Differences in absorption and distribution of foliarly-applied zinc in maize and wheat by using stable isotope of ^{70}Zn and Zn-responsive fluorescent dye Zinpyr

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Introduction

Zinc (Zn) deficiency is an important health problem worldwide especially in developing countries with cereals as staple food (Cakmak, 2008). Zn concentration in cereals can be improved by genetic or agronomic biofortification. Optimized applications of soil and foliar Zn fertilizers has been found very effective strategy to increase the grain Zn concentration for some cereals like wheat and rice but not significantly in maize (Cakmak and Kutman., 2017). However, no clear evidence exists about the mechanisms of limited response of maize to Zn foliar application compared to wheat. Aim of the current study was to elucidate the physiological reasons behind the poor response of maize to foliar Zn applications as compared to wheat.

Materials and Methods

Wheat and maize plants were grown in nutrient medium solution supplied with either low or adequate Zn in nutrient solution under greenhouse conditions. Second leaf of maize and wheat plants were treated with stable isotope of ^{70}Zn solution to trace the movement of foliarly applied Zn. ^{70}Zn concentration in roots ad shoots were measured after digesting the samples in a closed vessel microwave digestion system in the presence of concentrated HNO_3 and analyzed by ICP-MS for determination of ^{70}Zn.

To visualize the localization and remobilization of Zn in maize and wheat plants a soil culture experiment was conducted. Fully developed leaves of maize and wheat plants grown in low Zn soil were immersed in $ZnSO_4$ solution. Following the foliar treatment, zinc-responsive fluorescent dye Zinpyr and fluorescence microscopy was used to visualize the Zn localized in the cells of application leaf and younger shoots.

Results

The foliar application of ^{70}Zn solution increased ^{70}Zn concentrations in roots and shoots of wheat plants significantly higher than maize.

Zn supply in nutrient solution	Relative Absorption of leaf-applied ^{70}Zn	
	Maize	Wheat
	(%)	
Low Zn	12.9 B	16.5 A
Adequate Zn	13.4 B	17.3 A

Table 1. Relative absorption of leaf-applied ^{70}Zn in maize and wheat plants grown in nutrient solution with low (10^{-8} M) or adequate Zn (10^{-6} M) supply.

The increased leaf zinc uptake and localization in wheat was confirmed by a visual demonstration by using zinc-responsive fluorescent dye Zinpyr and fluoresce microscopy (Fig 1)

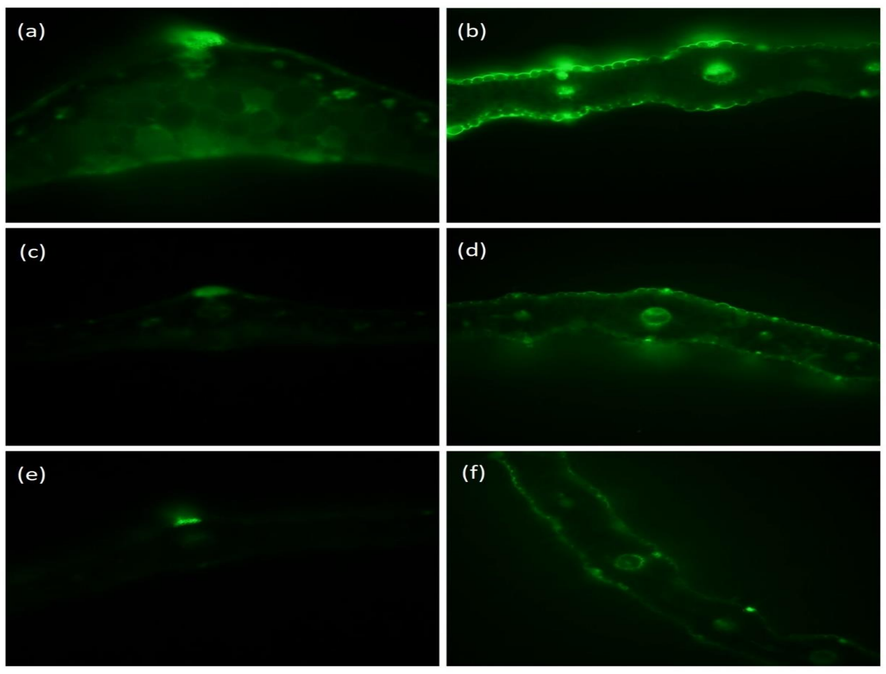

Fig 1: Microscopic images (10X) cross section of (a) maize application leaf (b) wheat application leaf (c) maize 2nd younger leaf (d) wheat 2nd younger leaf (e) maize 3rd younger leaf (f) wheat 3rd younger leaf. Zinpyr inflorescence intensity indicates the translocation of absorbed Zn from foliar fertilizer application.

Conclusion

The main reason for poor response of foliar Zn spray in terms of low grain Zn accumulation is mainly reduced uptake capacity of maize leaves compared to wheat.

References

Cakmak I (2008) Enrichment of cereal grains with zinc: Agronomic or genetic biofortification? *Plant and Soil*. 302: 1–17

Cakmak I, Kutman UB (2017) Agronomic biofortification of cereals with zinc-a review. *Eur. J. Soil Sci.* in press.