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Original Research

The effects of micronutrient fertilizers, ferrous sulfate and zinc on the yield and yield components at different cultivars of maize (*Zea mays*) in the Sistan region

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ABSTRACT:

Plants generally take up minerals from soils through their roots although minerals can be supplied to plants as fertilizers by foliar sprays. Foliar nutrition is a relatively new and controversial technique of feeding plants by applying liquid fertilizer straight to their leaves. Throughout the world, micronutrient such as Fe, Zn, Mn and Cu are added to foliar fertilizers, in order to atone their deficiency especially in arid and semi-arid regions. The test was conducted in the Sistan region. Mixture of soil sampling was done in the empirical area before the infliction of treatments and was analyzed for physical and chemical specifications. The field experiment was laid out factorial with randomized complete block design with four replications. Analysis of variance showed that the effect of cultivar on all characteristics was significant.

Keywords:

Biological yield, Grain yield, Harvest index

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INTRODUCTION

Nutrient limitations to plant production result from deficit of not only major nutrients but also micro-element such as molybdenum (Mo), zinc (Zn), boron (B) and iron (Fe) (Bhuiyan *et al.,* 1999). Therefore, foliar-applied micronutrients are of importance in nutrient correction within a given growing season. However, an unknown fraction of foliar-applied micronutrients are either sprayed directly onto the soil due to gaps in canopy cover or sprayed onto the foliage and subsequently washed off. In these circumstances, the foliar application can be effective, but soil-applied nutrients may also contribute to the micronutrient supplementation. Recent research on foliar-applied micronutrients in maize production has reported mixed results (Heckman 2002; Mueller and Diaz 2012). Insufficient nodulation of pigeon pea can be associated with low availability of microelement. Increase in flower numbers, pod set betterment, and reduction in days to flowering are influenced by microelement (Prasad *et al.,* 1998). Foliar-applied microelements can interpenetrate leaves through the cuticle (solutes) or the stomata (gases and solutes) (Marschner, 2011).

Maize leaves are specialized to enthrall light and CO_2, but their ability to absorb certain nutrients has long been used in element management (Fernández and Eichert, 2009; Gris, 2004). The efficiency of foliar-applied microelement varies among plant species and also in relation to the chemical structure *viz*: salts, complexes (Fernández and Ebert, 2005; Wojcik, 2004; Zhang and Brown, 1999) or nanoparticles. Soil properties can limit nutrient solubility and uptake by plant roots. Elements sprays are of general interest for use as tools to administer these elements and elapse soil limitations.

Hence, the present research was attempted to study the effects micronutrient fertilizers, ferrous sulfate and zinc on the yield and yield components at different cultivars of maize (*Zea mays*) such as KSC 704, KSC 720 and KSC 770 in the Sistan region.

MATERIAL AND METHODS

Area of the study and soil polling

The experiment was conducted in the Sistan region. Mixture soil polling was made in the experimental area before the infliction of treatments and was analyzed for physical and chemical specifications..

Irrigation and Fertilization

Irrigation was proceeded according to the propose design throughout the growing season. A identical basic dose of 30 kg nitrogen per hectare was blended with the dirt during seedbed preparation to all piece. Phosphor fertilizer was used at the time of planting. Entire other agricultural practices were accomplished equally within the growth season. Weeds were manually eradicated whenever they were observed in the field.

Field experiment

The field experiment was laid out factorial with randomized complete block design with four replications.

Treatments

Treatments included cultivars that involves KSC 704, KSC 720 and KSC 770 and nutrients include zinc sulfate, ferrous sulfate, zinc sulfate + ferrous sulfate along with a suitable control. Harvest index, grain yield, biological yield and plant height was estimated.

Data decomposition

Statistical analysis was done by using SAS Program (Mervyn *et al.,* 2008). Least significant difference test (LSD) at 5% and 1% probability level was applied to compare the diversity among means of the treatment.

RESULTS AND DISCUSSION

Harvest Index

The maximum of harvest index was obtained KSC 770 treatments (37.12%) whereas, the minimum was obtained in KSC 704 (27.95%). Analysis of variance showed that the effect of cultivar on harvest index at the probability level of 1% ($p<0.01$) was significant (Table 1).

Table 1. Anova analysis of the maize affected by micronutrient and cultivar

Sov	df	Harvest Index (%)	Grain yield (kg/ha)	Biological yield (kg/ha)	Plant height (cm)
R	2	00.30^{ns}	531302.5*	7057275.01**	75.65^{ns}
Cultivar (C)	3	77.59**	1901664.7**	238096408.3**	797.52*
Micro nutrient (M)	2	44.01**	3974743.9**	3938013.8*	667.80*
C*M	6	32.82**	7890905.4**	5174038.8**	342.40^{ns}
Error	22	5.74	171789.8	1382208.3	163.62
CV	-	7.71	5.56	5.20	7.62

*, **, ns: significant at p<0.05 and p<0.01 and non-significant respectively.

The maximum of harvest index was observed in zinc sulfate + ferrous sulfate treatment (36.56%), whereas, the minimum value was recorded in control (31.80%). Analysis of variance showed that the effect of micronutrient on harvest index at the probability level of 1% (p<0.01) was significant (Table 1). Zayed *et al.* (2011) reported that application of Zn, Fe and Mn as single or in combination as soil or comparative foliar treatment significantly improved yield components as compared to control treatment. Most of the studied treatments of nutrient application were similar on their effect on panicle umbers except the combination of Zn + Mn. The latter combination increased panicle number of rice but without significant differences with those produced by control treatment (none of micronutrient application).

Grain yield

The topmost of grain yield was obtained in KSC 704 (7803.9 kg/ha). The minimum of grain yield was obtained in KSC 770 (7115.6 kg/ha). Analysis of variance demonstrated that the effect of cultivar on grain yield at the probability distribution level of 1% (p<0.01) was significant (Table 1). The maximum of grain yield was obtained zinc sulfate + ferrous sulfate (8051.5 kg/ha) treatment, whereas, the minimum of grain yield was noticed in control (6739.4 kg/ha). Analysis of variance showed that the effect of micro nutrient on grain yield at the probability level of 1% (p<0.01) was significant (Table 1). Sultana *et al.* (2001) found that foliar spray of micronutrient partially minimized the salt-induced nutrient deficiency and increased grain yield.

Biological yield

The topmost of biological yield was obtained in KSC 704 (26800 kg/ha). The minimum of biological yield was obtained in KSC 770 (19210 kg/ha). Analysis of variance demonstrated that the effect of cultivar on biological yield at the probability distribution level of 1% (p<0.01) was significant (Table 1). The maximum of biological yield was obtained in the Zinc sulfate + Ferrous sulfate (23094.2 kg/ha). The minimum of biological yield was obtained in the control (21805 kg/ha). Analysis of variance showed that the effect of Micro nutrient on biological yield at the probability level of 5% (p<0.05) was significant (Table 1). The observed phenomena suggest a seemingly higher response of maize vegetative than reproductive organs to zinc foliar application. However, maize plants receiving optimal external zinc supply

Table 2. Comparison of different traits affected by micronutrient and Cultivar

Treatment	Harvest Index (%)	Grain yield (kg/ha)	Biological yield (kg/ha)	Plant height (cm)
Cultivar				
KSC 704	27.95^{b}	7803.9^{a}	26800.0^{a}	175.93^{a}
KSC 720	36.21^{a}	7424.6^{b}	21806.3^{b}	164.00^{b}
KSC 770	37.12^{a}	7115.6^{c}	19210.0^{c}	163.43^{b}
Micronutrient				
Control	31.80^{c}	6739.4^{c}	21805.0^{b}	160.67^{b}
Zinc sulfate	32.52^{bc}	7253.8^{b}	22593.3^{ab}	163.00^{b}
Ferrous sulfate	34.17^{b}	7747.4^{a}	22929.2^{a}	170.41^{ab}
Zinc sulfate + Ferrous sulfate	36.56^{a}	8051.5^{a}	23094.2^{a}	177.08^{a}

Any two means not sharing a common letter differ significantly from each other at 5% probability significantly increased biological yield. This specific plant behavior can be explained by enhanced leaf longevity, as induced by an extra N uptake (Rajcan and Tollenaar, 1999).

Plant height

The maximum of plant height was obtained in the KSC 704 (175.93 cm). The minimum of plant height was obtained in the KSC 770 (163.43 cm). Analysis of variance demonstrated that the effect of cultivar on biological yield at the probability distribution level of 1% ($p<0.01$) was significant (Table 1). The maximum of plant height was obtained in the zinc sulfate + ferrous sulfate (177.08 cm) treatment. The minimum of plant height was obtained in the control (160.67 cm). Analysis of variance showed that the effect of Micro nutrient on plant height at the probability level of 5% ($p<0.05$) was significant (Table 1). Sultana *et al*. (2001) found that foliar spray of $MnSO_4$ increased dry matter and plant height.

Foliar spray is mostly used because plant responses to foliar-applied micronutrients are normally more rapid than soil applications and generally have higher recovery rates compared to soil applications (Marschner, 2011). Potarzycki and Grzebisz (2009) reported an increase in maize grain yield of nearly 18% (three-year average) with the application of 1.0 to 1.5 kg foliar Zn ha^{-1} in sandy, high P soils while many others report no yield increases in high yielding situations. Responses have been most common in cases of confirmed micronutrient deficiency by soil or plant analysis prior to supplementation (i.e. deficiency correction theory). However, the effect of foliar micronutrients on maize grain yield in high yielding scenarios where there are sufficient soil concentrations and no confirmed micronutrient deficiency remains unclear and largely untested. Ross *et al.* (2013) discussed the need to develop tools to better time nutrient applications to match each nutrient's uptake and mobilization characteristics especially during periods of high vegetative uptake for high-yielding modern hybrids. For example, more than 70% of Zn uptake occurs during only one-third of the growing season, during late vegetative and early reproductive growth (Ross *et al.,* 2013). Also, increased plant development can induce low microelement condensation due to dilution. As the crop plants increment in biomass, the crop plants may have a lower doping of the micronutrient even though the total nutrient content has not changed or increased at a lower rate than the rate of volumetric efficiency increase (Jarrell and Beverly, 1981).

Additionally, plants often respond to nitrogen and zinc together but not to zinc alone. The zinc deficit is brought on by the increase in plant growth due to increased sharply supplementation of N (Alloway, 2004). About 65% of B uptake occurs during one-fifth of the growing season, during late vegetative and early reproductive growth (Ross *et al.,* 2013). The increase in grain yield of modern hybrids has also been accompanied by an increase in total biomass yield. This increase in biomass is the driving force for increased nutrient uptake and removal during harvest (Karlen *et al.,* 1988). As yield increases, producers are generally applying higher levels of macronutrients which may increment the risk of a elements being most limiting. Liebig's legislation of the minimum states that yield is proportional to the most limiting nutrient. For example, as adequate levels of each of the nutrient and all other constraints are being met, this increases the probability of a nutrient dearth being the yield limiting invoice (Marschner, 2011).

CONCLUSION

The maximum of harvest index was obtained KSC 770 treatments and zinc sulfate + ferrous sulfate treatment whereas the topmost of grain yield, biological yield and plant height was obtained in KSC 704 and zinc sulfate + ferrous sulfate treatment.

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