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Iron and Zinc Bio-Fortification Strategies in Wheat Crop by Exogenous Application of Micronutrients

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Abstract
Under nutrition or nutrient deficiency is a major concern in third world, and is an underlying cause for millions of deaths each year. Biofortification is an important technique to increase the concentration of trace mineral elements in the grain which improve the nutritional value of cereal and solve health problems in poorer areas of world. A pot experiment was conducted to evaluate the biofortification potential of wheat crop by exogenously applied micro nutrients (Fe & Zn). Soil and foliar application with two levels of Fe and Zn (2 mg kg^{-1} and 4 mg kg^{-1}) were applied according to CRD under factorial design. Results showed that soil application of Fe and Zn at 4 mg kg^{-1} is significant effect on plant available nutrients and nutrient concentration in wheat straw and grain. Application of micronutrients also increased and improved growth parameters.
Keywords: Wheat, Zinc, Iron, Biofortification, Plant Nutrient.

1. INTRODUCTION

Physiological growth and development of plant is control by micronutrients which increase the yield and yield contributing parameter of wheat plant (Dewal & Pareek 2004). Bio membranes function and structure control by Zn its only metal which present in all six classes of enzyme (Allowy, 2008; Brown, Cakmak, Zhanq). Zn interrelated with sulfhydryl group and phospholipid of cell membranes which retain the integrity of cell membranes (Tisdal, Nelson, Beaten,). Iron having a property of redox reaction due to which it performs the formation of complex with ligands (Hell & Stephan, 2003). As well as iron have a pivotal part of cytochrome in chlorophyll preparation, and retention of chloroplast (Mamatha, 2007; Ziaeian, & Malakoti, 2006; Zaharieva, & Abadia, 2003; Welch, 2002).

Carbonic anhydrase activity disturb during photosynthesis caused by Zn deficiency which disturb carbohydrates metabolism and Co_2 assimilation in photosynthesis (Alloway, 2004; Brown, Cakmak, & Zhang, 1993). Iron transport and store the oxygen while zinc performs the acidic insulin action and helps growth and reproduction Iron is a pivotal nutrient of hemoglobin (RBC's) and a basic source of intake of oxygen from lungs to tissues (Both well1979,Mascotti Dp,RuPD,Thac RE 1995). One third world population affected by deficiency of Zn 4-73% from different countries caused several serious health problems which include cancer development, DNA damage, affect immune system and learning ability in human (Hotz, & Brown,2004). Deficiency of Zn in children which are below 5 year of age is 37% and 41% in pregnant women reported (Anonymous 2004).

Pakistani soils are alkaline calcareous in nature whose pH is more than 7 high concentration of $CaCO_3$ decrease availability of trace mineral elements for plant growth (Allowy, 2009). Agronomic biofortification increase the concentration of trace mineral elements which efficaciously solve the health related problems in developing areas of globe (Cakmak, 2009).

Foliar application of trace mineral elements rapidly absorbed by leaf epidermis of plant and available to other plant parts through xylem and phloem (Hasslett, Reid, & Rengel, 2001). Micro-nutrients fertilizer when applied at milking dough stage of grain it increase the mineral contents of grain and improve its nutritional quality (zhang, Shi, Rezaul, Zhang, Zou, 2010)

2. MATERIAL AND METHODS

A pot Experiment which describe in this paper were conducted in Pakistan in 2012 where soil is micronutrients deficient. Nine treatments were applied by soil and foliar mode of nutrition each treatment replicate three times [T_1= Control , T_2= Fe (soil L1) , T_3= Fe (soil L2) , T_4= Zn (soil L1) , T_5= Zn (soil L2) , T_6= Fe (foliar L1) , T_7 = Fe (foliar L2) , T_8= Zn (foliar L1) , T_9= Zn (foliar L2)] . Treatments were applied according to CRD under factorial. Foliar spray was done at milking stage of wheat crop. Zn was applied as $ZnSO4.7H_2O$ and Fe was applied as $FeSO_4$ 2ppm Zn and Fe was applied in level one and 4ppm was applied in level two in soil mode of nutrition 1% solution of Zn and Fe was applied in level one and 2% solution of Zn and Fe was applied in foliar mode of nutrition. Ten seed of wheat sow in all experimental pot after establishment of seedling thinning was done left three plants in each pot at maturity stage harvest plant. Collect data regarding agronomic parameters. Oven dry plant sample and prepare plant sample for chemical analysis Study the different physiochemical parameter such as plant height, number of tiller , shoot dry weight , soil Zn contents , soil Fe contents , flag leaf

Zn and Fe concentration.

3. RESULTS AND DISCUSSION

3.1. Plant height(cm)

Results showed that application of Zn significantly increase the plant height maximum plant height was observe due to application of Zn @ 4ppm in soil application method than other levels of Zn and Fe and mode of application are non-significant with each other. Mode of soil application of Zn was superior to all other nutrients levels and mode of application show in figure (1). Similar results were observed by Cakmak, & Allowy in 2008 trial soil application of Zn increase maximum plant height of wheat.

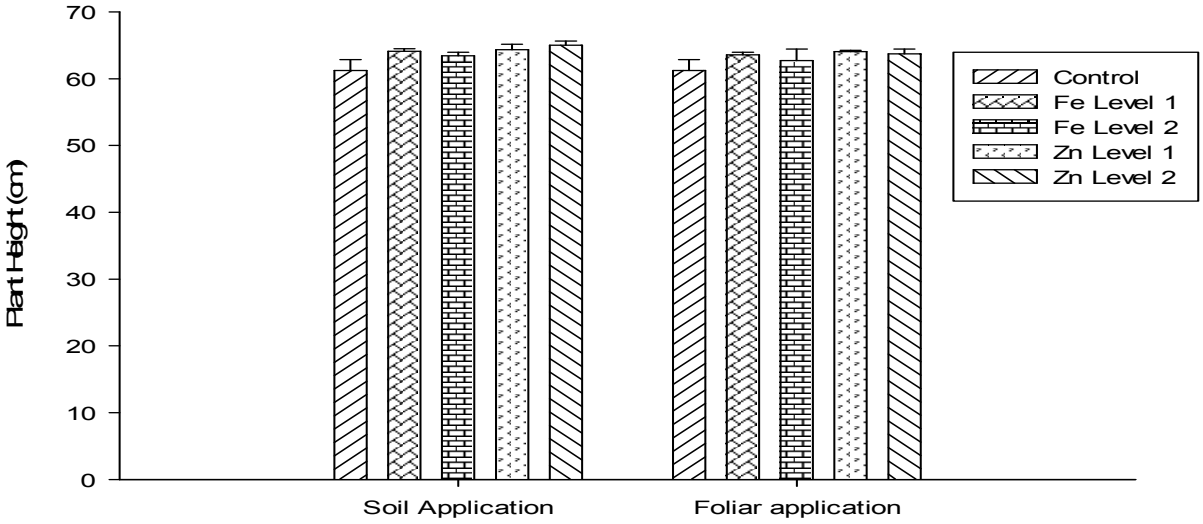

Figure 1. Effect of soil and foliar application Fe and Zn on plant height (cm)

3.2. Shoot dry weight(g/pot)

Results of experiment was shows application of micronutrients was increase shoot dry weight of wheat plant. Soil application of Zn @ 4 mg per kg soil increase shoot dry weight which was 43.91 of wheat plant than other nutrients levels and mode of application shows in figure (2). Our findings are related with results of cakamak, (2010); Zeidan, Manal, Mohamed, & Hamouda, (2010) shows application of trace mineral element increase shoot dry weight of wheat plant.

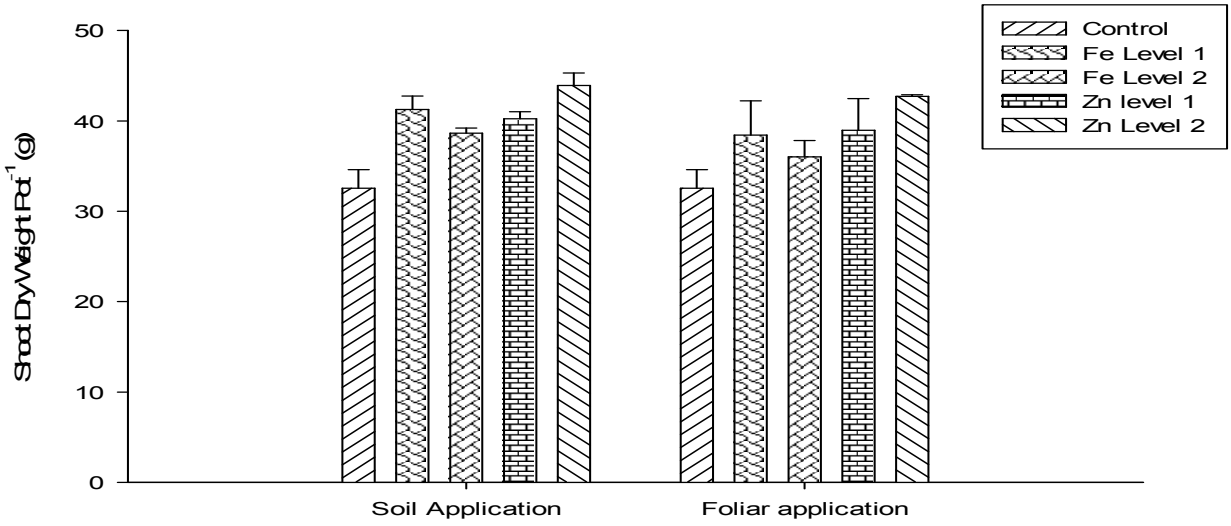

Figure 2. Effect of soil and foliar application Fe and Zn on Shoot dry weight (g)

3.3. Number of productive Tiller

Results of this research trial shows application of Zn @ of 4 mg per kg soil increase number of productive tiller in wheat plant which was 15 than other Nutrients level and mode of application (figure 3). Number of productive tiller is key component of yield parameter of wheat plant. Results of our research related with Niramani, Rahimi, Ahmadikah, & Vaezi (2010) research experiment shows soil application of $ZnSO_4$ increase number of productive tiller of wheat plant.

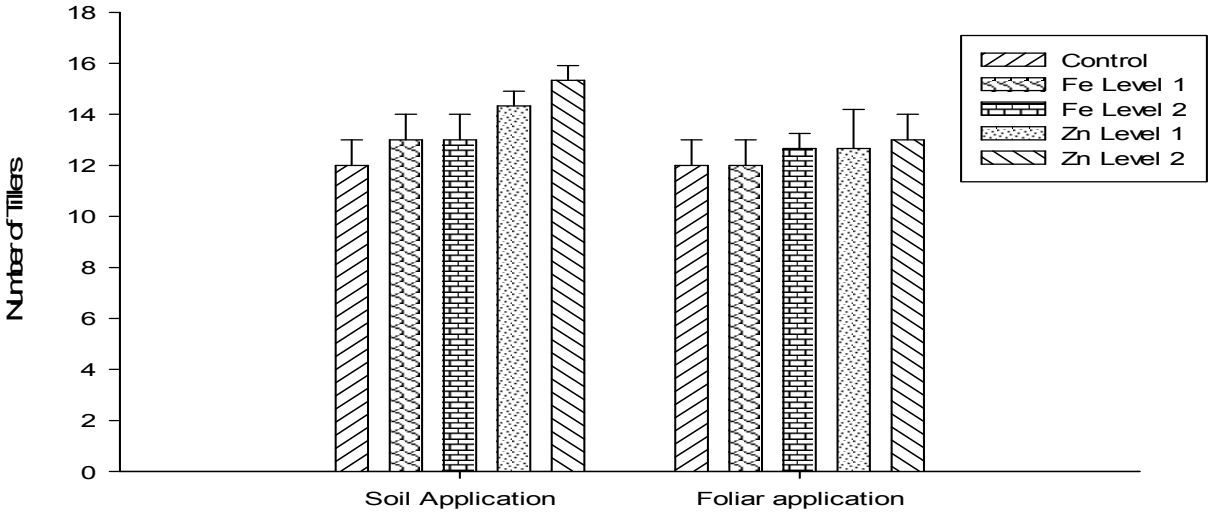

Figure 3. Effect of soil and foliar application Fe and Zn on Number of tillers

3.4. Number of Grain per spike

It was observed that number of grains per pot increase due to the application of Fe and Zn in growth media. Number of grain per pot is basic parameter of crop yield. Data regarding number of grains per pot presenting in the form of figure shows Fe application of 4mg per kg soil more effective to increase number of grain per pot which was 37 as compare to all other nutrients level. Minimum value of number of grain per pot was observed in T1 (control)which was 30.Mode of soil application of Fe and Zn was significantly increased the number of grains per pot. Difference among the various treatments was statistically significant were mention in figure. The treatment T3(Fe @ 4mg kg-) showed statistically marked difference to treatment T2 (Fe @ 2 mg kg-1 soil),T4 (Zn @ 2m kg-1 soil),Zn @ 4mg kg-1).the treatment T1 (control) non-significant with value of 30 .The foliar application of Zn @1% solution more effective than Zn @ 2% .The result of present study was conform those of Abbas, et.al (2009); Narimani, Rahimi, Ahmadika, & Vaezi (2010); Hussain, Maqsood, Rengel, & Aziz (2012) observed that Soil and foliar application of Fe significantly increase the number of grain of wheat plant.

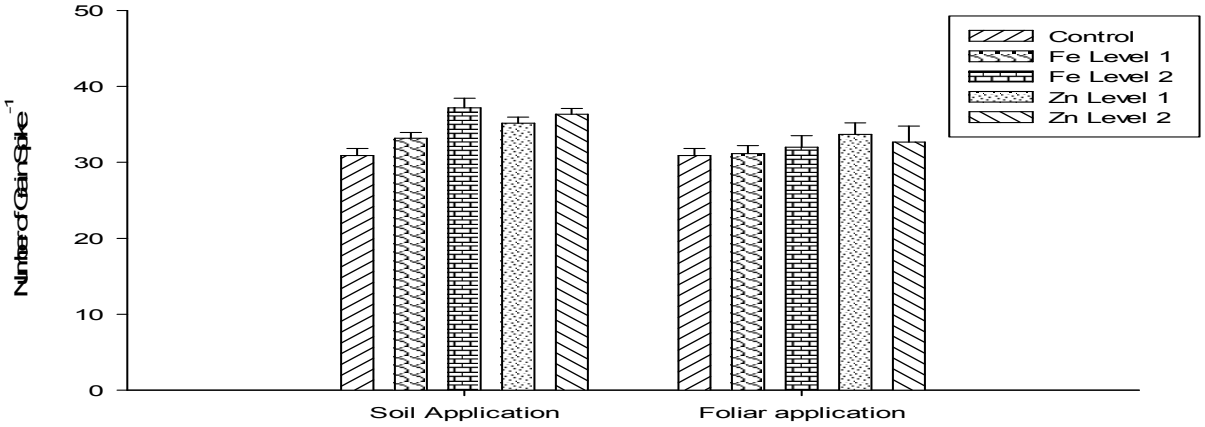

Figure 4. Effect of soil and foliar application Fe and Zn on number of grain per spike

3.5. Soil Zn contents

Results of this research soil application of Zn significantly increase soil Zn contents. Soil application of Zn not only increase yield of wheat crop it also increase the soil Zn contents. Zn application @ 4 mg per kg soil increase maximum Zn contents in soil (figure 4).Our Finding relate with results of the results of experiment conducted by Cakmak in 2010 shows soil application of Zn increase soil Zn contents.

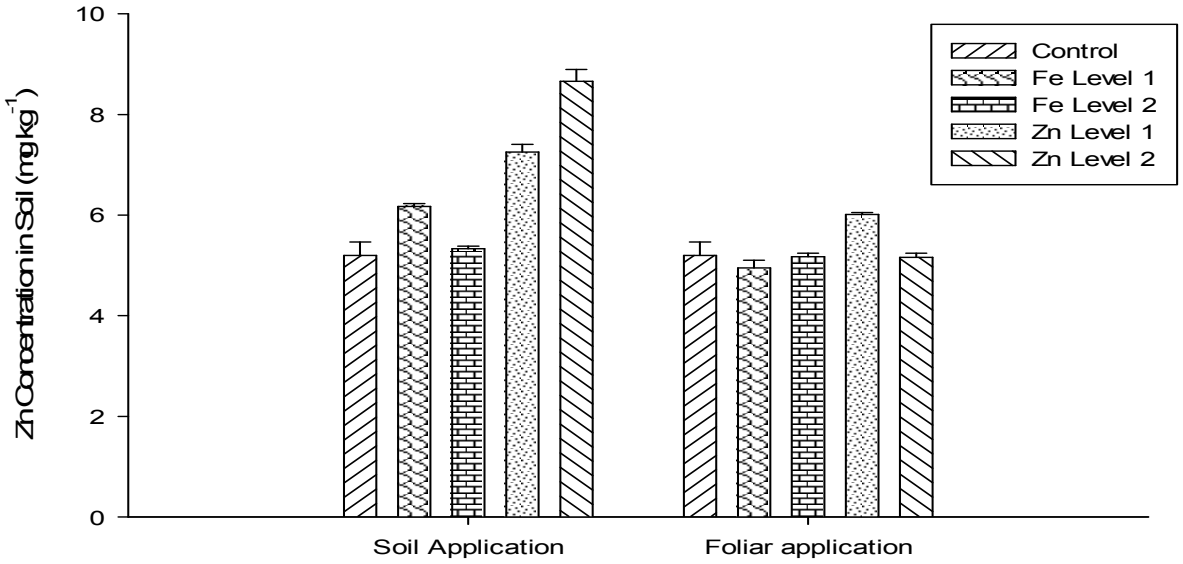

Figure 5. Effect of soil and foliar application Fe and Zn on Zinc Concentration in soil (mg kg^{-1})

3.6. Soil Fe contents

Soil application of $FeSO_4$ @ 4 mg per kg soil increase soil Fe contents than all other nutrients level and mode of application 11.30 ppm soil Fe contents increase due to $FeSO_4$ soil apply. Graphical figure shows soil mode of application more effect to increase soil Fe contents Abbas, Khan, Khan, Husssain & Hussain in 2009 experimental results shows soil application of Fe significantly increase soil Fe contents and wheat yield.

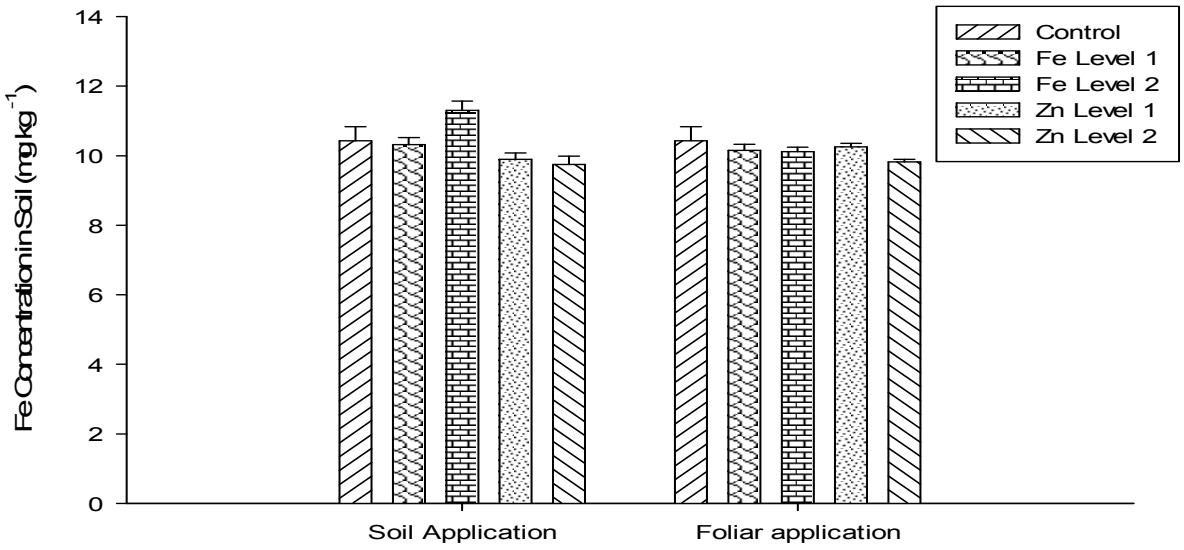

Figure 6. Effect of soil and foliar application Fe and Zn on Iron Concentration in soil (mg kg^{-1})

3.7. Flag leaf Zn and Fe concentrations

Results of research trial shows foliar application of Zn was significantly increase contents of flag leaf Zn

concentration (figure 6). Foliar application of $FeSO_4$ not increases flag leaf Fe concentration. Soil and foliar mode of Fe is nonsignificant with each other. Results of present experiment are related with Potarzycki, & Grzebisz 2009; Ziaeian, & Malakouti, 2001 foliar application of micronutrients increase flag leaf Zn concentration.

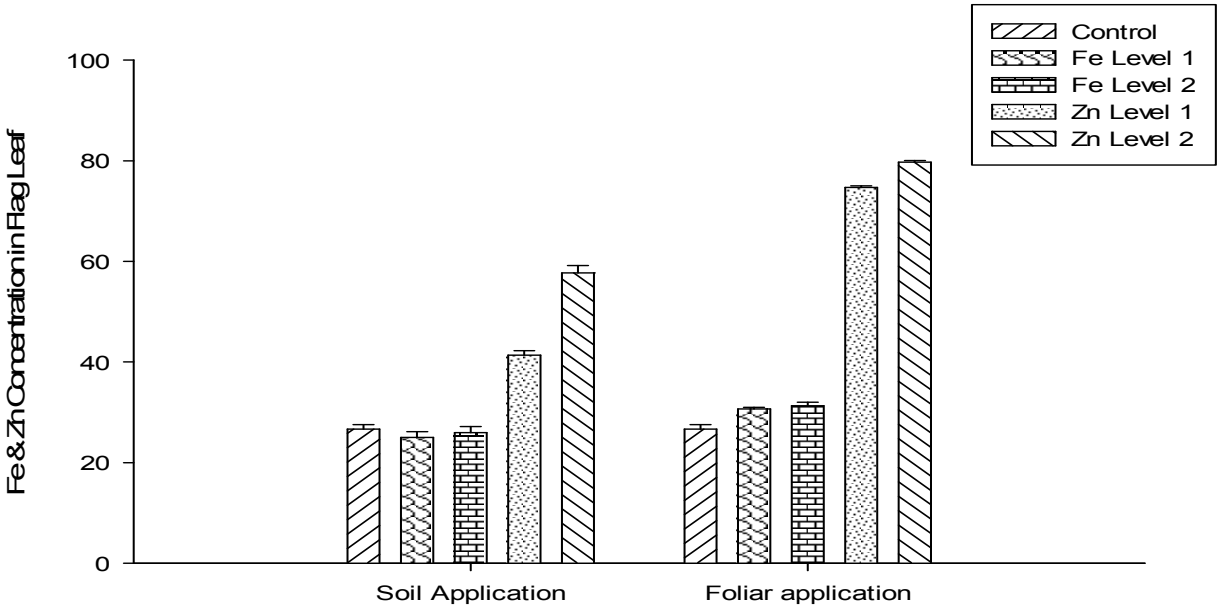

Figure 7. Effect of soil and foliar application Fe and Zn on Zinc & Iron Concentration in wheat (mg kg^{-1})

Conclusion

In conclusion we purposed that application of exogenous trace mineral elements improved the Zn and Fe contents in wheat crop. Our data support the evidence that a combination of foliar and soil apply mineral nutrition enhance biofortificaton of field crop especially wheat.

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