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Morpho- physiological response of maize (*Zea mays* L.) to zinc nano-chelate foliar and soil application at different growth stages

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ABSTRACT

In order to investigate the effect of zinc nano-chelate foliar and soil application on Morpho- physiological characteristics of maize (*Zea mays* L.), an experiment was conducted in the factorial form based on Completely Randomized Block Design with three replications during growing seasons of 2013-2014. Treatments were nano-chalate zinc application in four levels: a_1: soil application, a_2: foliar application, a_3: soil application + foliar application, a_4: control and different growth stage in three levels contain b_1:8-10-leaves stage, b_2: taselling and b_3: SA grain filling stage. The analysis of variance showed significant effect of nano-chalate Zn application on plant height, 100-grain weight, seed yield and harvest index. Also, effect of different growth stage on plant height, number of seed per row and 100-grain yield was significant ($p<0.01$). The detailed results of the study showed that soil application of nano-chalate Zn had 15/67% and 5/53 plant height and 100-grain yield. Moreover, foliar application of nano-chalate Zn had 94% more seed yield per plant. The means comparison of the measured showed that Soil application+ foliar application of Zn-nano chalate had 51% more HI.

Key Words: Foliar application, nano-chalate zinc, maize, soil application.

INTRODUCTION

Micronutrient deficiencies such as limited zinc (Zn) availability are one of the main problems limiting agricultural productivity, especially in alkaline calcareous soils. Therefore, Zn is often included in macronutrient fertilizers to improve crop quality and productivity (Khalilvand *et al.*, 2012). Zinc is an essential element that plays many important roles in various physiological and metabolic processes in plant. This trace element plays vital function in structural molecules such as DNA and activates different metabolic and regulatory enzymes. It has been reported that nearly 925 proteins in humans and over 500 proteins in plant contain Zn (Graham, 2008). It also plays a role in photosynthesis, protein synthesis, cell division, maintaining integrity of the membrane structure (Marschner, 1995), resistance against the pathogen infection (Sarwar, 2011), and sexual reproduction through affecting production and shape of pollen and changes in the stigma. Plants also may develop symptoms such as interveinal chlorosis, bronzing of leaves, abnormally shaped leaves, stunting or resetting which can effectively reduce crop production and health (Alloway, 2009). According to the World Health Organization, the average prevalence of Zn deficiency in the world population is 31% which may range from 4% to 73% in different countries (Caulfield and Black, 2004). Agricultural systems are the main pathway from which nutrients including Zn enter the human food chain. Therefore, Zn malnutrition must be directly dependant on the inability of cropping systems to deliver enough Zn to the food crops (Welch, 2008). Nanotechnology is a multidisciplinary and rapidly growing field in science and technology which involves the manufacture, processing and application of nanometer scale assemblies of atoms and molecules. Nanomaterials are classified as materials with at least one dimension less than 100 nm (Wiesner *et al.,* 2006). Thus, nanomaterials between ions and macroscopic materials (Banfield and Zhang, 2001) and mat contain 20-15000 atoms (Liu, 2006). Nonmaterial could to be applied in designing more soluble and diffusible sources of Zn fertilizer for increased plant productivity. The smaller size, higher specific surface area and reactivity of nanoparticulate Zn may affect Zn solubility, diffusion and hence availability to plants. Gangloff *et al.,* (2002) found that an application of zinc sulphate in maize plants increased dry matter and zinc accumulation in leaf and grain. In the dry and semi-dry areas of Iran, the absorption of micronutrients is low due to a high pH level of the soil. According to the limitations of soil usage of micro-nutrients, foliar spraying or leaf feeding is one of the effective ways in resolve plants food requirement to micro-nutrients (Wang *et al.,* 2010).

In order to use chemical fertilizers efficiently, it is essential that fertilizer is applied by foliar-applications. The foliar application is the best way to nourish plants that grow up in the soil with poor quality due to adverse pH (Ishii *et al.,* 2002). The aim of this study was to investigate the effects of zinc nano-chelate foliar and soil application on morpho-physiological characteristics of maize at different growth stages.

MATERIAL AND METHODS

The field experiment was carried out in factorial form by Completely Randomized Block Design with three replicates at the Research Station of the Islamic Azad University, Tabriz Branch, north-western Iran, during the 2013 - 2014. The first factor was nano-chalate zinc application in four levels: a_1: soil application, a_2: foliar application, a_3: soil application + foliar application and a_4: control. The second factor was different growth stage in three levels [b_1:8-10-leaves stage, b_2: taselling, b_3: SA grain filling stage. Each plot consists of 4 rows, 75 cm row spacing and 25 cm plant interval. There were 2-5 seeds beside each other and they were thinned at three leaves stage to obtain plant density of 5 plants per m^2. On the basis of the soil test (table. 1), 1 in 1000 foliar application and 4 $Kgha^{-1}$ were determined. Taking into account the size of the plots and in order to ease foliar application and to increase the delicacy of the spraying, a hand sprayer was used. In order to have an even and efficient spraying, 50 cm distance from the plants seemed reasonable. The spraying was carried out thoroughly until the foliar was dropping from the plants. Furthermore, Tween80 was used as surfactant to have the leaves absorb nutrient mineral. The control plots were water sprayed consistently to avoid the effects of foliar application used for experimental plots.

The seed yield contributing parameters like number of seed per row, seed yield (g) per plant and 100- grain weight (g) was determined at the time of harvest.

STATISTICAL ANALYSIS

In order to check the normality of data, analysis of variance, and mean comparison MSTAT-C software were used. The means of the treatments were compared using the Duncan's test at P<0.05.

RESULTS AND DISICUSSION

The analysis of variance showed significant effect of nano-chalate Zn application on plant height, 100-grain weight, seed yield and harvest index. Also, effect of different growth stage on plant height, number of seed per row and 100-grain yield was significant (Table 2).

Plant height

Results showed that nano-chalate Zn soil application and control had the highest (185/08 Cm) and lowest (160 Cm) plant height, respectively (tab.3). Meanwhile, this treatment had 15/67% more plant height than control treatment. Also, there was no significant effect between Zn soil application, foliar application and Zn soil application + foliar application. The increase in plant height in corn might be due to fundamental role of Zn in maintaining structural stability of cell membranes (Welch *et al.,* 1982) and use in protein synthesis, membrane function and cell elongation (Cakmak, 2000). Datir *et al.,* (2012) reported that amino acid application containing Zn enhanced growth and productivity in chili (*Capsicum annum* L.). Deore *et al.,* (2010) studied the effect of liquid organic fertilizer supplemented with chelated micronutrients (containing Zn) on red pepper and observed increased growth and yield Similar results were noted by Racuciu and Creanga (2007) on plant growth in Zea mays at early ontogenetic

Table 1: Soil Physical and chemical analysis

Clay %	Silt %	Sand %	K(ava) P.P.M	P(ava) P.P.M	Zn (ava) P.P.M	Mn (ava) P.P.M	N %	Ec* 10^3	PH
10	14	76	168	0/8	1/08	0/84	0/056	1/76	8/25

Table 2: The analysis of variance of measured traits in experiment

S.O.V	df	Plant Height	Number of seed/row	100-grain weight	Seed yield	HI
Rep	2	255/8 ns	895 **	0/088 ns	3889**	52/74 ns
NZn	3	1184**	68/13 ns	0/46 *	9752**	204*
GS	2	547/8*	311 **	0/52 *	754 ns	8/014 ns
Zn× GS	6	100/04 ns	4/053 ns	0/16 ns	676 ns	676 ns
Error	22	148/67	63/52	0/088	931	931
CV		6/9	19/11	2/83	24/84	24/84

* and ** significant at 5% &1% respectively, NZn: nano-chalate Zn, GS: Growth Stage

Table 3: **Mean comparison of Zn nano-chalate application on traits**

Zn nano-chalate application	Plant height (Cm)	100-grain yield (g)	Seed yield (g/plant)	Harvest Index (%)
Soil application	185/08 a	10/12 a	133/98 a	27/71 a
Foliar application	178/86 a	9/91 a	143/44 a	29/83 a
Soil application + foliar application	50/95 a	9/99 a	140/44 a	30/19 a
control	15/66 b	9/95 b	73/85 b	19/97 b

Table 4: **Mean comparison of different growth stage on traits**

Different growth stage	Plant height (Cm)	100-grain yield (g)	Number of seed per row
8-10- leaves stage	183/69 a	10/14 a	47/58 a
Taselling	170/19 a	9/78 b	38/96 b
Grain filling stage	176/42 b	9/78 b	38/58 b

stages due to treatment of magnetic NPs coated with tetramethyl ammonium hydroxide.

Number of seed per row

Based on the results, the highest (47/58) and the lowest (38/58) number of seed per row were related to 8-10 leaves stage and grain filling rate (tab.4). Tahir *et al.*, (2009) expressed among yield components, number of fertile tillers is very important because the higher number of fertile tillers can be formed the more final crop yield. Zoz *et al.*, (2012) stated that the application of higher concentration of zinc foliar application allowed obtaining 26% more in the number of wheat spikes per square meter compared to non-supply of nutrient. Similarly, Seadh *et al.*, (2009) showed that

foliar Zn application provided 21% increase in the number of wheat spikes per m^{-2}.

100-grain yield

Soil application of Zn-nano chalate and control treatment had the highest (10/12 g) and lowest (9/59 g) 100-grain weight (tab.3). This treatment had 5/53 % more 100-grain yield than without Zn application treatment.

Seed yield

Our results also showed that the highest seed yield was related to nano-chalate Zn foliar application (143/44 g/plant). Also, control (without application) had the lowest seed yield per plant (73/85 g), (tab.3). Nanoparticles (NPs) with small size and large surface area are expected to be the ideal material for use as a Zn fertilizer in plants. It is because of that when materials are transformed to a nanoscale, they change their physical, chemical and biological characteristics as well as catalytic properties and even more increase the chemical and biological activities (Mazaherinia *et al.*, 2010). Prasad *et al.*, (2012) studied the effect of nanoscale zinc oxide on the germination, growth and yield of peanut and observed significantly more growth and yield. Reynolds (2002) demonstrated that micronutrients in the form of NPs can be used in crop production to increase yield.

Harvest index

Soil application+ foliar application of Zn-nano chalate and control treatment had the highest (30/19 %) and lowest (19/97 %) HI (tab.3). This treatment had 51% more HI than without Zn application treatment. The increase in the Harvest index due to micronutrients may be attributed to its influences in enhancing the photosynthesis process and translocation of photosynthetic products to economic parts as well as increase enzymatic activity and other biological activities (Bameri *et al.,* 2012). Tahir *et al.*, (2009) expressed the more harvest index will be for the reason of the physiological potential for converting dry matter into grain yield.

CONCLUSION

It could be concluded that, use of nano-chalate zinc application had positive effect on yield and yield components. Based on the results, soil application of nano-chalate zinc had the highest plant height. Also, 100-grain weight and seed yield were found by soil nano-chalate zinc application. Soil application+ foliar application of Zn-nano chalate treatment had the highest harvest index.

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