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SHORT COMMUNICATION

Effect of Zinc Sulphate as Foliar Application on the Yield and Quality of Maize

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ABSTRACT

Zinc shortage is the leading problem in the world, resulting in the reduction of maize yield. Therefore, an experiment was carried out to evaluate the influence of zinc sulphate as foliar application on the yield and quality of maize (*Zea mays* L.) The treatments were: control, one water spray at 4-5 leaves stage, one foliar spray of 0.5% $ZnSO_4$ at 4-5 leaves stage, two water sprays (1st at 4-5 leaves stage and 2nd after one week), two foliar sprays of 0.5% $ZnSO_4$ (1^{st} at 4-5 leaves stage and 2^{nd} after one week), three water sprays (1^{st} at 4-5 leaves stage 2^{nd} and 3^{rd} after one-week interval) and three foliar sprays of 0.5% $ZnSO_4$ (1^{st} at 4-5 leaves stage and 2^{nd} and 3^{rd} after one-week interval). Data regarding various parameters showed that three foliar sprays of 0.5% $ZnSO_4$ (1^{st} at 4-5 leaves stage 2^{nd} and 3^{rd} after one-week interval) gave significantly higher plant height (159.73cm), 1000- grain weight (294.90), number of grains per cob (401.83), grain yield (6.10 t ha^{-1}), biological yield (16.58t ha^{-1}) harvest index (36.78%) and protein content (10.02%). The maximum economic return (Rs.71742 ha^{-1}) for maize hybrid-6525 under agro-ecological conditions of Faisalabad was obtained where three foliar sprays of 0.5% $ZnSO_4$ (1^{st} at 4-5 leaves stage 2^{nd} and 3^{rd} after one-week interval) were applied. So, keeping in view the above stated results, it can be concluded that, higher yield, quality and more economic benefit can be obtained by applying the three foliar sprays of 0.5% $ZnSO_4$ under agro climatic conditions of Faisalabad, Pakistan.

INTRODUCTION

In the world, it is a key crop among cereals, which have huge economical value in poultry and livestock production. In Pakistan, after wheat and rice crops, maize is the most important cereal. It is serving as staple food for many countries. In Pakistan, average grain yield of maize is 4.695 million tonnes during 2014-15 (GOP, 2015). Which is very low the reason being improper micronutrient managements. Maximum research on foliar and soil use of Zn concentrated on lessening its shortages, mainly on rice and wheat in arid or semi arid areas of the world (Cakmak, 2008). In temperate areas, because of low temperatures and much shorter vegetation Zn deficiency appears in initial phases. Maize development seems to be extremely sensitive to numerous stresses, which in order declined grain yield (Subedi and Ma, 2009). Recommended Technologies and Production Practices at Farm give good yield of crops (Ather et al., 2006) and crops which were sown with recommended practices produced high yield (Anjum et al., 2004). It is essential for the synthesis of auxin because Zn helps in tryptophan production, which is a precursor of Indole-3-acetic acid (IAA). Zinc has a pronounced effect on the important processes of plants like photosynthesis, protection against reactive oxygen species, nitrogen metabolism, carbonic anhydrase activity, chlorophyll synthesis and resistance to biotic and abiotic stresses (Cakmak, 2008; Monreal et al., 2015). Numerous trace nutrients comprising Zn and its using methods had influence on plant progress and yield. Application of zinc fertilizers to maize crop not only boost its production, but also improve zinc contents in tissues (Cakmak, 2008).

However, to overcome zinc shortage for human beings there is a dire need to feed them with zinc increased foods on sustainable basis. Based on new inquiries connected to reasons of low maize yield, an assumption was framed that the use of Zn as foliar increases processes accountable for the yield and quality of maize. The overall objective of the study was to assess the effect of zinc sulphate as foliar use on the yield and quality of maize.

MATERIALS AND METHODS

The trial was conducted at the research area of Department of Agronomy, University of Agriculture, Faisalabad, Pakistan during 2011. The experiment was laid out in randomized complete block design with three replications and a net plot area of 5×4.20 m^2. Soil analysis was done before sowing of crop which indicated that sandy clay loam soil, having soil pH (7.8), organic matter (0.45%), Electrical Conductivity (1.6dSm-1), N (0.05%), P (7.12 $mg.Kg^{-1}$), K (175ppm), Mn (2.6$mg.Kg^{-1}$), Zn (0.28$mg.Kg^{-1}$). Maize variety "Monsanto-6525" was selected as test crop and seed rate of 25 $kg.ha^{-1}$ was used. The treatments were: control, one water spray at 4-5 leaves stage; one foliar spray of 0.5% $ZnSO_4$ at 4-5 leaves stage; two water sprays (1st at 4-5 leaves stage and 2nd after one week); two foliar sprays of 0.5% $ZnSO_4$ (1^{st} at 4-5 leaves stage and 2^{nd} after one week); three water sprays (1^{st} at 4-5 leaves stage 2^{nd} and 3^{rd} after one week interval) and three foliar sprays of 0.5% $ZnSO_4$ (1^{st} at 4-5 leaves stage and 2^{nd} and 3^{rd} after one week interval).The crop was harvested manually after its maturity on 23^{rd} of June, 2011. All agronomic practices except those under study were kept common and constant for all the treatments. Data regarding all agronomic and yield related parameters was recorded. Economic analysis was carried out on the basis of fixed and variable costs. The collected data was examined statistically using Fisher's analysis of variance technique and treatments' means were compared by least significant difference (LSD) test at 5% probability level (Steel et al., 1997).

RESULTS AND DISCUSSION

Results of the present study revealed that significantly longer plant height (159.73 cm) was attained in treatment T_7 (three foliar sprays of 0.5% $ZnSO_4$, 1^{st} at 4-5 leaf stage 2^{nd} and 3^{rd} after one-week interval). However, the treatment T_3 (one foliar spray 0.5% $ZnSO_4$ at 4-5 leaves stage) and treatment T_5 (two foliar sprays 0.5% $ZnSO_4$; 1st at 4-5 leaves stage 2^{nd} after one week) having plant height 156.88 cm and 156.50 were followed by the treatment T_7. The significantly lower plant height (147.40 cm) was obtained in treatment T_1 (no water and $ZnSO_4$ spray).

Zinc is a structural part of number of enzymes which control the maize height. $ZnSO_4$ shortage also distresses pollen structure, carbohydrate metabolism and declines the yield. Shortage of zinc sulphate has been observed to diminish the leaf size and reduced internodes and therefore, bound plant growth accompanied by post emergence reduces early weed crop competition by suppressing weed flora, leading to greater plant height. These outcomes are in close covenant with the results of Aref (2011) who stated that foliar use of $ZnSO_4$ increased the plant height over the control treatment. Data showed that the significantly maximum value of numbers of grains per cob (401.83) was recorded in treatment T_7 (three foliar spray of 0.5% $ZnSO_4$; 1^{st} at 4-5 leaves stage 2^{nd} and 3^{rd} after one-week Interval). The treatment T_5 (two foliar sprays of 0.5% $ZnSO_4$ at 4-5 leaves stage and after one-week interval) having the number of grain per cob 398.13 was followed by T_7. However, the significantly lower numbers of grain per cob (384.97) was observed in treatment T_1 (no water and $ZnSO_4$ spray). Zinc act as a structural, functional or regulatory co-factor in numerous enzymes and these enzymes play significant part in increasing the numbers of grains in crop (Cakmak, 2008).

Significantly higher value of 1000-grain (294.90g) was recorded in treatment T_7 followed by treatment T_5 with two foliar sprays of 0.5% $ZnSO_4$; 1^{st} at 4-5 leaves stage 2^{nd} after one-week interval) having 1000-grain weight of 290.56 g. The significantly lower value of 1000-grain weight (270.13 g) was obtained for treatment T_1 (no water and zinc sulphate spray). In previous studies, $ZnSO_4$ has been reported for enhanced growth hormone biosynthesis, formation of starch and maturation leading to enhanced seed weight (Tariq et al., 2014). Outcomes are in agreement with the finding of Tariq et al. (2002) who stated that yield donating components of maize were considerably improved by the use of $ZnSO_4$. According to data, the significantly maximum value of grain yield (6.10 t ha^{-1}) was recorded in treatment T_7; whereas, significantly lower value of grain yield (4.91 t ha^{-1}) was observed in treatment T_1 (no water and zinc sulphate spray). The results are well supported by the result of Potarzycki and Grzebisz (2009) who found that the Zinc foliar application at 5^{th} leaf stage resulted in significant increase in grain yield by 16% and 27% with 0.5 and 1.0 kg Zn ha^{-1}, respectively.

The biological yield (16.58 $t.ha^{-1}$) was noted in treatment T_7 (three foliar spray of $ZnSO_4$, 1st at 4-5 leaves stage 2^{nd} and 3^{rd} after one-week interval). Ali et al. (2008) indicated that use of micronutrients mixtures provided maximum biological affects which may be accredited to the extra accessibility of nutrients. Significantly the maximum value (36.78%) of harvest index was recorded in treatment T_7 (three foliar spray

Table 1: Effect of Zinc sulphate as foliar application on the yield and quality parameters of maize

Treatments	Plant height (cm)	1000 grain weight (g)	Grains per cob	Biological yield (tha^{-1})	Grain yield (tha^{-1})	Harvest index (%)	Protein contents (%)	Total variable ($Rs\ ha^{-1}$)	Gross income ($Rs\ ha^{-1}$)	Net field benefit ($Rs\ ha^{-1}$)	Net return ($Rs\ ha^{-1}$)
$T_{1=}$(Control)	147.40^{e}	$270.13e$	$384.96e$	14.50^{f}	4.91^{f}	32.72^{c}	8.12^{g}	0	145670	145670	40557
$T_{2=}$one water spray	152.86^{cd}	280.83^{d}	390.13d	14.94^{e}	4.96^{e}	33.18^{bc}	8.22^{f}	490	148035	147547	41944
$T_{3=}$ One foliar spray of 0.5% $ZnSO_4$	156.88^{b}	288.50^{c}	397.36c	15.96^{c}	5.48^{c}	34.30^{b}	9.25^{c}	608	162946	162338	56617
$T_{4=}$ Two water sprays	151.10^{d}	280.86^{d}	390.13d	15.11^{d}	4.98^{e}	32.94^{c}	8.33^{e}	980	148819	147839	41796
$T_{5=}$ Two foliar sprays of 0.5% $ZnSO_4$	156.50^{b}	290.56^{b}	398.13b	16.10^{b}	5.53^{b}	34.37^{b}	9.60^{b}	1216	164503	162387	56058
$T_{6=}$ Three water sprays	154.14^{c}	281.33^{d}	390.13d	14.92^{e}	5.06^{d}	33.91^{c}	8.80^{d}	1470	150668	149198	42615
$T_{7=}$ Three foliar sprays of 0.5% ZnSO4	159.73^{a}	294.90^{a}	401.83a	16.58^{a}	6.10^{a}	36.78^{a}	10.02^{a}	1824	180503	178679	71742
LSD	2.1841	1.2082	0.7574	0.0937	0.0304	1.2933	0.525				

Any two means not sharing a letter in common differ significantly at $P \leq 0.05$.

of 0.5% $ZnSO_4$, 1st at 4-5 leaves stage 2nd and 3rd after one-week interval). $ZnSO_4$ may be attributed for enhanced grain yield and biological yield which directly enhanced harvest index.

Protein content is one of the most essential parameters which describe the quality of the grain. Significantly higher values of protein contents (10.02%) were recorded in treatment T_7; whereas, significantly lower value (8.12%) of protein contents was observed in treatment T_1 with no water and $ZnSO^4$ spray). These results are well supported by the findings of Shamsa et al. (2010) who described that use of $ZnSO_4$ might be a feasible choice to improve protein contents in grains.

Economic analysis

The maximum net field benefit (NFB) of Rs.178679 was achieved in Monsanto-6525 with the three foliar application of 0.5% ZnSO4 (1st at 4-5 leaves stage and 2nd and 3rd after one-week interval). The minimum NFB of Rs.145670 was obtained in treatment T_1 (no water and $ZnSO_4$ spray). Application of micronutrients like Zn, Cu and Fe in addition of NPK fertilizers was essential to obtain maximum benefits from field crops like sugar cane and maize etc. as reported by Yadav and Yaduvanshi (1989).

Conclusions

From results of this study, it can be concluded that three foliar applications of $ZnSO_4$ (1st at 4-5 leaves stage and 2nd and 3rd after one-week interval) gave 24% and more grain yield 14% more biological yield than control where no water $ZnSO_4$ foliar sprays were applied. So, keeping in view the above stated results, it can be concluded that, higher yield, quality and more economic benefit can be obtained by applying the three foliar sprays of 0.5% $ZnSO_4$ under agro climatic conditions of Faisalabad. Pakistan.

Authors' Contributions

All authors contributed equally in conceived the idea, designing the research project, conducting the experiments, collect and analyze the data, write-up the research paper and making the conclusions. All authors read the final manuscript.

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