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IMPACT OF ZINC AND MANGANESE APPLICATION TO INCREASE PRODUCTIVITY OF AUTUMN PLANTED MAIZE (*ZEA MAYS* L.)

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ABSTRACT. Micronutrients play a significant role in various plant metabolic processes and are required in much smaller amount by the plants as compared to the macronutrients. An experiment was conducted during 2011, at the Agronomic research area, University of Agriculture, Faisalabad, Pakistan, to investigate the response of autumn planted maize to $ZnSO_4$ and $MnSO_4$ levels (10, 20 and 30 kg ha^{-1}) and in combinations (5 kg ha^{-1} $ZnSO_4$ + 5 kg ha^{-1} $MnSO_4$, 10 kg ha^{-1} $ZnSO_4$ + 10 kg ha^{-1} $MnSO_4$ and 15 kg ha^{-1} $ZnSO_4$ + 15 kg ha^{-1} $MnSO_4$). The randomized complete block design (RCBD) having three replicates was used with plot size of 3 m x 6 m. The crop was planted on ridges 75 cm apart with recommended plant to plant distance of 25 cm. Maximum values for plant height at maturity (225 cm), cob diameter (4.29 cm), number of grains per cob (415), biological yield (20.15 tons ha^{-1}), grain yield (7.42 tons ha^{-1}) and seed protein content (8.96%) were recorded where 15 kg ha^{-1} $ZnSO_4$ + 15 kg ha^{-1} $MnSO_4$ was applied.

Key words: Maize; Zn; Mn.

INTRODUCTION

Maize (*Zea mays* L.) is ranked 3rd among all the cereals in the world. The area under maize cultivation in Pakistan is 1083 thousand hectares with the average production of 4271 thousand tons/ha (Govt. of Pakistan, 2012). Food security accomplishment is one among thousands of the millennium goals, attainment mainly depends on increasing productivity of crops. Mostly in developing countries, unavailability of plant nutrients in proper form, at proper time and in proper amount are the major crop productivity constraints (Hussain *et al.,* 2006). Being an exhaustive crop, its nutrient prerequisite is very high and its production mostly depends on the proper management of the nutrients. Plants need particular amount of some specific nutrients at a proper time in a particular form, for their proper growth and development. Both micro and macronutrients play a

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significant role for getting higher yield and to fulfill the crop needs (Arif *et al.,* 2006).

In Pakistan, the factor responsible for low productivity of maize is the depletion of plant nutrients due to extensive cropping system. It is cleared evidently that proper functioning of plant nutrients role about 30-50% for getting higher yield (Stewart *et al.,* 2005). The potential yield of maize cannot be achieved by only using the major plant nutrients (Hussain *et al.,* 2005). The amount of trace elements needed by crops is very small that play a significant role in various plant metabolic processes where they work as a cofactor (Modaihsh, 1997). In Asian countries, mostly plants, animals and humans are found to be deficient in micronutrients due to abiotic factors such as calcareous nature of soils, drought stress, higher soil pH, salt stress, and irrigation water with higher value of bicarbonate, low organic matter and mismanagement of fertilizer application.

To achieve higher yield, $ZnSO_4$ is limiting among all the micronutrients in cereal crops because of its low availability at pH above 7.0 (Alloway, 2008). The yield is reduced extensively without showing any deficiency symptoms due the shortage of minor nutrients (Alloway, 2004). Plant physiologist reported that deficiency of $ZnSO_4$ affects various plant metabolic processes such as nitrogen uptake, photosynthetic activity, nitrogen metabolism, chlorophyll synthesis and protein quality (Cakmak, 2008). Chloroplast (most active part of the plant cell) is affected by the deficiency of $MnSO_4$, as a result chloroplast structure is injured (Ndakidemi *et al.,* 2011). Several studies on $ZnSO_4$ and $MnSO_4$ showed that their deficiency caused reduction in yield and level may differ from plant to plant and region to region (Kalayci *et al.,* 1999). Viewing all the considerations given above, the experiment was performed to investigate the proper dose of $MnSO_4$ and $ZnSO_4$ with the suggested rate of NPK for increasing the production/unit area of maize.

MATERIALS AND METHODS

In order to study the effect of micronutrients (Zn and Mn), a field experiment was carried out as randomized complete block design with three replicates. Experiment was conducted at Agronomic Research Area, University of Agriculture Faisalabad, Pakistan (31.25°N, 73.05°E and 605 feet above sea level) in 2011. Experimental units comprised of 4 lines, 75 cm apart of 6 m length. In this experiment, treatments were (T_0) Control, (T_1) 10 kg ha^{-1} $ZnSO_4$, (T_2) 10 kg ha^{-1} $MnSO_4$, (T_3) 20 kg ha^{-1} $ZnSO_4$, (T_4) 20 kg ha^{-1} $MnSO_4$, (T_5) 30 kg ha^{-1} $ZnSO_4$, (T_6) 30 kg ha^{-1} $MnSO_4$, (T_7) 5 kg ha^{-1} $ZnSO_4$+ 5 kg ha^{-1} $MnSO_4$, (T_8) 10 kg ha^{-1} $ZnSO_4$+ 10 kg ha^{-1} $MnSO_4$, (T_9) 15 kg ha^{-1} $ZnSO_4$+ 15 kg ha^{-1} $MnSO_4$. The crop was sown in the 25th of July, 2011 with the help of dibbler using seed rate of 30 kg ha^{-1}. Recommended rate of nitrogen (250 kg ha^{-1}), phosphorus (125 kg ha^{-1}) and potassium (125 kg ha^{-1}) was fulfilled from urea, DAP and SOP, respectively. At the end of the growth period, different parameters (plant height at maturity, cob diameter, number of grains per cob, biological yield, grain yield and seed protein content) were studied using standard procedure. The data was analyzed by using Fisher's analysis of variance technique and the difference among the treatment means were compared by employing LSD at 5% probability.

RESULTS AND DISCUSSION

Data concerning to plant height are given in *Table 1*. In general, it was revealed that different rates of $ZnSO_4$ and $MnSO_4$ significantly affected the plant height. The individual treatments means comparison (*Table 1*) indicates that maximum plant height was attained with the application of 15 kg $ZnSO_4$ and 15 kg $MnSO_4$ ha^{-1} as compared to control. This increase in plant height might be due to the additional application of $ZnSO_4$ and $MnSO_4$. The results of experiment studied are also supported by the findings of NDFC (1998) and Bukvic *et al*. (2003), who also observed increase in plant height with the application of $ZnSO_4$ and $MnSO_4$.

Number of grains and grain size both are influenced mostly by the cob diameter. Effect of applied levels of $ZnSO_4$ and $MnSO_4$ on the cob diameter elaborates in *Table 1*. In general, it is exposed that the application of different levels of $ZnSO_4$ and $MnSO_4$ had significant effect on the cob diameter. Maximum cob diameter was obtained with the application of 15 kg $ZnSO_4$ ha^{-1} +15 kg $MnSO_4$ ha^{-1} that was statistically different with all other treatments. At the same time minimum increase in cob diameter was observed in response to control. These findings were also supported by the findings of Khaliq *et al.* (2004) and Boateng *et al.* (2006), who elaborated that the application of various levels of micronutrients resulted in increase of cob diameter.

Data presented in *Table 1* showed significant increase in number of grains per cob in response to different levels of $ZnSO_4$ and $MnSO_4$. The individual treatments means in the *Table 1* indicate that with the application of 15 kg $ZnSO_4$ +15 kg $MnSO_4$ ha^{-1}, maximum number of grains per cob (6.03%) are gained that is statistically different from all other treatments. Whereas the lowest number of grains per cob was found with control. The trend of increasing number of grains per cob with the applied $ZnSO_4$ and $MnSO_4$ was also in line with the findings of Bakyt and Zade (2002) and Harris *et al.* (2007).

Results regarding 1000 grain weight affected by various levels of $ZnSO_4$ and $MnSO_4$ are presented in *Table 1*. The individual treatments means reflects that highest 1000 grain weight was gained in response to 15 kg $ZnSO_4$ ha^{-1} + 15 kg $MnSO_4$ ha^{-1}. While, minimum increase in 1000 grain weight was achieved in control treatment. Due to the application of macro as well as micronutrients particularly $ZnSO_4$ and $MnSO_4$ plants received maximum nutrients throughout their growth period and nourished properly which resulted in maximum 1000 grain weight.

Table 1 - Effect of $ZnSO_4$ and $MnSO_4$ on growth, yield and quality of hybrid maize

	Treatments	Plant height at maturity (cm)	No. of grains cob^{-1}	Cob diameter (cm)	1000 grain weight (g)	Biological yield (t ha^{-1})	Grain yield (t ha^{-1})	Seed protein contents (%)
T_0	Control	239.33f	390.33f	4.19f	255.48f	19.20f	6.95f	7.24f
T_1	10 kg ha^{-1} $ZnSO_4$	241.92e	395.00e	4.21e	258.65e	19.39e	7.04e	7.67e
T_2	10 kg ha^{-1} $MnSO_4$	242.00e	394.60e	4.21e	258.72e	19.40e	7.04e	7.66e
T_3	20 kg ha^{-1} $ZnSO_4$	245.00d	400.67d	4.23d	261.13d	19.59d	7.13d	8.00d
T_4	20 kg ha^{-1} $MnSO_4$	244.80d	400.33d	4.22d	261.18d	19.58d	7.13d	8.02d
T_5	30 kg ha^{-1} $ZnSO_4$	248.00c	405.00c	4.25c	264.08c	19.78c	7.24c	8.33c
T_6	30 kg ha^{-1} $MnSO_4$	248.20c	405.50c	4.25c	264.30c	19.77c	7.23c	8.32c
T_7	5 kg ha^{-1} $ZnSO_4$+5 kg ha^{-1} $MnSO_4$	245.00d	400.63d	4.23d	261.26d	19.57d	7.13d	8.00d
T_8	10 kg ha^{-1} $ZnSO_4$+10 kg ha^{-1} $MnSO_4$	251.33b	410.00b	4.27b	267.40b	19.98b	7.32b	8.66b
T_9	15 kg ha^{-1} $ZnSO_4$+15 kg ha^{-1} $MnSO_4$	255.00a	415.00a	4.29a	270.46a	20.15a	7.42a	8.96a
LSD		2.5722	3.4312	0.0174	1.5873	0.0161	0.0174	0.0433

Means not sharing similar letter(s) differ significantly at $p=0.05$.

These results are also supported by Harris *et al.* (2007), who also observed linear increase in 1000 grain weight by increasing levels of $ZnSO_4$ and $MnSO_4$.

The represented data (*Table 1*) showed significant increase in biological yield with the application of $ZnSO_4$ and $MnSO_4$ on autumn planted maize. Results showed a prominent increase (up to 4.72%) in biological yield with15 kg $ZnSO_4$ +15 kg $MnSO_4$ ha^{-1} as compared to the control plots. The trend of increasing biological yield with $ZnSO_4$ and $MnSO_4$ was also found by Safaya and Gupta (1979) and Trehan and Sharma (2000).

Data regarding the effect of $ZnSO_4$ and $MnSO_4$ on the grain yield are presented in the *Table 1*. Data showed the positive effect of the applied treatments (different combinations of $ZnSO_4$ and $MnSO_4$ levels) on the grain yield. The individual treatments means comparison given in the table indicates that with the application of 15 kg $ZnSO_4$ +15 kg $MnSO_4$ ha^{-1} highest grain yield (7.42 tons ha^{-1}) was gained. While, lowest grain yield was found in control. The highest grain yield may be obtained because all the cereal crops are efficient to use both macro as well as the micronutrients. The findings of the present study are also in line with the findings of Mar *et al.* (1996), Bakyt and Zade (2002) and Alvarez *et al.* (2006).

Seed protein content is most significant among all the quality parameters. Data regarding the seed protein content as affected by the applied $ZnSO_4$ and $MnSO_4$ are presented in *Table 1*. According to the data, the parameter under study was significantly affected by the applied $ZnSO_4$ and $MnSO_4$. The results indicated that with the application of 15 kg $ZnSO_4$ +15 kg $MnSO_4$ ha^{-1} maximum seed protein content were gained. Against, the lowest seed protein content with control. The findings of the present study are also supported by the findings of Khan *et al.* (2008), who observed that seed protein content is increased with the additional application of $ZnSO_4$ and $MnSO_4$.

CONCLUSION

Potential yield of maize can be achieved by the additional application of $ZnSO_4$ and $MnSO_4$, with the recommended dose of NPK. Increasing levels increased maize grain yield, so further studies are needed with even higher application rates.

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