry matter, yield, 1000-grain weight, number of tiller, grain Zn content, flag leaf Zn content, plant height, number of node, protein content and grain Fe content

In the study of Marcar and Graham (2006), increased grain yield and grain Mn content in wheat from priming with $MnSO_4$ has also been observed. It was done to explore the effect of manganese content on the growth of wheat under manganese deficiency. Mn seed priming also has the potential to improve stand establishment. They reported that Mn contributes in substantial improvement in stand establishment, growth, yield, and grain enrichment.

Khalid and Malik (2002) worked with pre-sowing soaking of wheat seeds in copper and manganese solutions. Mn contents grain yield and Mn contents increased linearly with increasing priming solution concentration up to a maximum of .2% $MnSO_4$ solution for 12h. They reported that priming wheat seeds in $MnSO_4$ solutions significantly improved growth, grain yield and grain.

Hussain *et al.* (1999) showed that application of fertilizer at 150±30 and 150+20 kg N and S per hectare, respectively greatly increased dry weight per plant, No. of grains per cob and grain weight per cob over other treatments, Similarly, highest grain yield of 8.59 tons per hectare was recorded from plot fertilized at 150 kg N and 30 kg S per hectare. While maximum grain oil and crude protein contents were recorded from plot fertilized at 150+30 and 150 20 kg N and S per hectare, respectively.

CHAPTER III

MATERIALS AND METHODS

A brief description about experimental site, climatic condition, planting materials, treatments, experimental design and layout, crop growing procedure, intercultural operations, data collection and statistical analysis has been presented in this chapter.

3.1 Experimental site

The experiment was conducted at Sher-e-Bangla Agricultural University, Dhaka-1207 during the period from November, 2017 to April, 2018.

3.1.1 Geographical and Agro-Ecological Region

Geographically the experimental field is located at 23°46' N latitude and 90° 22' E longitude (Google maps, 2014) at an elevation of 8.2 m above the sea level belonging to the Agro-ecological Zone “AEZ-28” of Madhupur Tract (BBS, 2011). The location of the experimental site has been shown in Appendix I.

3.1.2 Climate

The experimental area is situated in the sub-tropical climatic zone and characterized by heavy rainfall during the months of April to September (Kharif Season) and scanty rainfall during the rest period of the year. The Rabi season (October to March) is characterized by comparatively low temperature and plenty of sunshine from November to February (SRDI, 1991). The weather data during the study period at the experimental site including maximum and minimum temperature, total rainfall and relative humidity were shown in (Appendix-II).

3.1.3 Soil

The soil of research field was general soil type and shallow red brown terrace soils under Tejgaon series. The selected plot was above flood level and sufficient sunshine was available having available irrigation and drainage system during the experimental period. The experimental plot was a high land. The top soil was characterized by silty clay in texture, olive- gray whitish with common fine to medium distinct dark whitish brown mottles was seen on the top soil and the soil had pH- 6.3 and organic carbon- 1.8%. The experimental area was flat and medium high topography with available easy irrigation and drainage system. The soil status was shown in (Appendix III).

3.2 Details of the experiment

3.2.1 Treatments

Two sets of treatments included in the experiment were as follows:

Factor A: Variety - 2

V_1= White maize (PSC-121)

V_2= Yellow maize (BARI hybrid maize 7)

Factor B: Micronutrient combinations

F_0 = No Fertilizer (control)

F_1= NPK (no micronutrient)

F_2= NPK+Zn+B+S+Mn

F_3= NPK+Zn+B+S (no Mn)

F_4= NPK+Zn+B+Mn (no S)

F_5 = NPK+Zn+Mn+S (no B)

F_6 = NPK+Mn+S+B (no Zn)

All the fertilizers were applied at their recommended doses and the rate of fertilizers have been presented in section 3.3.3.

3.2.1 Experimental design

The experiment was laid out in a Split Plot design with three replications. The total numbers of unit plots were 42. The size of unit plot was 3.6 m × 1.5 m. The spacing 75 cm × 40 cm was used under present study. The final layout of the experimental plots has shown in Appendix-IV.

3.3 Crop management

3.3.1 Seed collection

Seeds of white maize (PSC-121) was collected from Sher-e-Bangla Agricultural University and yellow maize (BARI hybrid bhutta 7) was collected from Bangladesh Agricultural Institute (BARI), Joydebpur, Gazipur.

3.3.2 Land preparation

The land of the experimental field was first opened on November 22, 2017 with a power tiller. Then it was exposed to the sunshine for 7 days prior to the next ploughing. Thereafter, the land was ploughed and cross-ploughed to obtain good tilth. Deep ploughing was done to produce a good tilth, which was necessary to get better plant stand and yield of the crop. Laddering was done in order to break the soil clods into small pieces followed by each ploughing. All the weeds and stubbles were removed from the experimental field. The soil was treated with Furadan 5G @ 20 kg ha^{-1} when the plot was finally ploughed to protect the young plant from the attack of cut worm.

3.3.3 Fertilizers

At final land preparation the soil was provided with N, P, K, S, Zn, Mn and B from urea, triple super phosphate, muriate of potash, gypsum, zinc sulphate, manganese sulphate and boric acid at the rate of 500, 250, 200, 250, 12.5, 3.5 and 6.00 kg per hectare (BARI, 2011). One third of urea, full dose of triple super phosphate, muriate of potash were applied during land preparation but zinc sulphate, manganese sulphate and boric acid were applied according to treatment specifications. Rest of the urea was top dressed in two equal splits at 45 and 70 DAS.

3.3.4 Seed treatment

Seeds were treated with Provex-200 @ 0.25% before sowing to prevent seeds from the attack of soil borne disease.

3.3.5 Seed sowing

Healthy and uniform sized white maize and yellow maize seeds were collected. Seed of maize were sown in lines each having a line to line distance of 60 cm and plant to plant distance of 20 cm having 3 seeds hole^{-1} under direct sowing in the well-prepared plot at a depth of 3-4 cm on December 2, 2017 for easy emergence.

3.4 Intercultural operations

3.4.1 Ridging of soil

To reduce the lodging of maize plant the soil was uplifted to near the base as ridge at 30 DAS.

3.4.2 Removal of weeds

It was required to keep the crop free from weeds and to keep the soil loose for proper aeration and for proper growth and development of maize plant. First weeding was done two weeks after emergence. Another weeding was done before 2nd top dressing of urea.

3.4.3 Thinning and gap filling

Seeds were emerged at 6th and 7th days after sowing. After emergence of seedling, gap filling was completed within 15 days after sowing. Overcrowded seedlings were thinned out for two times. First thinning was done after 10 days of sowing which was done to remove unhealthy and lineless seedlings. The second thinning was done 15 days after first thinning keeping one healthy seedling in each hill according to the treatment.

3.4.4 Watering and drainage

Three irrigations were provided throughout the growing period in controlled way. The first irrigation was given at 20 DAS. Subsequently, two irrigations were given at 45 and 70 DAS. Top dressing of fertilizers was followed by irrigation for proper utilization of fertilizers.

3.4.5 Control of insects and diseases

All possible phyto-sanitary measures were adopted to keep plant healthy. Dursban @ 7.5 litre ha^{-1} was drenched on both sides of ridges at 25 DAS to control the cutworm. Dimecron 100 EC @ 2% and Admire 200 SL @ 0.5% were applied to control leaf folder and roller.

3.4.6 Harvest and post-harvest operation

The crop was harvested 22 April, 2018 when the husk cover was completely dried and black coloration was found in the grain base. The five cobs of five randomly selected plants of each plot were separately harvested for recording yield attributes data. The inner two lines were harvested for recording grain and stover yield. The harvested products were taken on the threshing floor and it was dried for about 3-4 days.

3.5 Collection of data

Data were collected on the following parameters-

3.5.1 Crop growth characters

- Plant height (cm) at 25, 50, 75, 100 days after sowing (DAS) and at harvest
- Number of leaf plant^{-1} at 25, 50, 75, 100 DAS and at harvest
- Dry weight plant^{-1} (g) at 30, 60, 90 DAS and at harvest

3.5.2 Yield contributing characters

- Number of cobs plant^{-1}
- Cob length (cm)
- Cob diameter (cm)
- Number of rows cob^{-1}
- Number of grains row^{-1}
- Number of seeds cob^{-1}
- Weight of 1000 grains (g)

3.5.3 Yield and harvest index

- Grain yield (t ha^{-1})
- Stover yield (t ha^{-1})
- Biological yield (t ha^{-1})
- Harvest index (%)

3.6 Procedure of sampling and data collection for growth parameters

Plant height (cm)

At different stages of crop growth (25, 50, 75, 100 DAS and at harvest), the height of three randomly selected plants from the inner rows of every plot was measured from ground level to the tip of the plant portion and the mean value of plant height was recorded in cm. Plant height data was taken from the same plants in every stage.

Number of leaf plant^{-1}

At different stages of crop growth (25, 50, 75, 100 DAS and at harvest), the total number of collar leaf of five randomly selected plants from the inner rows of each plot was counted and the mean value of the number of collar leaf was recorded in number. Leaf number was taken from the same plants in every time.

Dry weight plant^{-1}

From each plot 3 plants were uprooted randomly. Then the stem, leaves and roots were separated. The shoot sample (stem and leaves) was sliced into very thin pieces and put into envelop and placed in oven maintaining 65^{0}C for 72 hours. Then the shoot sample was transferred into desiccators and allowed to cool down at room temperature. Then weight of the sample was taken. It was done at 30, 60, 90 DAS and at harvest.

3.7 Procedure of data collection for yield and yield components

Number of grains cob^{-1}

Five cobs from each plot were selected randomly and the number of grains was counted and then the average result was recorded.

Number of rows cob^{-1}

Five cobs from each plot were selected randomly and the number of rows was counted and then the average result was recorded.

Number of grains rows^{-1}

Five cobs from each plot were selected randomly and the number of grains was counted in each row and then the average result was recorded.

Number of grains cob^{-1}

Five cobs from each plot were selected randomly and the number of grains was counted in each cob and then the average result was recorded.

Weight of 1000 grains

From the seed stock of each plot 1000 seeds were counted and the weight was measured by an electrical balance. It was recorded in gram.

Grain and stover yield (t ha^{-1})

Plants of inner two rows avoiding border plants were harvested for taking grain and stover yield data. The crop of each plot was bundled separately, tagged properly and brought to threshing floor. The bundles were dried in open sunshine, cobs were threshed and grains were cleaned. The grain and stover weights for each plot were recorded after proper drying in the sun.

Biological yield (t ha^{-1})

Biological yield was calculated by using the following formula:

Biological yield = Grain yield + straw yield

Harvest index (%)

Harvest index was calculated by using the following formula:

$$\text{Harvest index (\%)} = \frac{\text{Grain yield (t/ha)}}{\text{Biological yield (t/ha)}} \times 100$$

3.9 Statistical analysis

The recorded data were subjected to statistical analysis. Analysis of variance was done following two factor split plot design with the help of MSTAT-C software program. The mean differences among the treatments were adjusted by DMRT at 5% level of significance (Gomez and Gomez, 1984).

CHAPTER IV

RESULT AND DISCUSSION

An experiment was conducted to observe the influence of different combinations of micronutrients S on the growth and yield of white and yellow maize. Data on different growth and yield parameters of maize were recorded. The analysis of variance on different growth and yield contributing characters as well as yield of maize was influenced by different micronutrient combinations treatment presented in Appendix V-IX. The results have been presented and discussed with the help of either table or graphs and possible interpretations have been given under the following headings.

4.1 Growth Parameters

4.1.1 Plant height

4.1.1.1 Effects of variety

Plant height recorded at 25, 50, 75, 100 DAS and at harvest of maize plants have been presented in Figure 1 and Appendix V. The figure shows that plant height increased straightly up to 100 DAS after that the rate of increase was much slower. The tallest plants were recorded 40.94cm, 87.53cm, 183.38cm, 227.73cm and 229.12cm at 25, 50, 75, 100 DAS and at harvest stage respectively from $V_{2,}$ whereas, the shortest plants were recorded 35.25cm, 67.23cm, 169.98cm, 223.83cm and 225.77cm at 25, 50, 75, 100 DAS and at harvest stage respectively from V_1. The highest plant height in V_2 may perhaps the longer in these two varieties. Biswas *et al.* (2014) also reported that BARI hybrid bhutta 7 had higher plant height which confirms the present findings.

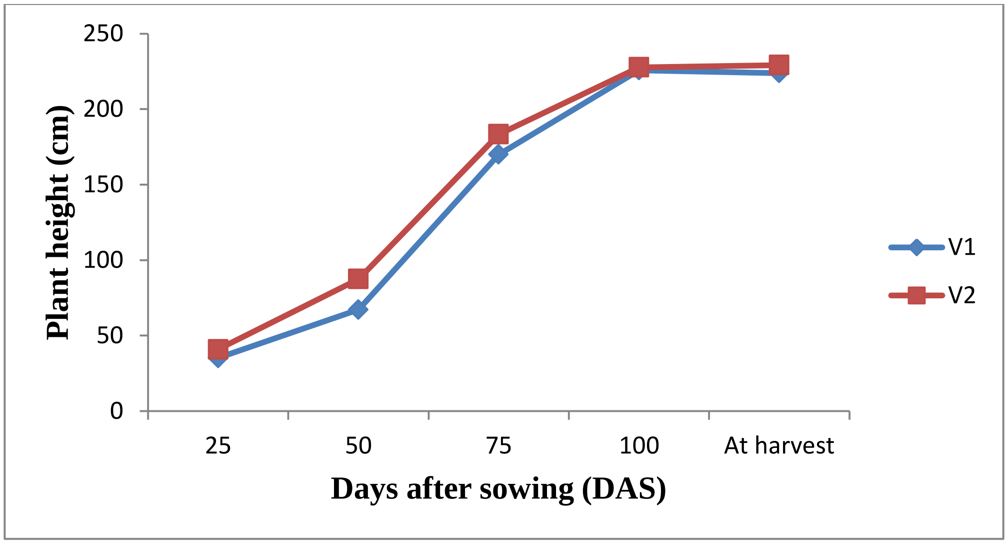

Figure 1. Plant height of maize per plant affected by variety (SE= 0.3516, 0.5351, 0.1785, 0.152, 1.0505 at 25, 50, 75, 100 DAS and at harvest respectively)

V_1 = White maize (PSC-121), V_2 = Yellow maize (BARI hybrid bhutta 7)

4.1.1.2 Effects of micronutrient

Plant height of maize was significantly affected by the application of micronutrients (Figure 2 and Appendix V). The result revealed that application of micronutrient with NPK in general, increased the plant height of maize over control for all growth stages. The figure shows that F_2 gave the tallest plant at 25 and 75 DAS and at harvest (47.22 cm, 198.10 cm and 240.70 cm, respectively). On the other hand, F_4 shows the tallest plant at 50 and 100 DAS (85.76 cm and 241.90 cm respectively). For all growth stages F_0 shows the shortest plant 34.10 cm, 63.74 cm, 102.60 cm, 186.80 cm and 189.90 cm, respectively at 25, 50, 75, 100 DAS and at harvest. The present result fairly agrees with the findings of Adhikary *et al.* (2010) and Mona E. El-Azab (2010) who reported that micronutrients in contribution with NPK showed the tallest plant in maize.

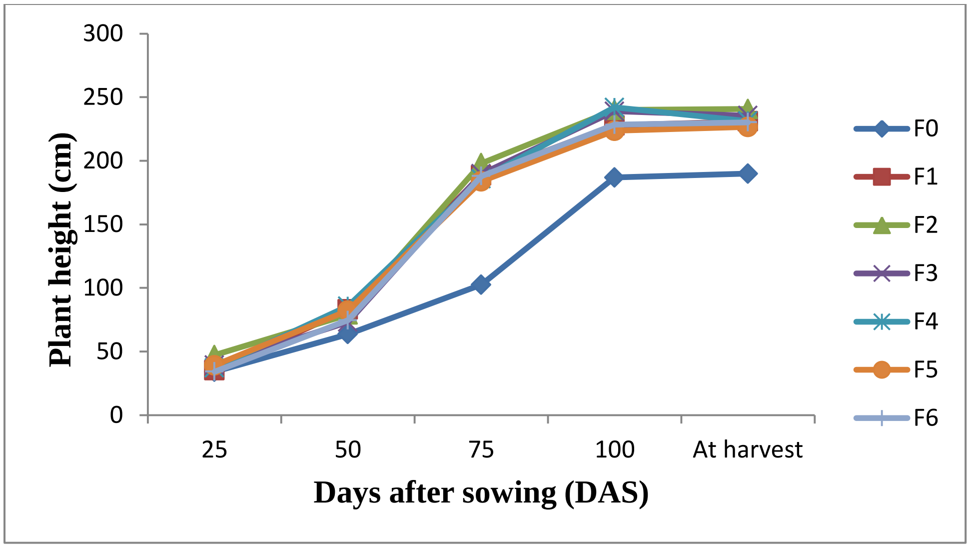

Figure 2. Plant height of maize as affected by micronutrient (SE= 0.4122, 0.8053, 1.3847, 0.131, 1.8964 at 25, 50, 75, 100 DAS and at harvest, respectively)

F_0 = No fertilizer, F_1 = NPK, F_2 = NPK + Zn + B + Mn + S, F_3 = NPK + Zn + B + S, F_4 = NPK + Zn + B + Mn, F_5 = NPK + Zn + Mn + S, F_6 = NPK + B + Mn + S

4.1.1.3 Interaction effect of variety and micronutrient

From the value of plant height it was found that interaction effect of variety and micronutrients with the combination of macronutrients showed significant differences. At 25 DAS, the highest plant height was recorded from V_1F_2 (51.26 cm) and the lowest from V_1F_0 (30.38 cm). Whereas, V_2F_1 (96.39 cm) gave the tallest plant which was statistically similar with V_2F_4 (97.01 cm) at 50 DAS. On the other hand, at 75 DAS, the tallest plant was found at V_2F_2 (204.1 cm) treatment combination and the lowest one was found at V_1F_0 (88.72 cm). At 100 DAS, the highest plant height was given by treatment V_2F_3 (243.80 cm) which is statistically similar with V_1F_4 (243.00 cm), V_2F_2 (241.90 cm) and V_2F_4 (243.00 cm) and the lowest height was given by V_1F_0 (185.10 cm) which is statistically similar with V_0F_2 (188.40 cm). However, at harvest V_2F_2 gave the highest plant height (247.60 cm) which is statistically similar with V_2F_3 (244.00 cm) and V_1F_0 gave the lowest one (187.70 cm) as interaction effect.

Table 1. Plant height of maize as affected by the interaction effect of variety and micronutrient

Treatments	Plant height (cm)				
	25 DAS	50 DAS	75 DAS	100 DAS	At harvest
V_1F_0	30.38 fg	56.52 j	88.72 h	185.10 g	187.70 g
V_1F_1	31.87 f	69.77 g	186.3 cd	227.50 e	230.60 d
V_1F_2	51.26 a	66.06 h	192.0 bc	238.00 bc	237.30 bc
V_1F_3	35.08 e	67.82 gh	190.4 bc	234.00 d	223.60 e
V_1F_4	31.17 f	74.51 e	177.8 ef	243.00 ab	229.30 d
V_1F_5	38.02 d	73.43 ef	180.9 de	217.30 f	219.30 e
V_1F_6	28.98 g	62.49 i	173.7 f	237.00 cd	239.00 b
V_2F_0	37.83 d	70.96 fg	116.5 g	188.40 g	192.10 f
V_2F_1	38.70 cd	96.39 a	190.9 bc	228.20 e	231.30 d
V_2F_2	43.18 b	92.14 b	204.1 a	241.90 a	247.00 a
V_2F_3	43.67 b	78.58 d	189.0 bc	243.80 a	244.60 a
V_2F_4	43.18 b	97.01 a	194.0 b	243.00 a	233.40 cd
V_2F_5	40.37 c	90.84 b	186.9 c	229.90 e	233.80 cd
V_2F_6	39.63 cd	86.76 c	202.3 a	218.90 f	221.50 e
SE	**0.5829**	**1.1389**	**1.9583**	**0.168**	**2.6819**
CV(%)	**5.65**	**10.55**	**8.92**	**10.43**	**8.05**

V_1 = White maize (PSC-121), V_2 = Yellow maize (BARI hybrid bhutta 7)

F_0 = No fertilizer, F_1 = NPK, F_2 = NPK + Zn + B + Mn + S, F_3 = NPK + Zn + B + S, F_4 = NPK + Zn + B + Mn, F_5 = NPK + Zn + Mn + S, F_6 = NPK + B + Mn + S

4.1.2 Number of leaves plant^{-1}

4.1.2.1 Effect of variety

Number of leaves plant^{-1} taken at different growth stages of maize showed non-significant variation at 25, 50 and 75 DAS but significant variation was observed at 100 DAS and at harvest stage between the varieties (Figure 3 and Appendix VI). The figure revealed that leaf number plant^{-1} increased sharply up to 75 DAS in respect of varieties after that V_2 variety produced lower leaf plant^{-1} (11.67 and 12.20) than V_1 (12.78 and 13.15) at 100 DAS and at harvest, respectively. Highest number of leaves plant^{-1} with V_1 may be attributed to shorted internode distances in the variety. The result correlates with the findings of Biswas *et al.* (2014) who reported leaves plant^{-1} valued among the varieties due to internode distances.

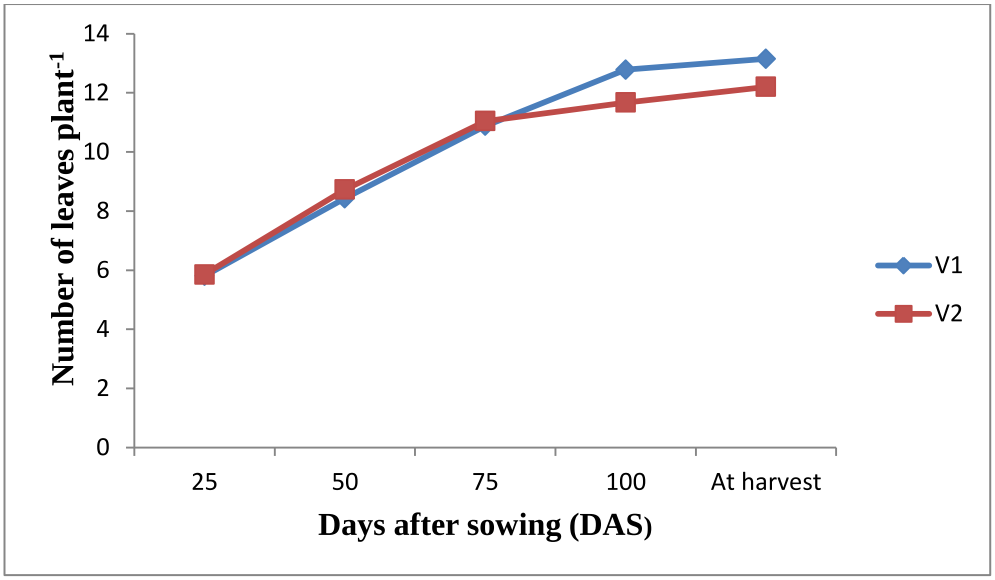

Figure 3. Number of leaves plant^{-1} of maize as affected by variety (SE= 0.0044 (NS), 0.1465 (NS), 0.108 NS), 0.113, 0.107 at 25, 50, 75, 100 DAS and at harvest, respectively)

V_1 = White maize (PSC-121), V_2 = Yellow maize (BARI hybrid bhutta 7)

4.1.2.2 Effect of micronutrient

Number of leaves plant^{-1} varied significantly due to micronutrient treatment at all sampling dates except 25 DAS (Fig. 4 and Appendix VI). The figure indicates that irrespective of micronutrient treatments, number of leaves plant^{-1} increased gradually with the advancement of growth stages and the values were found with at harvest sampling date. It can be also observed that application of micronutrients increased the leaf number plant^{-1} over control. At 50 DAS, highest number of leaves per plant was recorded at F_3 (9.00) which is statistically similar to F_1 (9.00), F_2 (8.99), F_4 (8.72) and F_5 (8.83) and the lowest number of leaves was recorded (7.17) in F_0. On the other hand, highest number of leaves plant^{-1} was found in F_1 (11.53) at 75 DAS and that of lowest in F_0 (10.39) which was statistically similar with F_4 (10.50). At 100 DAS, F_2 gave the highest number of leaves plant^{-1} (13.67) compared to other treatment and the lowest number of leaves plant^{-1} was given by F_0 (11.03). However, at harvest stage highest leaves number per plant was recorded from F_2 (13.64) which is statistically similar with F_3 (13.58) and lowest number was recorded from F_0 (12.00). The result correlates with the findings of Gillani *et al.* (2014) who observed that number of leaves plant^{-1} influenced by micronutrients.

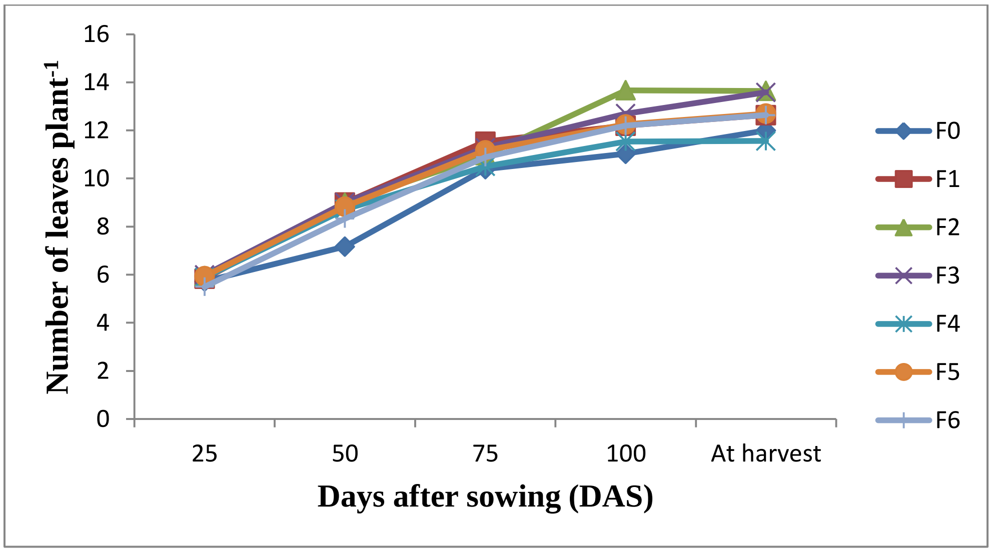

Figure 4. Number of leaves plant^{-1} of maize as affected by micronutrient (SE=NS, 0.372, 0.287, 0.252, 0.193 at 25, 50, 75, 100 DAS and at harvest respectively)

F_0 = No fertilizer, F_1 = NPK, F_2 = NPK + Zn + B + Mn + S, F_3 = NPK + Zn + B + S, F_4 = NPK + Zn + B + Mn, F_5 = NPK + Zn + Mn + S, F_6 = NPK + B + Mn + S

4.1.2.3 Interaction effect of variety and micronutrient

Significant variation was found on the number of leaves plant^{-1} due to combined effect of variety and micronutrients combination for all sampling dates except 25 DAS in maize (Table 2 and Appendix VI). At 50 DAS the highest number of leaves plant^{-1} was recorded from V_2F_4 treatment (9.55) which was statistically similar with V_2F_2 (9.32) and the lowest number of leaves was recorded V_1F_0 (6.89). From the recorded data, it was found that, at 75 DAS the highest number of leaves was given by V_1F_3 (11.78) which is statistically similar with V_2F_5 (11.67) where the lowest number of leaves was given by V_2F_0 (10.0) which was statistically similar to V_1F_4 (10.10). At 100 DAS and at harvest stages the highest number of leaves was observed with V_1F_2 (14.45 and 14.56, respectively). The lowest number of leaves per plant was observed in V_2F_0 at 100 DAS (10.10) and V_2F_4 (11.61) at harvest stage.

Table 2. Number of leaves plant^{-1} of maize as affected by the interaction effect of variety and micronutrient

Treatment	Number of leaves plant^{-1}				
	25 DAS	**50 DAS**	**75 DAS**	**100 DAS**	**At harvest**
V_1F_0	5.44	6.89 h	10.67 e	11.55 gh	11.61 gh
V_1F_1	5.77	8.78 c	11.50 b	13.00 c	13.33 b
V_1F_2	6.11	8.67 cd	11.00 cd	14.45 a	14.56 a
V_1F_3	5.99	9.22 b	11.78 a	13.56 b	14.44 a
V_1F_4	5.89	7.89 f	10.10 f	11.67 fg	11.77 fg
V_1F_5	6.11	9.10 b	10.66 e	12.55 d	13.00 c
V_1F_6	5.33	8.44 de	10.55 e	12.67 d	13.33 b
V_2F_0	6.00	7.44 g	10.00 f	10.10 i	12.22 e
V_2F_1	5.89	9.22 b	10.56 e	11.39 h	11.94 f
V_2F_2	5.77	9.32 ab	10.94 d	12.89 c	12.72 d
V_2F_3	6.00	8.78 c	10.78 de	11.83 ef	12.72 d
V_2F_4	5.88	9.55 a	11.00 cd	11.40 h	11.50 h
V_2F_5	5.77	8.55 cd	11.67 ab	11.94 e	12.39 e
V_2F_6	5.66	8.22 e	11.22 c	11.72 f	11.94 f
SE	NS	0.5253	0.504	0.517	0.465
CV(%)	3.87	3.61	2.14	3.16	3.88

NS = Non-significant

V_1 = White maize (PSC-121), V_2 = Yellow maize (BARI hybrid bhutta 7)

F_0 = No fertilizer, F_1 = NPK, F_2 = NPK + Zn + B + Mn + S, F_3 = NPK + Zn + B + S, F_4 = NPK + Zn + B + Mn, F_5 = NPK + Zn + Mn + S, F_6 = NPK + B + Mn + S

4.1.3 Dry matter weight plant^{-1}

4.1.3.1 Effect of variety

Dry weight plant^{-1} of maize affected significantly between the varieties at all sampling dates except at 30 DAS (Fig. 5 and Appendix VII). The figure shows that the dry weight of plant showed an increasing trend with the increases of varieties. But the rate of increase was much higher up to 90 DAS, after that the rate of growth was much slower. However, V_1 variety showed the higher dry weight (40.00, 78.32 and 86.92g, respectively) at 60, 90 DAS and at harvest than V_2 variety (38.51, 74.28 and 83.54 g, respectively) at 60, 90 DAS and at harvest. Similar observation was reported by Gillani *et al.* (2014) that dry weight plant^{-1} of maize varied among the varieties.

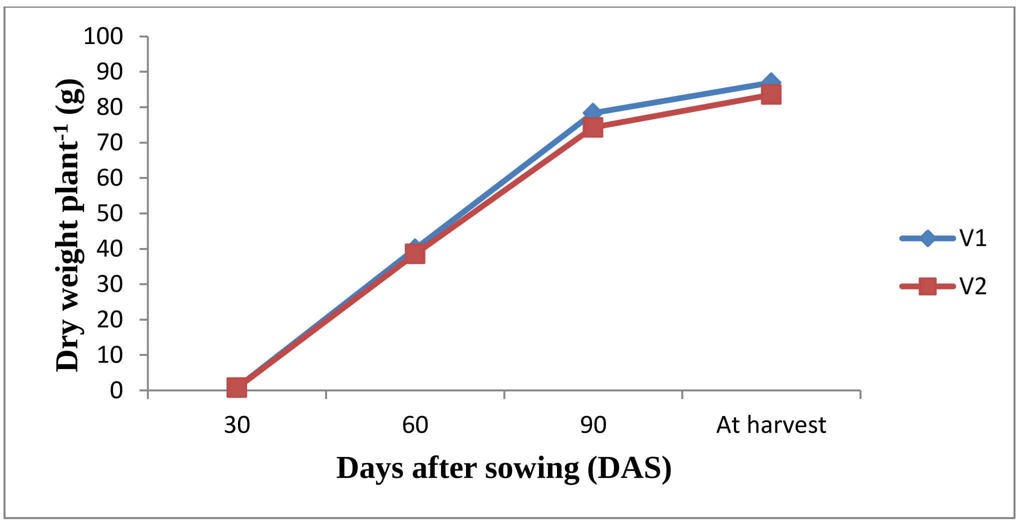

Figure 5. Dry weight plant^{-1} of maize as affected by variety (SE= 0.018 (NS), 0.071, 0.242, 0.113 at 30, 60, 90 DAS and at harvest, respectively)

V_1 = White maize (PSC-121), V_2 = Yellow maize (BARI hybrid bhutta 7)

4.1.3.2 Effect of micronutrients

Application of micronutrient had significant effect on dry weight plant^{-1} of maize for all sampling dates except 30 DAS (Fig. 6 and Appendix VII). The figure exhibits that F_2 showed the highest dry weight plant^{-1} (42.76, 90.04 and 96.76g, respectively) at 60, 90 DAS and at harvest which was followed by F_3 and F_4 for same dates. However, the lowest values of dry weight plant^{-1} was found with F_0 for 60, 90 DAS and at harvest (32.69, 53.65 and 63.36g plant-1, respectively). This finding was similar with Galavi *et al.* (2011), Soomro *et al.* (2011), and Adiloglu and Adiloglu (2006) who reported that dry weight plant^{-1} of maize varied due to micronutrient application.

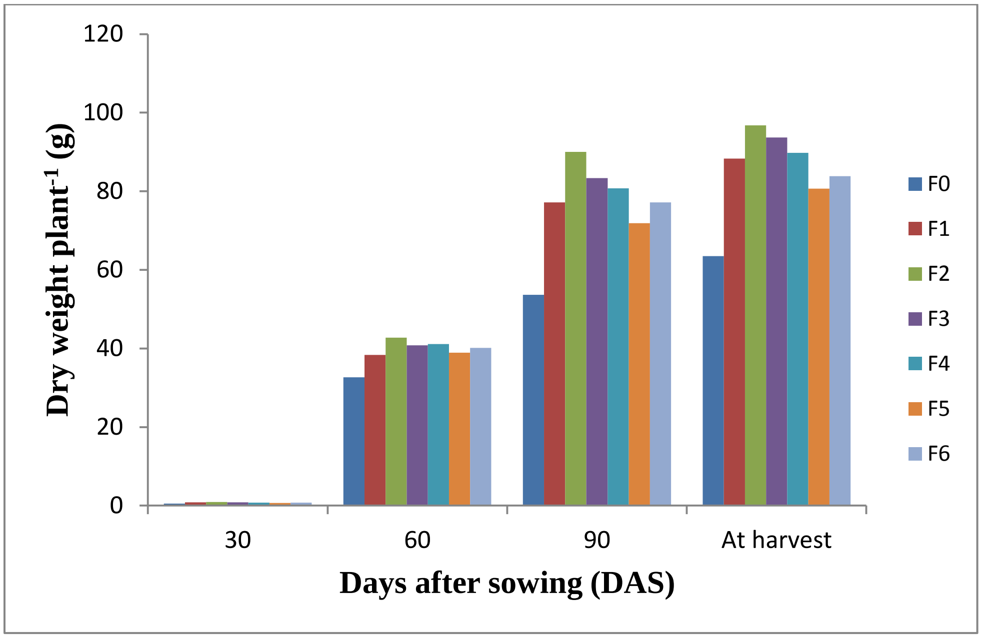

Figure. 6 Dry weight plant^{-1} of maize as affected by micronutrient (SE= NS, 0.215, 0.385 and 0.358 at 30, 60, 90 DAS and at harvest, respectively)

F_0 = No fertilizer, F_1 = NPK, F_2 = NPK + Zn + B + Mn + S, F_3 = NPK + Zn + B + S, F_4 = NPK + Zn + B + Mn, F_5 = NPK + Zn + Mn + S, F_6 = NPK + B + Mn + S

4.1.3.3 Interaction effect of variety and micronutrient

Dry matter plant^{-1} was significantly influenced by the interaction effect between maize variety and micronutrient combination at 60 and 90 DAS and at harvest but it was no-significant at 30 DAS (Table 3 and Appendix VII). At 60 DAS, the highest dry matter weight plant^{-1} (44.10 g) was obtained from V_1F_2 where white maize (PSC-121) interacted with NPK+S+Zn+B+Mn and the lowest dry weight was obtained from V_2F_0 (31.55 g). At 90 DAS, the magnitude of dry matter production was to some extent changed where the highest dry weight plant^{-1} was recorded as 90.33 g from the treatment V_1F_2 which was statistically similar to 89.76 g from V_2F_2 when both of the crop was supplied all micronutrients and sulphur with NPK. The second highest dry weight plant^{-1} was recorded 83.61g from V_2F_3 which was statistically similar with V_1F_6 (83.19 g), V_1F_3 (83.09 g) and V_2F_4 (82.00 g). At harvest, maximum dry matter accumulation was obtained by plant of V_1F_2 (97.38 g) which was statistically similar with V_2F_2 (96.11 g) and V_1F_3 (95.92 g). The lowest dry weight was recorded from the treatment combination of V_2F_0 (59.71 g).

Table 3. Dry weight plant^{-1} of maize as affected by the interaction effect of variety and micronutrient

Treatment	Dry weight plant^{-1} (g)			
	30 DAS	**60 DAS**	90 DAS	**At harvest**
V_1F_0	0.57	33.83 h	57.85 f	67.29 h
V_1F_1	0.85	39.44 ef	79.29 c	86.79 d
V_1F_2	0.92	44.10 a	90.33 a	97.38 a
V_1F_3	0.85	41.21 cd	83.09 b	95.92 a
V_1F_4	0.81	42.22 b	79.52 c	91.61 b
V_1F_5	0.73	39.08 f	74.93 d	82.15 e
V_1F_6	0.76	40.12 e	83.19 b	87.32 d
V_2F_0	0.51	31.55 i	49.46 g	59.71 i
V_2F_1	0.80	37.21 g	75.04 d	89.88 c
V_2F_2	0.80	41.42 bc	89.76 a	96.11 a
V_2F_3	0.80	40.40 de	83.61 b	91.49 b
V_2F_4	0.75	40.03 e	82.00 b	88.00 cd
V_2F_5	0.70	38.76 f	68.90 e	79.16 g
V_2F_6	0.75	40.21 e	71.18 e	80.41 fg
SE	**0.008 (NS)**	**0.304**	**0.566**	**0.512**
CV(%)	**3.87**	**5.34**	**6.276**	**4.286**

NS = Non-significant

V_1 = White maize (PSC-121), V_2 = Yellow maize (BARI hybrid bhutta 7)

F_0 = No fertilizer, F_1 = NPK, F_2 = NPK + Zn + B + Mn + S, F_3 = NPK + Zn + B + S, F_4 = NPK + Zn + B + Mn, F_5 = NPK + Zn + Mn + S, F_6 = NPK + B + Mn + S

4.2 Yield contributing characters

4.2.1 Cobs plant^{-1} (no.)

4.2.1.1 Effect of variety

There exists a significant variation between the tested on cobs plant^{-1} of maize (Table 4 and Appendix VIII). The variety V_1 (1.19) was superior over V_2 (1.0) by producing 19.0% higher cobs plant^{-1} in maize. However, V_1 produced 1.19 cobs plant^{-1} whereas V_2 showed 1.0 cobs plant^{-1}. Biswas *et al.* (2014) found the similar result in his experiment.

4.2.1.2 Effect of micronutrient

The number of cobs plant^{-1} was affected due to micronutrients (Table 4 and Appendix VIII). Maximum cobs were found from F_6 (1.33) where micronutrients were used along with NPK and the minimum cobs were given by the treatment F_0 (1.00) which is statistically similar with F_1 (1.00), F_2 (1.00) and F_5 (1.00). The second highest number of cobs were recorded from treatment F_3 (1.17) that statistically similar with F_4 (1.17). This result was closely similar to the result of the experiment of Mona E. El-Azab (2015).

4.2.1.3 Interaction effect of variety and micronutrient

Interaction effect of variety and micronutrient was significant on the production of cobs plant^{-1} in maize (Table 4 and Appendix VIII). The maximum number of cobs plant^{-1} (1.67) was found from V_1F_6 combination due to the combination effect of variety and NPK+Zn+B+Mn+S, which treatment was V_1F_6 (1.67). The lowest number of cobs plant^{-1} (1.00) was given by all the combinations except V_1F_6, V_1F_3 and V_1F_4.

4.2.2 Cob length

4.2.2.1 Effect of variety

Significant variation was recorded for cob length of maize between the two varieties (Table 4 and Appendix VIII). The variety V_2 (BARI hybrid bhutta 7) was superior in producing maximum cob length than V_1 (PSC-121) which was 5.80% higher. However, cob length produced by V_2 variety was 17.88 cm and that was 16.90 cm from V_1 variety. The result was similar with the findings of Biswas *et al.* (2014) who reported that the BARI hybrid bhutta 7 had the highest cob length compared to any other hybrid variety.

4.2.2.2 Effect of micronutrient

Cob length exerted significant effect due to micronutrient application in maize (Table 4 and Appendix VIII). In general, application of micronutrient increased the cob length than control (no fertilizer plot) and only macronutrient (without micronutrient) applied plots. The longest cob was observed (18.63 cm) from F_2 treatment and the shortest cob (15.61 cm) was observed from F_0 treatment. The second longest cob was recorded from F_6 (17.72 cm) that is statistically similar with F_3 (17.61 cm), F_4 (17.60 cm) and F_5 (17.59 cm). Similar finding was reported by Hossain *et al.* (2011) that micronutrient increased the cob length of maize.

4.2.2.3 Interaction effect of variety and micronutrient

The interaction effect of variety and micronutrient on cob length (cm) of maize was highly significant in maize (Table 4 and Appendix VIII). The highest length was recorded from the treatment combination V_2F_2 (19.33 cm) which was statistically similar to V_2F_5 (18.63 cm), whereas the shortest cob was recorded as 14.77 cm from V_1F_0. That means, the longest cob was given by NPK+Zn+B+Mn+S than no fertilizer and only NPK treatment due to the combined effect of variety and micronutrients along with NPK. The second highest cob length was found at V_1F_2 (17.93 cm) that is statistically similar to the treatment V_2F_4 (17.91cm), V_2F_5 (18.63 cm), V_2F_6 (17.90 cm).

4.2.3 Cob diameter

4.2.3.1 Effect of variety

The cob diameter was significantly affected due to the varietal effect in maize (Table 4 Appendix xii). Cobs found from V_1 (PSC-121) had the highest diameter (16.58 cm) compared to the cobs from V_2 (BARI hybrid bhutta 7) with diameter 16.25 cm. Variation in cob diameter may be attributed by the varietal character of maize. Hossain *et al.* (2011) showed the cob diameter was affected by the varietal characteristics which supports the present findings.

4.2.3.2 Effect of micronutrient

From the Table 4 it was found that, application of micronutrients in combination with NPK had the significant influence on cob diameter. The highest cob diameter was recorded from the treatment F_2 (17.32 cm) which is statistically similar with F_3 (16.98 cm). The lowest cob diameter was recorded from the treatment F_0 (15.44 cm). So, it may be concluded that, the cob diameter was higher in the treatment with micronutrient with NPK than the treatment without fertilizer and with only NPK. The result agrees with the findings of Tahir (2012) that the cob diameter increased with the application of micronutrients.

4.2.3.3 Interaction effect of variety and micronutrient

Interaction of variety and micronutrient treatment exerted significant variation on cob diameter of maize (Table 4 and Appendix VIII). The highest diameter was recorded from the treatment combination of V_1F_3 (17.46 cm) which is statistically similar to the V_1F_2 (17.43 cm) and V_2F_2 (17.21 cm) where variety V_1 and NPK+Zn+B+Mn+S interacted with each other. The lowest cob diameter was recorded from the treatment combination of V_1F_0 (15.35 cm) and V_2F_0 (15.54 cm). It was found that the combined effects of variety and micronutrient along with NPK increase the cob diameter.

4.2.4 Rows cob^{-1}

4.2.4.1 Effect of variety

Maize variety exhibited significant difference in respect of the number of grain rows cob^{-1} (Table 4 and Appendix VIII). Between two varieties, V_2 (BARI hybrid bhutta 7) showed the maximum number of row cob^{-1} (16.40) and V_1 (PSC-121) showed the minimum number of row cob^{-1} (14.20). Hussain *et al.* (1999) observed that number of rows cob^{-1} varied between the varieties which correlate the present finding.

4.2.4.2 Effect of micronutrient

Significant response among the micronutrient treated plots was observed on the rows cob^{-1} in maize (Table 4). The highest number of kernel rows cob^{-1} (15.82) was produced when the crop received all micronutrients and NPK fertilizers (F_2) followed by F_4 (15.81) and F_5 (15.78) which were statistically similar. The second highest number of kernel rows cob^{-1} (15.42) was produced when the crop was supplied with NPK along with B, Zn and S but lacked Mn application (F_3) followed by F_6 which produced 15.27 kernel rows cob^{-1} when the crop was supplied with B, Mn and S applied lacked Zn but along with NPK fertilizers which were statistically similar. However, lower number of rows cob^{-1} (14.70) was produced at only NPK fertilizer (F_1) and followed by F_0 which produced 14.31 rows cob^{-1}. Similar finding was found by Adhikary *et al.* (2010) which supports the present result.

4.2.4.3 Interaction effect of variety and micronutrient

Combined effect of variety and micronutrient combination along with NPK on number of rows cob^{-1} was significant (Table 4). The highest kernel rows cob^{-1} (17.37) from the interaction of V_2F_2 (BARI hybrid bhutta 7×NPK+Zn+B+Mn+S) which was statistically similar with V_2F_4 (17.02). The second highest number of kernel rows cob^{-1} (16.51) was produced when the crop was supplied with NPK along with Zn, B and S but lacked Mn application (V_2F_5) followed by V_2F_1 and V_1F_2 (15.99 and 15.00, respectively). However, lower number of rows cob^{-1} (13.41) was produced by the interaction effect of V_1F_1 (PSC-121×NPK) and followed by V_1F_0 (PSC-121×no fertilizer) which produced 12.90 rows cob^{-1}.

4.2.5 Grains row^{-1}

4.2.5.1 Effect of variety

Significant difference was found on number of grains cob^{-1} in maize due to varieties (Table 4 and Appendix VIII). Between two varieties, V_1 (PSC-121) gave the maximum number of grain row^{-1} (16.40) and V_2 (BARI hybrid bhutta 7) showed the minimum number of grains row^{-1} (14.20). The data indicates that V_1 gave 15.49% higher number of grains row^{-1} in maize. This result agrees with the finding of Hussain *et al.* (1999) who noticed that the grains row^{-1} varied among the varieties in maize.

4.2.5.2 Effect of micronutrient

Significant response among the micronutrient treated plots was observed on the grain row^{-1} in maize (Table 4). The highest number of grains row^{-1} (30.82) was recorded in the F_2 plot (all micronutrients along with NPK fertilizers). The lowest number of grains row^{-1} (21.44) was produced with F_0 treatment. The result was similar with the findings of Adhikary *et al.* (2010) who reported that grains row^{-1} varied with micronutrient treatment.

4.2.5.3 Interaction effect of variety and micronutrient

Number of grains row^{-1} was significant due to the combined effect of variety and micronutrients along with NPK (Table 4). The highest number of grains row^{-1} (32.88) was produced with the interaction of V_1F_2 when the V_1 crop received all micronutrients and NPK fertilizers. The second highest number of grains rows^{-1} (30.37) were produced with V_1F_5 interaction. However, the lowest number of grains row^{-1} (21.24) was produced by the interaction of V_1F_0 which was statistically similar with V_2F_0 (21.63) combination.

4.2.6 Grains cob^{-1}

4.2.6.1 Effect of variety

Number of grains cob^{-1} varied significantly with different varieties of maize (Table 4 and Appendix VIII). The result revealed that V_2 (BARI hybrid bhutta 7) gave the highest grains cob^{-1} (437.54) and V_1 (PSC-121) showed the lower number of grains cob^{-1} (416.10). It can be inferred from the result that V_2 produced 5.15%

higher grains cob^{-1}than V_1. The higher grains cob^{-1} in V_2 may be attributed to higher cob length and rows cob^{-1} in the V_2 variety. Similar finding was reported by Tariq *et al.* (2014) who observed that number of grains per cob varies with maize variety.

4.2.6.2 Effect of micronutrient

Different micronutrient treatment exhibited significant difference on grain cob^{-1} in maize (Table 4 and Appendix VIII). Significantly highest grains cob^{-1} (30.82) was obtained from F_2 (NPK+Zn+B+Mn+S) and the lowest (21.44) was obtained from F_0 (without fertilizer). This result was close to the result of the experiment conducted by Tahir *et al.* (2012).

4.2.6.2 Interaction effect of variety and micronutrient

Interaction of variety and micronutrients significantly influenced the number of grains cob^{-1} in maize (Table 4). The highest number of grains cob^{-1} (472.10) was produced by the treatment combination of V_1F_2 which was statistically similar with V_2F_2 (468.70) when crop was treated by all micronutrients and NPK fertilizers. Second highest number of grains cob^{-1} (462.30) was produced with the treatment combination $V_2F_{3.}$ However, the lowest number of grains cob^{-1} was produced by the interaction of V_1F_0 (273.00).

4.2.7 Weight of 1000 grains

4.2.7.1 Effect of variety

Thousand grains weight was significantly affected due to variety of maize (Table 4 and Appendix VIII). The higher 1000 grain weight (390.18 g) was found from V_1 (PSC-121) than V_2 (BARI hybrid bhutta7). This result indicates that variety V_1 produced 12.75% heavier seed than V_2 variety. This result correlates with the findings of Hussain *et al.* (1999) who reported that 1000 grain weight varied among the maize varieties.

4.2.7.2 Effect of micronutrient

Weight of 1000 grains had significant effect due to micronutrient treatments in maize (Table 4 and Appendix VIII). The highest 1000 grain weight (389.50 g) was found with F_2 (NPK+Zn+B+Mn+S) which was statistically similar with F_3 and F_4 treatment (386.70 and 381.80 g, respectively). On the other hand the lowest 1000 grain weight was found with F_0 (326.90 g) which was closed to F_1 (353.40 g). The result fairly agreed with the findings of Adhikary *et al.* (2010) who reported that 1000 grain weight with micronutrient treatment.

4.2.7.3 Interaction effect of variety and micronutrient

Interaction of variety and micronutrient exerted significant variation on weight of 1000 seed of maize (Table 4 and Appendix VIII). The data revealed that irrespective of micronutrient treatment V_1 variety gave higher 1000 grain weight than V_2. The highest 1000 grain weight (408.80 g) was found with the interaction of V_1F_2 which was statistically similar with V_1F_3 (405.10 g). The lowest weight of 1000 seed was found with the interaction of V_2F_1 (338.50 g) which was statistically similar with V_2F_5 interaction (344.30 g).

Table 4. Interaction effect of variety and micronutrient on yield contributing character of maize

Treatment	Yield contributing parameters						
	Cobs $plant^{-1}$ (no.)	Cob length (cm)	Cob diameter (cm)	Row cob^{-1} (no.)	Grains row^{-1} (no.)	Grains cob^{-1} (no.)	Weight of 1000 grains (g)
Effect of variety							
V_1	1.19 a	16.90 b	16.58 a	14.20 b	29.07 a	416.10 b	390.18 a
V_2	1.00 b	17.88 a	16.25 b	16.40 a	26.39 b	437.54 a	346.06 b
SE	**0.0891**	**0.2266**	**0.101**	**0.244**	**0.514**	**1.066**	**3.967**
CV(%)	**3.73**	**5.96**	**2.80**	**7.27**	**7.13**	**4.53**	**5.55**
Effect of micronutrients							
F_0	1.00 c	15.61 d	15.44 e	14.31 d	21.44 f	305.90 f	326.90 f
F_1	1.00 c	16.97 c	15.85 d	14.70 c	27.00 e	432.80 e	353.40 e
F_2	1.00 c	18.63 a	17.32 a	15.82 a	30.82 a	470.40 a	389.50 a
F_3	1.17 b	17.61 b	16.98 ab	15.42 b	29.59 b	456.40 b	386.70 a
F_4	1.17 b	17.60 b	16.63 bc	15.81 a	28.28 d	445.00 c	381.80 b
F_5	1.00 c	17.59 b	16.35 c	15.78 a	27.98 d	437.20 d	365.60 d
F_6	1.33 a	17.72 b	16.33 c	15.27 b	29.03 c	440.00 d	372.90 c
SE	**0.1521**	**0.1878**	**0.1792**	**0.259**	**0.528**	**2.025**	**2.414**
CV(%)	**2.03**	**4.63**	**3.66**	**4.143**	**4.122**	**7.863**	**6.748**
Interaction effect of variety and micronutrients							
V_1F_0	1.00 c	14.77 f	15.35 f	12.90 f	21.24 g	273.00 i	368.00 de
V_1F_1	1.00 c	16.58 de	15.88 de	13.41 ef	29.00 c	425.70 g	368.30 c
V_1F_2	1.00 c	17.93 bc	17.43 a	15.00 cd	32.88 a	472.10 a	408.80 a
V_1F_3	1.33 b	17.67 c	17.46 a	14.84 d	30.19 b	450.50 d	405.10 ab
V_1F_4	1.33 b	17.29 cd	16.84 bc	14.61 d	29.66 bc	433.30 f	400.90 b
V_1F_5	1.00 c	16.55 de	16.44 cd	14.25 d	30.37 b	430.70 fg	387.00 c
V_1F_6	1.67 a	17.49 c	16.68 bc	14.37 d	30.13 b	430.80 fg	393.00 c
V_2F_0	1.00 c	16.46 e	15.54 ef	15.71 c	21.63 g	338.80 h	285.70 h
V_2F_1	1.00 c	17.36 cd	15.81 de	15.99 c	25.00 f	439.80 e	338.50 g
V_2F_2	1.00 c	19.33 a	17.21 ab	17.37 a	28.75 cd	468.70 a	370.20 d
V_2F_3	1.00 c	17.54 c	16.50 cd	16.00 c	28.98 c	462.30 b	368.30 de
V_2F_4	1.00 c	17.91 bc	16.41 cd	17.02 ab	26.89 e	456.80 c	362.70 e
V_2F_5	1.00 c	18.63 ab	16.27 cd	16.51 bc	25.59 f	443.70 e	344.30 g
V_2F_6	1.00 c	17.94 bc	15.98 de	16.17 c	27.92 d	449.30 d	352.70 f
SE	**0.2152**	**0.2656**	**0.2535**	**0.366**	**0.693**	**3.114**	**3.311**
CV(%)	**2.03**	**4.63**	**3.66**	**4.143**	**4.122**	**7.863**	**6.748**

V_1 = White maize (PSC-121), V_2 = Yellow maize (BARI hybrid bhutta 7)

F_0 = No fertilizer, F_1 = NPK, F_2 = NPK + Zn + B + Mn + S, F_3 = NPK + Zn + B + S, F_4 = NPK + Zn + B + Mn, F_5 = NPK + Zn + Mn + S, F_6 = NPK + B + Mn + S

4.2.8 Grain yield

4.2.8.1 Effect of variety

Variety acts as one of the most important factors on grain yield. In this experiment, V_1 (PSC-121) gave the higher yield (10.67 t ha^{-1}) whereas 8.84 t ha^{-1} grain yield was obtained from V_2 (BARI hybrid bhutta 7). The yield data indicated that variety PSC-121 (V_1) out yielded by providing 20.70% higher yield over BARI hybrid bhutta 7 (Table 5 and Appendix IX). The result was in accordance with Biswas *et al.* (2014) and Tariq *et al.* (2014) who found that hybrid variety gave the highest grain. On the other hand, Rahman *et al.* (2017) showed that hybrid maize produced 50% more yield than inbred variety.

4.2.8.2 Effect of micronutrient

The data revealed that application of micronutrient increased grain yield over control (no fertilization) and fertilization with only NPK (macronutrient). The highest grain yield (11.81 t ha^{-1}) found with F_2 (NPK+Zn+B+Mn+S). The second highest yield was recorded with treatment of F_3 (10.63 t ha^{-1}). On the other hand, the lowest grain yield was found with F_0 (6.97 t ha^{-1}). Mona E. El-Azab (2015) reported the similar result in respect of grain yield and micronutrient combinations.

4.2.8.3 Interaction effect of variety and micronutrient

Grain yield was significantly influenced by interaction effect of variety and micronutrients application (Table 5 and Appendix IX). Results showed that the highest grain yield (12.78 t ha^{-1}) was found with the treatment combination of V_1F_2. The second highest grain yield was obtained from V_1F_4 and V_1F_3 which were 11.36 and 11.56 t ha^{-1}, respectively. On the other hand, the lowest grain yield (6.16 t ha^{-1}) was observed with V_2F_0. The result was in accordance with Gillani *et al*. (2014) and Tahir *et al.* (2011) who found the similar result in respect of grain yield.

4.2.9 Stover yield

4.2.9.1 Effect of variety

Stover yield of maize showed statistically significant variation due to varietal effect (Table 5). The highest stover yield of 12.69 t ha^{-1} was recorded from V_1 (PSC-121) variety. On the other hand, the lowest stover yield (11.00 t ha^{-1}) was observed from V_2 (BARI hybrid bhutta 7). Hossain *et al.* (2011) and Tariq *et al.* (2014) reported that the grain yield and stover yield were affected by variety of maize which confirms the present findings.

4.2.9.2 Effect of Micronutrient

Maize responded significantly to the application of micronutrient on the Stover yield of maize (Table 5). The highest stover yield (13.43 t ha^{-1}) was produced when all micronutrients and sulphur (Zn, B, Mn and S) were applied in combination with NPK fertilizers at recommended doses (F_2) followed by F_3 (12.55 t ha^{-1}) and F_4 (12.46 t ha^{-1}). The lowest stover yield (8.11 t ha^{-1}) was produced by the control treatment (F_0). This result was similar to Hossain *et al.* (2011); Ziaeyana and Rajaiea (2009) who reported that Zn and B fertilization significantly increased grain yield, stover yield and biological yield.

4.2.9.3 Interaction effect of variety and micronutrient

Significant influence had been found by the interaction of variety and micronutrients application on Stover yield of maize (Table 5 and Appendix IX). Results showed that the highest stover yield (14.16 t ha^{-1}) was found with the treatment combination of V_1F_2. The second highest and statistically similar stover yield was obtained from V_1F_3, V_1F_4 and V_1F_6 (13.46 t ha^{-1} and 13.30 t ha-1, 13.05 t ha^{-1}, respectively). On the other hand, the lowest grain yield (8.11 t ha^{-1}) was observed with V_2F_0. Gillani *et al*. (2014) and Tahir *et al.* (2011) also reported the similar result in respect of stover yield in maize.

4.2.10 Biological yield

4.2.10.1 Effect of variety

It was revealed from the experiment that biological yield of maize showed significant variation due to varietal effect (Table 5 and Appendix IX). The highest biological yield (23.36 t ha^{-1}) was observed from V_1 (PSC-121). On the other hand, the lowest biological yield (19.84 t ha^{-1}) was observed from V_2 (BARI hybrid bhutta 7). The result fairly corroborates with the findings of the experiment of Tariq *et al.* (2014) and Biswas *et al.* (2014) who reported that biological yield varied among the varieties of maize.

4.2.10.2 Effect of micronutrients

Application of micronutrient combinations significantly influenced the biological yield of maize (Table 5 and Appendix IX). The highest biological yield (25.24 t ha^{-1}) was produced when all micronutrients and sulphur (Zn, B, Mn and S) were applied in combination with NPK fertilizers at recommended doses (F_2). The lowest biological yield (16.06 t ha^{-1}) was produced by the control treatment (F_0). Ziaeyana and Rajaiea (2009) reported that Zn and B fertilization significantly increased grain yield, Stover yield and plant biological yield of maize which corroborate the present findings.

4.2.10.3 Interaction effect of variety and micronutrient

Interaction of variety and micronutrient varied significantly on biological yield of maize (Table 5 and Appendix IX). In general, interaction of F_0 and F_1 with both the varieties (PSC-121 and BARI hybrid bhutta7) showed lower biological yield than interaction treatments comprised with micronutrients. The highest biological yield (26.74 t ha^{-1}) was found with V_1F_2 and that of lowest (14.27 t ha^{-1}) was observed with V_2F_0 interaction.

4.2.11 Harvest index

4.2.11.1 Effect of variety

Harvest index was affected significantly due to variety in maize (Table 5 and Appendix IX) by varietal effect. Here, the highest harvest Index was obtained from V_1 (PSC-121) as 45.56% whereas, V_2 (BARI hybrid bhutta7) gave the lowest Harvest index 44.45%. The result of the present experiment corroborates with the findings of Potarzycki and Grzebisz (2009) who reported that harvest index varied among the varieties.

4.2.11.2 Effect of micronutrient

Micronutrient application significantly influenced the harvest index of maize (Table 5 and Appendix IX). The highest harvest index was revealed from F_2 treatment (46.73 %) when all micronutrient and sulphur (Zn, B, Mn and S) were applied in combination with NPK fertilizers at recommended doses and the lowest harvest index was found from F_0 (43.35%) when no fertilizer was applied. The result was consistence with the findings of Esmaeili *et al.* (2016) reported that micronutrient supplement increased harvest index of maize crop.

4.2.11.3 Interaction effect of variety and micronutrients

Interaction of variety and micronutrient combinations exhibits significant variation on harvest index of maize (Table 5 and Appendix IX). The highest Harvest Index (47.44%) was recorded by the interaction of V_1F_2 and the lowest biological yield was observed by treatment combination of V_2F_0 (43.54%) which was statistically similar with V_2F_5 (43.18 %) and V_1F_0 (43.54%). The second highest harvest index was found from the treatment V_1F_3 (46.20%) which was statistically similar to the treatment V_1F_4 (46.07%) and V_2F_2 (46.03%).

Table 5. Interaction effect of variety and micronutrient on yield parameters of maize

Treatments	Yield parameters			
	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Effect of variety				
V_1	10.67 a	12.69 a	23.36 a	45.56 a
V_2	8.84 b	11.00 b	19.84 b	44.45 b
SE	**0.038**	**0.169**	**0.271**	**1.125**
CV(%)	**2.21**	**9.98**	**7.58**	**10.36**
Effect of micronutrients				
F_0	6.970 f	9.100 e	16.06 e	43.35 d
F_1	9.390 e	11.32 d	20.70 d	45.30 b
F_2	11.81 a	13.43 a	25.24 a	46.73 a
F_3	10.63 b	12.55 b	23.17 b	45.83 b
F_4	10.42 c	12.46 b	22.88 b	45.50 b
F_5	9.510 d	11.95 c	21.46 c	44.25 c
F_6	9.570 d	12.12 c	21.68 c	44.08 c
SE	**0.066**	**0.211**	**0.314**	**2.357**
CV(%)	**4.816**	**6.352**	**5.513**	**11.376**
Interaction effect of variety and micronutrients				
V_1F_0	7.770 h	10.08 g	17.85 h	43.54 gh
V_1F_1	10.30 d	12.21 e	22.51 d	45.76 cd
V_1F_2	12.78 a	14.16 a	26.94 a	47.44 a
V_1F_3	11.56 b	13.46 b	25.02 b	46.20 b
V_1F_4	11.36 b	13.30 b	24.66 b	46.07 bc
V_1F_5	10.41 d	12.56 de	22.97 cd	45.32 e
V_1F_6	10.49 cd	13.05 bc	23.54 c	44.56 f
V_2F_0	6.160 i	8.110 h	14.27 i	43.17 h
V_2F_1	8.470 g	10.42 g	18.89 g	44.84 f
V_2F_2	10.83 c	12.70 cd	23.53 c	46.03 bc
V_2F_3	9.690 e	11.63 f	21.32 e	45.45 de
V_2F_4	9.000 f	11.62 f	21.10 e	44.93 f
V_2F_5	8.610 fg	11.33 f	19.94 f	43.18 h
V_2F_6	8.640 fg	11.18 f	19.82 f	43.59 g
SE	**0.101**	**0.312**	**0.533**	**3.042**
CV(%)	**4.816**	**6.352**	**5.513**	**11.376**

V_1 = White maize (PSC-121), V_2 = Yellow maize (BARI hybrid bhutta 7)

F_0 = No fertilizer, F_1 = NPK, F_2 = NPK + Zn + B + Mn + S, F_3 = NPK + Zn + B + S, F_4 = NPK + Zn + B + Mn, F_5 = NPK + Zn + Mn + S, F_6 = NPK + B + Mn + S

CHAPTER V

SUMMERY AND CONCLUSION

Summary

The field experiment was conducted at the Agronomy Field of Sher-e-Bangla Agricultural University farm, in rabi season during the period from November 2017 to April 2018 with a view to find out the influence of different combinations of micronutrient and sulphur on growth and yield of maize (*Zea mays* L.). The experiment was carried out in split-plot design with 3 replications having two varieties (White maize and yellow maize) in main plot and 7 micronutrients combination along with NPK at recommended doses in the sub plot. The varieties were PSC-121 as white maize (V_1) and BARI hybrid bhutta7 (V_2) as well as micronutrients combinations were No Fertilizer (F0), NPK (F_1), NPK+Zn+B+Mn+S (F_2), NPK+Zn+B+S (F_3), NPK+Zn+B+Mn (F_4), NPK+Zn+Mn+S (F_5) and NPK+Mn+S+B (F_6).

The data on crop growth characters like plant height, number of leaves plant^{-1}, dry mater weight plant^{-1} were recorded at different days after sowing in the field and yield as well as yield contributing characters like number of cob plant^{-1}, cob length, cob diameter, number of rows cob^{-1}, number of grains row^{-1}, number of grains cob^{-1}, 1000-grain weight, grain and stover yield were recorded after harvest and analysed using the MSTAT-C computer package program. The mean differences among the treatments were compared by DMRT at 5 % level of significance.

Results showed that at 25, 50, 75, 100 days after sowing (DAS) and harvest stage, the higher plant height was recorded (40.94cm, 87.53cm, 183.38cm, 227.73cm and 229.12cm) from V_2 variety while V_1 gave the lower values (35.25cm,

67.23cm, 169.98cm, 223.83cm and 225.77cm). The higher leaves number was recorded from V_1 at 100 DAS (12.78) and also at harvest stage (13.15) compared to number of leaves of V_2 at the same stages. The higher plant dry weight was recorded from V_1 (40.00 g, 78.32 g, and 86.92 g) compared to V_2 (38.51 g, 74.28 g and 83.54 g) at 60 DAS, 90 DAS and at harvest stage. In case of yield contributing characters, the maximum number of cobs per plant was found in V_1 compared to V_2. The length of cob 17.88 cm was higher in V_2 than V_1 which was 16.90 cm. Cobs found from V_1 had the highest diameter (16.58 cm) compared to the cobs from V_2 with diameter 16.25 cm. V_2 showed the maximum number of row cob^{-1} (16.40) and V_1 showed the minimum number of row cob^{-1} (14.20). Maximum number of grain row^{-1} was given by V_1 (16.40) and minimum number of grains row^{-1} was showed by V_2 (14.20). Whereas, maximum number of grains cob^{-1} (437.54) was recorded from V_2 and minimum number of grains row^{-1} was found from V_1 (416.10). The higher 1000 grain weight (390.18 g), grain yield (10.67 t ha^{-1}), biological yield (23.36 t ha^{-1}), harvest index (45.56%) were obtained from V_1 when lower 1000 grains weight (346.06 g), grain yield (8.84 t ha^{-1}), stover yield (11.00 t ha^{-1}), biological yield (19.84 t ha^{-1}), harvest index (44.45%) were found from V_2.

In this trial the highest plant heights of maize was given at 25 DAS by F_2 (47.22 cm), F_4 (85.76 cm) at 50 DAS, F_2 (198.10 cm) at 75 DAS, F_4 (241.90 cm) at 100 DAS and F_2 (240.70 cm) at harvest stages whereas the lowest heights were recorded from F_0 at all stages of growth of maize plant. Leaves plant^{-1} were highest in F_3 (9.00) which was statistically similar to F_1 (9.00), F_2 (8.99), F_4 (8.72) and F_5 (8.83) at 50 DAS, when F_1 (11.53) at 75 DAS, at 100 DAS F_2 (13.67) and at harvest stage F_2 (13.64). The highest dry matter weight plant^{-1} was found At 60 DAS in F_2 (42.76 g), at 90 DAS in F_2 as (90.04 g) and at in harvest F_2 (96.75 g) and the lowest dry weight was found from F_0 at all growth stages of plant. Maximum cobs number was found from F_6 (1.33), the longest cob was observed

(18.63 cm) in F_2 and lowest one was found F_0 (15.61 cm). Likewise, the highest cob diameter (17.32 cm), row cob^{-1} (15.82 rows cob^{-1}), number of grains row^{-1} (30.82), number of grains cob^{-1} (470.40), 1000 grain weight (389.50 g), grain yield (11.81 t ha^{-1}), stover yield (13.43 t ha^{-1}), biological yield (25.24 t ha^{-1}), harvest index (46.73 %) were recorded from F_2 compared to treatment F_0 and F_1.

The interaction treatment V_1F_2 gave the highest plant height (51.26 cm) at 25 DAS, V_2F_1 (96.39 cm) at 50 DAS, V_2F_2 (204.1 cm) at 75 DAS, V_2F_3 (243.80 cm) at 100 DAS, V_2F_2 (247.60 cm) at harvest and the lowest plant height was recorded from V_1F_0 at all growth stages of plant. The highest number of leaves $plant^{-1}$ was recorded from V_2F_4 (9.55) at 50 DAS, V_2F_5 (11.67) at 75 DAS, V_1F_2 (14.45) at 100 DAS, V_1F_2 (14.56) at harvest and the lowest number of leaves $plant^{-1}$ was in V_1F_0 (6.89) at 50 DAS, V_2F_0 (10.0) at 75 DAS, V_2F_0 (10.10) at 100 DAS and V_2F_4 (11.61) at harvest stage. The highest dry matter weight $plant^{-1}$ was found in V_1F_2 at 60 DAS (44.10 g) and 90 DAS (90.33 g), in V_1F_2 (97.38 g) at harvest and the lowest dry matter weight $plant^{-1}$ was found from V_2F_0 for all growth stages. The highest number of cobs $plant^{-1}$ in V_1F_6 (1.67), cob length in V_2F_2 (19.33 cm), cob diameter V_1F_3 (17.46 cm) which is statistically similar to the V_1F_2 (17.43 cm) and V_2F_2 (17.21 cm), number of rows cob^{-1} in V_2F_2 (17.37), highest number of grains row^{-1} was produced by V_1F_2 (32.88), grains cob^{-1} by V_1F_2 (472.10), 1000 grain weight (408.80 g) by V_1F_2 compared to V_1F_0 and V_2F_0 (produced lowest values of the parameters).

Conclusion

i. The variety V_1 (PSC-121) i.e white maize performed better in respect of yield, yield attributes and other characters,

ii. Micronutrient treatment comprised of Zn+B+Mn+S along with NPK (F_2) showed the best performance on yield, yield attributes and other characters of maize, and

iii. Interaction of variety and NPK+Zn+B+Mn+S seems promising for cultivation of maize.

RECOMMENDATION

The study was undertaken at the environment of Sher-e-Bangla Agricultural University farm which may not be similar to those of the rural farmer's field environment. Moreover, the soil condition and nutritional status of the Sher-e-Bangla Agricultural University is different from the farmer's ones. So, results obtained from this study may not be applicable in the farmer's field. To optimize the obtained technology in this study, the trial must be repeated on-farm in the farmer's field at different ecological regions of Bangladesh.

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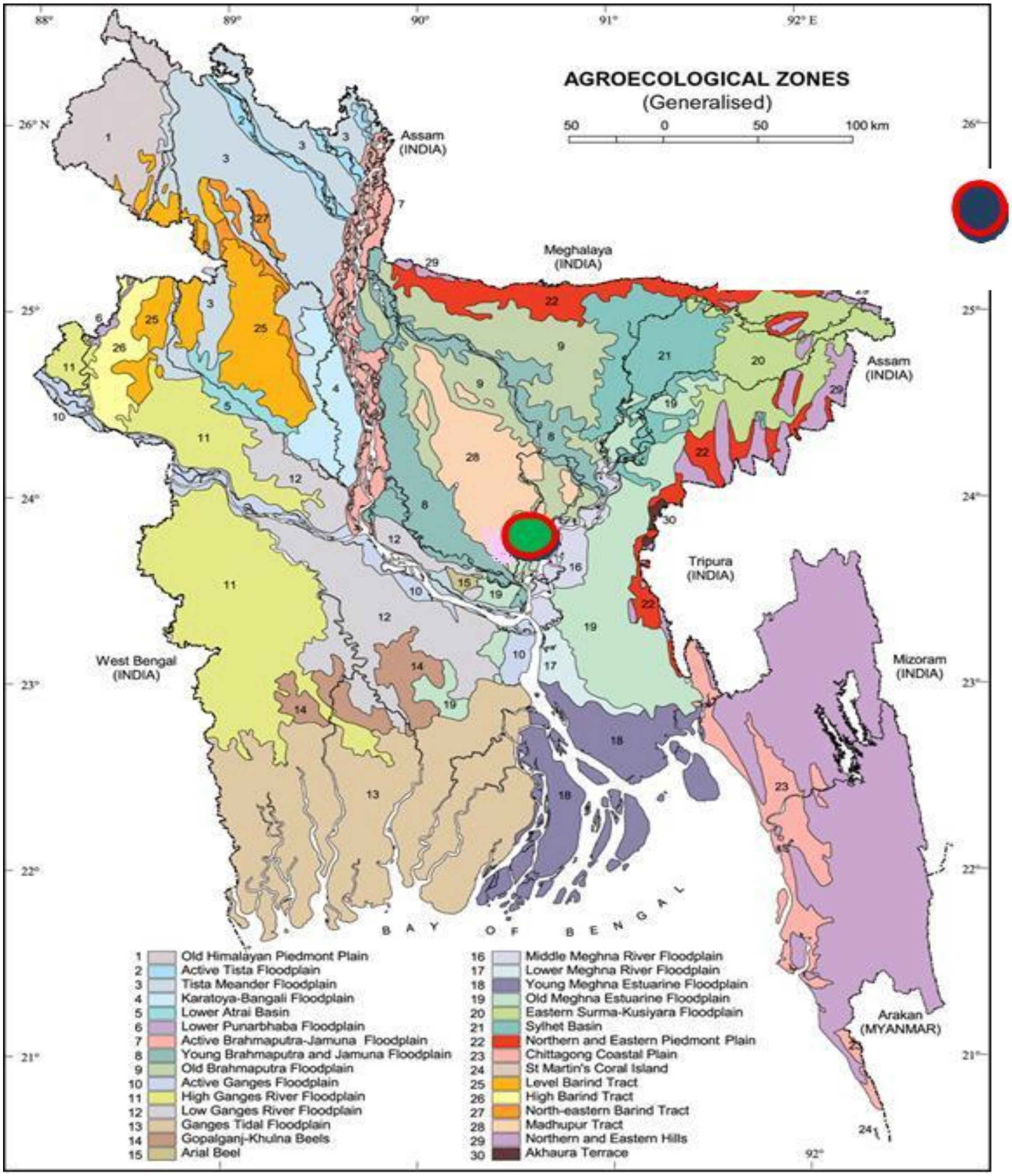
APPENDICES

Appendix I. Map showing the experimental site under study



Appendix II. Monthly meteorological information during the period from November, 2017 to April, 2018

Year	**Month**	**Air temperature (^oC)**		**Relative Humidity (%)**	**Total rainfall (mm)**
		Maximum	**Minimum**		
2017-2018	November	28.89	11.88	56.58	51
	December	25.13	8.98	69.85	1.21
	January	23.97	9.28	71.09	Trace
	February	25.12	13.89	76.99	Trace
	March	29.21	14.09	75.89	1.01
	April	30.85	16.96	65.98	63

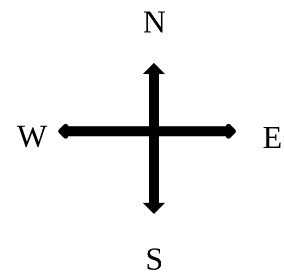
Source: Meteorological Centre (Climate Division), Agargoan, Dhaka

Appendix III. Physico-chemical properties of soil in the study area

Characteristics	**Value/concentration**
Particle size analysis.	
% Sand	26
% Silt	45
% Clay	29
Textural class	silty-clay
pH	6.3
Organic matter (%)	1.8
Total N (%)	.09
Phosphorus microgram/g soil	13.1
Potassium (ml equivalent/100 g soil	0.19

Appendix IV. Layout of the experiment

Replication-1		Replication-2		Replication-3	
V_1F_3	V_2F_0	V_2F_1	V_1F_5	V_1F_4	V_2F_2
V_1F_6	V_2F_5	V_2F_4	V_1F_0	V_1F_3	V_2F_5
V_1F_0	V_2F_3	V_2F_2	V_1F_4	V_1F_6	V_2F_1
V_1F_1	V_2F_2	V_2F_5	V_1F_2	V_1F_0	V_2F_3
V_1F_4	V_2F_6	V_2F_3	V_1F_6	V_1F_2	V_2F_6
V_1F_2	V_2F_1	V_2F_0	V_1F_1	V_1F_5	V_2F_4
V_1F_5	V_2F_4	V_2F_6	V_1F_3	V_1F1	V_2F_0



Plot size: 3.6 × 1.5
Plot spacing: 0.25 m
Between replication: 0.75m

Factor A: Variety (main plot)

V_1= PSC-121
V_2= BARI hybrid bhutta 7

Factor B: Micronutrient combinations (sub-plot)

F_0 = No Fertilizer (control)

F_1= NPK (no micronutrient)

F_2= NPK+Zn+B+S+Mn

F_3= NPK+Zn+B+S (no Mn)

F_4= NPK+Zn+B+Mn (no S)

F_5 = NPK+Zn+Mn+S (no B)

F_6 = NPK+Mn+S+B (no Zn)

Appendix V. Mean square of plant height of maize as affected by variety, micronutrients and their interaction

Sources of variation	Degrees of freedom	Mean square of plant height				
		25 DAS	50 DAS	75 DAS	100 DAS	At harvest
Replication	2	4.338	5.162	12.576	13.426	15.123
Factor A	1	339.49*	432.73*	188.24*	207.52*	292.35*
Error	2	2.596	6.012	0.669	0.440	23.175
Factor B	6	125.15*	339.39*	651.31*	992.16*	681.31*
AB	6	69.541*	16.990*	20.357*	25.327*	24.492*
Error	24	1.019	3.891	8.504	8.783	10.577

* Significant at 5% level
** Significant at 1% level

Appendix VI. Mean square of number of leaves plant^{-1} of maize as affected by variety, micronutrients and their interaction

Sources of variation	Degrees of freedom	Mean square of number of leaves plant^{-1}				
		25 DAS	50 DAS	75 DAS	100 DAS	At harvest
Replication	2	0.621	1.090	1.141	2.242	24241
Factor A	1	0.024^{NS}	0.957^{NS}	0.945^{NS}	1.059*	0.033*
Error	2	0.000	0.051	0.115	0.073	0.410
Factor B	6	0.177^{NS}	2.668**	2.588*	2.227*	3.385*
AB	6	0.161^{NS}	0.905*	0.853*	0.892*	0.523*
Error	24	0.028	0.828	0.048	0.068	0.095

* Significant at 5% level
** Significant at 1% level

Appendix VII. Mean square of dry weight plant^{-1} as affected by variety, micronutrients and their interaction

Sources of variation	Degrees of freedom	Mean square of dry weight plant^{-1} (cm)			
		30 DAS	60 DAS	90 DAS	At harvest
Replication	2	0.011	1.284	3.511	5.076
Factor A	1	0.018^{NS}	23.28**	194.66*	203.85*
Error	2	0.007	0.106	1.166	0.221
Factor B	6	0.079^{NS}	63.08*	784.53*	708.28*
AB	6	0.003^{NS}	1.853*	35.110*	31.150*
Error	24	0.001	0.278	0.954	0.776

* Significant at 5% level
** Significant at 1% level

Appendix VIII. Mean square of yield contributing parameters of maize as affected by variety, micronutrients and their interaction

Sources of variation	Degrees of freedom	Mean square of yield contributing parameters						
		Number of cobs plant^{-1}	Cob length (cm)	Cob diameter (cm)	Number of lines/ cob	Number of grains/ line	Number of grains/ cob	1000 seed weight (g)
Replication	2	0.167	1.730	1.639	2.151	2.363	25.440	29.059
Factor A	1	0.381*	9.381**	1.449**	56.56*	76.36*	515.19*	577.78*
Error	2	0.167	1.079	0.215	1.228	4.014	43.049	41.697
Factor B	6	0.103*	4.913*	2.087*	1.859**	57.39*	480.35*	517.07*
AB	6	0.103**	0.936*	0.209*	0.645*	5.142*	51.869*	45.270*
Error	24	0.139	0.212	0.193	0.399	1.239	12.419	12.656

* Significant at 5% level
** Significant at 1% level

Appendix IX. Mean square of yield parameters of maize as affected by variety, micronutrients and their interaction

Sources of variation	Degrees of freedom	Mean square of yield parameters			
		Grain yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Replication	2	0.894	1.781	2.052	4.832
Factor A	1	35.072**	26.196*	42.443*	62.977*
Error	2	0.046	1.324	2.536	23.616
Factor B	6	13.018*	29.136*	33.842*	56.728*
AB	6	0.017*	0.687**	1.214*	35.328*
Error	24	0.030	0.337	0.536	25.615

* Significant at 5% level
** Significant at 1% level

SOME PICTORIAL VIEW OF THE EXPERIMENT

Field view of maize plot at early stage

Field view at vegetative stage of maize

Reproductive stage of maize

Some cobs collected from my research field