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Effect of Zinc Nano-chelate Foliar and Soil Application and Different Growth stages on Physiological Performance of Maize (*Zea mays* L.)

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ABSTRACT: In order to investigate the effect of zinc nano-chelate foliar and soil application on physiological performance 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: a1: soil application, a2: foliar application, a3: soil application + foliar application, a4: control and different growth stage in three levels contain b1:8-10-leaves stage, b2: taselling and b3: SA grain filling stage. The analysis of variance showed significant effect of Zn nano-chalate application and different growth stage on Chl. a, Chl. b content and total Chl. a + Chl. b and biomass dry weight. Also, effect of Zn-chalate application on ear weight was significant ($p<0.01$). The detailed results of the study showed that Zn nano-chalate soil application+ foliar application at filling stage had more 72%, 77% and 75 % Chl. a, Chl. b content and total Chl. a + Chl. b. Moreover, Zn nano-chalate soil application+ foliar application at taselling stage had 54% more biomass dry weight. The means comparison of the measured showed that foliar application of Zn-nano chalate had 66% more ear yield.

Keyword: foliar application, nano-chalate zinc, maize, soil application

INTRODUCTION

In general zinc have main role in synthesis of proteins, enzyme activating, oxidation and revival reactions and metabolism of carbohydrates (Mousavi, 2011). In plants, zinc plays a key role as a structural constituent or regulatory co-factor of a wide range of different enzymes and proteins in many important biochemical pathways and these are mainly concerned with: carbohydrate metabolism, both in photosynthesis and in the conversion of sugars to starch, protein metabolism, auxin (growth regulator) metabolism, pollen formation, the maintenance of the integrity of biological membranes, the resistance to infection by certain pathogens (Alloway, 2008; Xi-Wen *et al.,* 2011). Recently, Nanoparticles have received considerable attention due to their increased uptake and high rate of penetration in plants. Nanomaterials are classified as materials with at least one dimension less than 100 nm (Wiesner *et al.,* 2006). Nonmaterial could to be applied in designing more soluble and diffusible sources of Zn fertilizer for increased plant productivity. Many zinc deficiency problems around the world are associated with sandy soils and calcium carbonate-rich soils (Akay, 2011). The aim of this study was to investigate the effects of zinc nano-chelate foliar and soil application on physiological performance of maize at different growth stages.

MATERIALS 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: a1: soil application, a2: foliar application, a3: soil application + foliar application and a4: control. The second factor was different growth stage in three levels [b1:8-10-leaves stage, b2: taselling, b3: 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, Tween 80 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. To determine leaf chlorophyll concentration, 1 g of the fresh leaf tissue was cut into small pieces and placed into a specimen bottle containing10 ml of absolute ethanol and stored in the dark for two weeks. One ml of the filtered extract was then diluted with 6 ml of absolute ethanol and the absorbance of the chlorophyll solution measured using a spectrophotometer at 645 and 663 nm. The Chl. a and Chl. b content and total Chl. a + Chl. b were estimated using the formula of Arnon (1949) as under :

Chl. a (mg g^{-1}) = 0.0127 A663-0.00269 A645

Chl. b (mg g^{-1}) = 0.0029 A663-0.00468 A645

Total Chl. (mg g^{-1}) = 0.0202 A663+0.00802 A645

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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.

Table 1: Soil Physical and chemical analysis.

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

RESULTS AND DISICUSSION

The analysis of variance showed significant effect of Zn nano-chalate application and different growth stage on Chl. a, Chl. b content and total Chl. a + Chl. b and biomass dry weight. Also, effect of Zn-chalate application on ear weight was significant (Table 2).

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

S.O.V	df	Chl. a	Chl. b	Chl. a + Chl. b	Ear weight	Biomass dry weight
Rep	2	7054 ns	579/7 ns	11678 ns	4293**	7388**
NZn	3	13617**	46729**	11070**	9062**	20483*
GS	2	57833 ns	35196**	69320 ns	798 ns	5596**
Zn× GS	6	19106**	33547**	99608**	752 ns	5093**
Error	22	5083	9739	2708	957	1472
CV		16/31	16/61	2/83	20/11	8/68

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

A. Chlorophyll a content

Results showed that Zn nano-chalate soil application+ foliar application at filling stage had the highest (600 mg g^{-1}) (Table 3). Also, there was no significant effect between Zn foliar application at 8-10 leaves and taselling stages, and Zn soil application + foliar application at taselling stage.

Table 3: **Mean comparison of Zn nano-chalate application and different growth stage on traits.**

Growth Stage	NZn	Chl. a (mg g^{-1})	Chl. b (mg g^{-1})	Chl. a+Chl. b (mg g^{-1})	Biomass dry weight (g)
8-10 leaves	**SA**	403/7 b	543/7 c	947/4 bc	492 abc
	FA	364/8 ab	490/8 bc	855/7 bc	500 abc
	SA + FA	372/1 b	493/6 c	865/8 c	421 d
	control	463/9 ab	623 bc	1086 bc	480 de
Tasseling	**SA**	468/2 b	530/9 c	999/2 c	447 ab
	FA	380/1 ab	537/3 c	917/4 bc	486 bcd
	SA + FA	435/5 ab	558 bc	993/6 bc	520 a
	control	347/9 b	479/3 c	827/2 bc	408 bcd
Seed-filling	**SA**	497/2 ab	738/3 ab	1235 ab	428 cd
	FA	490/3 b	651/7 c	1142 bc	400 abc
	SA + FA	600 a	851/3 a	1451 a	376 de
	control	421/4 b	629/1 c	1050 c	337 e

NZn: nano-chalate Zn, GS: Growth Stage, SA: Soil application, FA: Foliar application, SA+FA: Soil application + foliar application

In the present research Zn nano-chalate application lead to an increase in the rate of photosynthesis pigments. This fits with the results of Akay (2011) for the content of chlorophyll in chickpea. The results of the correlation analysis revealed significant relationships between Zn content in the leaves and total chlorophyll concentration (Akay, 2011).

B. Chlorophyll b content

Based on the results, the highest (851 mg g^{-1}) chl. b was related to Zn nano-chalate soil application+ foliar application at filling stage (Table 3). The results showed that zinc nano could stabilize the integrality of chloroplast membrane and protect the chloroplasts from aging in seed filling stage in contrast with control. Therefore with zinc nano treatment, content of chlorophyll (a and b), was higher than the control. The amount of chlorophyll in the reproductive stage was even more vegetative stage. In fact, Zn (nano) can improve structure of chlorophyll and better capture of sunlight, can facilitate manufacture of pigments and transformation of light energy to active electron and chemical activity and increases photosynthetic efficiency, stimulates rubisco activase and also increases photosynthesis (Yang and Hong. 2006).

C. Total chlorophyll a + b

Zn nano-chalate soil application+ foliar application at filling stage had the highest (1451 mg g^{-1}) Chl a + b (Table 3). The studies on improving photosynthesis of spinach suggested that nano-anatase TiO_2 could increase light absorbance, accelerate transport and transformation of the light energy, protect chloroplasts from ageing and prolong photosynthetic time of chloroplasts (Yang and Hong 2006).

D. Ear weight

Our results also showed that the highest ear weight was related to nano-chalate Zn foliar application (176/11 g). Also, control (without application) had the lowest ear weight (106/77 g), (Table 4). This treatment had 64% more ear yield than without Zn application treatment. 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.

Table 4: **Mean comparison of Zn nano-chalate application on traits.**

Zn nano-chalate application	Ear weight (g)
Soil application	165/7 a
Foliar application	176/11 a
Soil application + foliar application	166/84 a
control	106/77 b

E. Biomass dry weight

Based on the results, the highest (520 g) dry matter weight was related to Zn nano-chalate soil application + foliar application at tasselling stage (Table 3). Total biomass or crop dry weight (CDW) is the result of these two processes. Significant relationships between yield and biomass at synthesis or during grain filling have been reported in bread wheat (Turner, 1997) and durum wheat (Ramadani, 2004).

CONCLUSION

It could be concluded that, use of nano-chalate zinc application had positive effect on photosynthesis pigments. Based on the results, Zn nano-chalate soil application+ foliar application at taselling stage had the highest chlorophyll a, b and total chlorophyll a + b. Also, ear weight was found by zinc nano-chalate foliar application. Soil application+ foliar application of Zn-nano chalate treatment at tasselling stage had the highest biomass dry weight.

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