International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print) 2222-5234 (Online)
http://www.innspub.net
Vol. 5, No. 12, p. 258-265, 2014

RESEARCH PAPER OPEN ACCESS

Effect of zinc sulfate application in different growth stages on yield and yield components of sweet corn (Var. Chalenger)

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Key words: Consumption time, Production, Sweet corn, Zinc sulfate.

http://dx.doi.org/10.12692/ijb/5.12.258-265 Article published on December 20, 2014

Abstract

In order to assessment of zinc application effect in different growth stages on yield and yield components of sweet corn (var. Chalenger), the experiment was performed in 2013 cultivation season at Agriculture College of Islamic Azad University, Tabriz Branch in form of randomized complete block design with three replications. Studied treatments were included: control: non-use of zinc sulfate, (A) usage of zinc sulfate in soil, foliar application in: (B) stage of plants with 6-8 leaves, (C) tasselling, (D) grain filling stage, (B+C) stages of plants with 6-8 leaves and tasseling, (B+D) stages of plants with 6-8 leaves and grain filling, (B+C+D) stages of plants with 6-8 leaves, tasseling and grain filling, (A+B) soil using and foliar application at stages of plants with 6-8 leaves, (A+C) soil using and foliar application at stages of tasseling, (A+D) soil using and foliar application at stages of grain filling, (A+B+C+D) soil using and foliar application at stages of plants with 6-8 leaves, tasseling and grain filling in form of 5 per thousand using hand sprayer for foliar application and 25 kg/ha Zinc Sulfate for soil using. In this study the traits of ear fresh weight, ear yield, grain fresh weight per ear, grain yield, number of grain per ear, ear weight and 100 kernels weight were evaluated. The results demonstrated that zinc sulphate soil using and foliar application in 6-8 leaves, tasseling and grain filling stages (A+B+C+D), soil using and foliar application in grain filling stage (A+D) increased grain yield about 34.33g. and 32.74g., respectively; as compared with control. These treatments increased grain yield about 24.24g. and 22.42g., respectively in comparison with control treatment. So, revenue increment per hectare by foliar application of this element can be significant.

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Introduction

Among 350 million existent species on earth, only 150 species are used as food which only15 species produce in commercial scale and constitute main part of food supply in world market and more than half of these 15 species are cereals (Gallagher, 1984). Cereals supply 70% of mankind food in the world and actually these plants have been considered as main basic of nutrition and human survival (Emam, 2007), and have maximum necessity to chemical fertilizers (Zahir *et al.*, 1998). After wheat and rice, maize (*Zea mays* L.) is the most important source of food supplier for growing population of the world. In many countries, maize cultivate widely due to capabilities such as adaptation to different climatic conditions, relative resistance to drought and high yield (Emam, 2007).

As reported by Welch *et al.* (1991), about 40% of the world's population suffers from micronutrient deficiencies. Maize is sensitive to zinc deficiency (Viets *et al.*, 2003). Although necessity to zinc in plants is low, but inadequate amount of this element led to physiological stresses due to deficiency in various enzymatic systems and other associated metabolic functions (Baybordi, 2006). Among microelements, zinc deficiency makes maximum problem in crop production (Cakmak *et al.*, 1999). Zinc is an important microelement which is essential for metabolic activities in plants (Hassegawa *et al.*, 2008). Zinc plays a significant role in amount regulation of stomatal openness, because this element had main role in potassium maintenance at stomatal guard cells. Activity reduction of Carbonic anhydrase enzyme due to zinc deficiency can lead to decrement in rate of pure photosynthesis (Welch *et al.*, 1991). This element is also required for chlorophyll biosynthesis and has role in tryptophan synthesis which is a precursor for auxin synthesis (Salardini and Mojtahedi, 1987).

High reduction in levels of RNA and ribosome content of cells are the first probable symptoms of zinc deficiency. Decrease in RNA synthesis leads to prevention in protein formation but amount of glucose, non-protein nitrogen, and DNA increase relatively. Zinc is also necessary for tryptophan synthesis; this amino acid is a precursor for construction of indole acetic acid. Thus, construction of this hormone will be affected by zinc indirectly. Also, zinc had role in nitrogen metabolism of plant. In plants such as maize, chlorosis between nervure, followed by it white necrotic spots on older leaves occur. This chlorosis may become a reason for necessity of zinc in chlorophyll biosynthesis (Kafee *et al.*, 2002). Shaw and Laing (1998) reported that with augmentation of zinc application in all crops, its concentration increases in shoots. They declared that effect of zinc reduction on grain yield is more than straw yield. Hong and Ji-Yun (2007) stated that with augmentation in zinc application, concentration of zinc increases in roots, stems and leaves of maize so that its amount in shoots is more than root. Brown *et al.*, (1993) reported that in terms of zinc deficit, amount of protein content in total dry matter of plant reduce significantly, while rate of protein combinations remained almost unchanged. RNA reduction and ribosomes transform is the mechanism which affects protein synthesis by zinc. Application of fertilizers containing nitrogen and zinc has an important role on yield, kernel quality (included protein and mineral contents) and increment in 1000 kernel weight of maize.

Trehan and Sharma (2000) stated that usage of zinc caused to augmentation in dry matter yield of maize, wheat and sunflower. Larson and Schweissing (2001) reported that in condition which augmentation in maize production is considered, reduction in zinc level caused to decrease in yield and percentage of grain protein. Bukvic *et al.*, (2003) declared that application of zinc fertilizer in soil with rate of 10 kg Zn/ha, especially foliar application with amount of 5kg Zn/ha has increased total dry matter and stem diameter of maize. Also, they reported that consumption of zinc sulfate and potassium sulfate under drought stress condition increase grain yield. Thalooth *et al.*, (2006) reported that foliar application of zinc under water stress condition has positive impact on growth, yield and yield components of plants. Zinc has main role in pollination process, formation of male and female reproductive organs and grain formation process (Ziaeyan and Rajaie, 2009). Farajzadeh *et al*., (2009) declared foliar application of microelements acquitted all maize necessities and had the greatest influence on 1000 kernel weight, grain weight and yield. Also foliar application of zinc sulfate increased grain weight about 35.47%. Imanzade *et al*., (2014) reported that levels of zinc application in soil and foliar application in both stages of establishment and tasselling had the highest amount of grain weight per plant and levels of non-application in soil and non-foliar application in stage of tasseling had the lowest grain weight per plant. Cakmak *et al*., (2010) iron deficiency reduces total amount of proteins due to directly interference of iron in protein synthesis. Significant positive correlation among concentration of grain protein, zinc and iron have been identified in maize and controller genes of protein concentration, zinc and iron may also find segregation. Gathering of zinc, iron, protein and amino acids and significant positive correlations among protein, zinc and iron demonstrated that grain proteins are sink of zinc and iron. In embryo, zinc accumulating in protein forms with rate of less or equal to 600 mg/kg. According to studies of Farajzadeh *et al.,* (2009) optimal usage of iron and zinc in corn caused to increase in amount of grain protein.

According to the zinc amount was much lower in Iran soils and experimental field the aim of this study was investigation of application effect of zinc sulfate in different growth stages on yield and yield components of sweet corn (var. Chalenger).

Materials and methods

Experimental conditions

This research was performed at the Agricultural Research Station in Agriculture College of Islamic Azad University, Tabriz Branch with geographical coordinates of longitude: 46˚17'E and latitude: 38˚5'N at altitude of 1360 meters above sea level. The area climate is semi-arid and cold.

Soil Analysis

Some soil properties of experiment location, based on conventional methods of Soil and Water Research Institute have been presented in Table 1.

Statistical design and experimental factors

This study was conducted in form of randomized complete block design with three replications and on cultivars (*Zea mays* L. Sacchrata var. Chalenger) imported from America. Studied treatments were included: control: non-use of zinc sulfate, (A) usage of zinc sulfate in soil, (B) foliar application in stage of plants with 6-8 leaves, (C) foliar application in tasselling, (D) foliar application at grain filling stage, (B+C) foliar application at stages of plants with 6-8 leaves and tasseling, (B+D) foliar application in stages of plants with 6-8 leaves and grain filling, (B+C+D) foliar application at stages of plants with 6-8 leaves, tasseling and grain filling, (A+B) soil using and foliar application at stages of plants with 6-8 leaves, (A+C) soil using and foliar application at stages of tasseling, (A+D) soil using and foliar application at stages of grain filling, (A+B+C+D) soil using and foliar application at stages of plants with 6-8 leaves, tasseling and grain filling. In this experiment, similar fertilizer sources were used in both methods of micronutrients application (usage in soil and foliar application). In this study the traits of ear fresh weight, ear yield, grain fresh weight, grain yield, number of grain per ear, ear weight and 100-kernels weight were evaluated.

Planting conditions

Operations of field preparation were included plowing, disk and grading. After provision of experiment map, each replication was selected with dimensions of 4 meters by 36 meters and with distance of 1.5 meters from each other which were contained 12 plots and each plot had four planting rows and one non-planting row between plots and spacing between rows were 60 cm apart and 20 cm between plants in the rows. Planting was done on June 10, 2013 in form of streamlet and ridge. Irrigation was carried out once a week and fertilization of nitrogen was done in strip and based on 150 kg/ha in two stages (stage of plants with 6-8 leaf and tasseling), foliar application of zinc sulfate was performed in form of 5 per 1000 and 25 kg/ha Zinc Sulfate for soil using. Weeds control in form of hand weeding and mechanical was done in several stages and usage of chemical herbicides was avoided in order to better evaluation of studied fertilizers effect. Harvesting was performed in stage of maturity and necessary traits were measured.

Statistical analysis

MSTATC software for data analysis and Duncan's multiple range test at 5% probability level for mean comparisons were used. Statistical program SPSS-22 and Excel software were used in drawing shapes.

Results and discussion

Results of variance analysis for studied traits are presented in Table 2. The results demonstrated that there were significant differences at 1% probability level among studied treatments from view point of all traits.

Table 1. Physicochemical results of soil samples from experimental field.

Clay %	Silt %	Sand %	Absorbable Potassium (ppm)	Absorbable Phosphorus (ppm)	Absorbable Zink (ppm)	Total nitrogen %T.N	organic carbon %T.N	Percentage of %T.N	Saturation Soil acidity pH	Electrical conductivity Ec*103	Depth
10	18	72	428	30.8	1.1	0.117	1.07	15.75	8.18	0.99	0-30

Based on results of soil test, zinc amount was much lower and consumption of this element is justified.

Tassel length

Levels of soil using and foliar application at stages of tasseling (A+C), foliar application at stages of 6-8 leaves, tasseling, grain filling (B+C+D), and soil using with foliar application at grain filling stage (A+D) respectively with averages of 33.51cm, 33.37 cm and 33.16 cm had the highest length and were in superior statistically group. The lowest length of tassel was belonged to non-use of zinc sulfate level with average of 29.61cm and was placed in class e together with levels of zinc sulfate usage in soil and foliar application at stages of plants with 6-8 leaves. Soil using of zinc sulfate and foliar application in grain filling stage (A+D), soil using and foliar application in tasseling (A+C), foliar application in 6-8 leaves, tasseling and grain filling stages (B+C+D) led to significant increase in tassel length with rates of 10.71%, 11.63% and 11.26% respectively, as compared with non-use of this fertilizer (Table 3).

Table 2. Analysis of variance for on studied traits in sweet corn Var. Chalenger.

S.O.V	df	MS.							
		Tassel length	Ear fresh weight	Grain fresh weight per ear	Grain number per ear	Ear weight	100 kernel weight	Ear yield	Grain yield
Replication	2	4.23**	4811.2*	86.9ns	647.9ns	83.15ns	0.66*	33151.7*	5965.3
Treatment	11	5.22**	5198.8**	1658.6**	44500.1**	13497.2**	18.67**	358142.4**	114257.5**
Error	22	0.295	83.55	48.35	625.7	85.12	0.24	5755.5	3330.99
CV (%)		1.72	3.32	4.55	5.42	13.81	1.2	3.34	4.55

ns: non significant, *and **: represent significant difference at 5% and 1% probability levels, respectively.

Fresh weight of ear

Among studied treatments, treatment of soil using and foliar application at stages of grain filling (A+D) had maximum fresh weight of ear with average of 354.47g. and was in class A. The least amount of weight was related to level of zinc sulfate usage in soil with average of 213.53g. and was in class I. Soil using and foliar application at stages of grain filling (A+D), foliar application in 6-8 leaves, tasseling and grain filling stages (B+C+D) and stage of tasseling (C) caused to significant augmentation in fresh weight of ear with rates of 35.23%, 28.31% and 23.98% respectively, as compared with non-use of this fertilizer (Table 3).

Table 3. Mean comparisons of studied traits in sweet corn Var. Chalenger.

ZnSO4 Application	Tassel length (cm)	Ear fresh weight (g)	Grain fresh weight in ear (g)	Grain number per ear	Ear weight (g)	100 kernel weight (g)
Control	29.61 e	229.59 h	144.8 ef	293.13 e	179.9 f	36.39 f
Soil application (A)	40.12 de	213.5 i	125.53 h	296 e	185.2 ef	38.44 e
Foliar application in 6-8 leave stage (B)	30.21 de	245.3 gh	130.52 gh	383.73 d	221.9 d	37.02 f
Foliar application in tasseling (C)	31 cd	302.05 c	164.04 cd	386.93 d	221.8 d	39.64 d
Foliar application in grain filling stage (D)	31.37 bc	268.05 ef	154.47 de	362.13 d	199.2 e	40.57 c
B+C	32.19 bc	242.99 gh	122.92 h	502.4 bc	294.9 b	41.81 b
B+D	30.79 cd	252.68 fg	132.35 gh	484.93 c	269.8 c	42.28 b
B+C+D	33.27 a	320.29 b	175.77 bc	540.2 b	307.3 b	42.23 b
A+B	31.62 bc	284.9 d	141.99 f	472.2 c	273.6 c	41.80 b
A+C	33.51 a	270.77 de	161.56 d	511.07bc	298.9 b	43.91 a
A+D	33.16 a	354.47 a	186.64 ab	640.2 a	370.9 a	42.27 b
A+B+C+D	30.83 cd	314.49 bc	191.15 a	668.93 a	377.7 a	43.91 a

Means in each column with the same letter have not significant different at 5% probability level.

Fresh weight of grain per ear

Level of soil using and foliar application in 6-8 leaves, tasseling and grain filling stages (A+B+C+D) had the highest fresh weight of grains per ear with average of 191.15g. and together with treatment of soil using and foliar application in grain filling stage (A+D) were in class A and the lowest fresh weight of grains per ear was belonged to levels of zinc sulfate usage in soil (A) and foliar application in stages of 6-8 leaves and tasseling (B+C) with averages of 125.33 g. and 122.92 g., respectively and was in class H together with treatments of foliar application in stage of plants with 6-8 leaves (B) and foliar application at stages of 6-8 leaves and grain filling (B+D). Soil using and foliar application in 6-8 leaves, tasseling and grain filling stages (A+B+C+D), soil using and foliar application in grain filling stage (A+D), foliar application in 6-8 leaves, tasseling and grain filling stages (B+C+D) caused to significant increment in fresh weight of grains with amounts of 32.01%, 28.90% and 21.39% respectively, in comparison with non-use of this fertilizer (Table 3).

Number of grain per ear

Among studied treatments, treatments of soil using and foliar application in 6-8 leaves, tasseling and grain filling stages (A+B+C+D) and soil using and foliar application in grain filling stage (A+D) with averages of 668.93 and 640.20 numbers, respectively had maximum number of grains and were in class A and the lowest number of grains was related to non-use of zinc sulfate and application of zinc sulfate in soil (A) with averages of 293.13 and 296 numbers, respectively which were in class E. Soil using and foliar application in 6-8 leaves, tasseling and grain filling stages (A+B+C+D) and soil using and foliar application in grain filling stage (A+D) caused to significant increase in number of grains with amounts of 56.18% and 54.21% respectively, as compared with non-use of this fertilizer (Table 3). Arnel and Russell (1963) stated that foliar application of zinc sulfate has the greatest impact on number of grain per ear while the lowest number of grain per row was related to the treatment with no foliar application.

Ear weight

Among evaluated treatments, soil using and foliar application in 6-8 leaves, tasseling and grain filling stages (A+B+C+D) and soil using and foliar application in grain filling stage (A+D) with averages of 377.75g. and 370.96g. respectively had the highest ear weight and were placed in superior statistical group and the lowest ear weight with average of 179.90g. was belonged to non-use of zinc sulfate and was in class F together with level of zinc sulfate application in soil (A). Zinc sulphate soil using and foliar application in 6-8 leaves, tasseling and grain filling stages (A+B+C+D) and soil using and foliar application in grain filling stage (A+D) led to significant augmentation in ear weight with amounts of 52.37% and 51.5% respectively, in comparison with non-use of this fertilizer (Table 3).

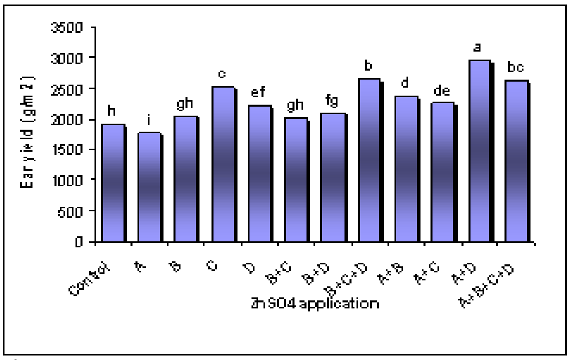

Fig. 1. Effect of zinc sulphate soil and foliar application on ear yield of sweet corn Var. Chalenger.

100 Kernel weight

Treatment of zinc sulphate soil using and foliar application in 6-8 leaves, tasseling and grain filling stages (A+B+C+D) and soil using and foliar application in tasseling stage (A+C) with averages of 43.91g. and 44.90g. respectively had maximum weight of 100 Kernel weight and were placed in superior statistical group and the least weight of 100 Kernel weight with averages of 36.38g. and 37.02g. were related to non-use of zinc sulfate and foliar application at stages of plants with 6-8 leaves (B) which were in class F. Zinc sulphate soil using and foliar application in tasseling (A+C) and soil using and foliar application in 6-8 leaves, tasseling and grain filling stages (A+B+C+D) caused to significant increase in weight of 100 Kernel weight with rates of 17.35% and 17.35% respectively, as compared with non-use of this fertilizer (Table 3).

Ear yield

Among evaluated treatments, zinc sulphate soil using and foliar application in grain filling stage (A+D) with average of 2942.13g. had the highest ear yield and was in class A and the lowest ear yield was belonged to treatment of zinc sulfate application in soil (A) with average of 1772.33g. and was in class I. Zinc sulphate soil using and foliar application in grain filling stage (A+D) and foliar application in 6-8 leaves, tasseling and grain filling stages (B+C+D) led to significant augmentation in ear yield with amounts of 35.22% and 28.31% respectively, in comparison with non-use of this fertilizer (Fig. 1). In the study of Farajzadeh *et al.*, (2009), using zinc sulfate as foliar application caused to highest yield of corn, which was higher about 37.52% than control treatment.

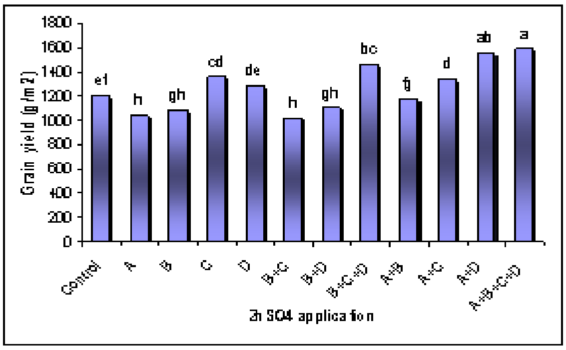

Fig. 2. Effect of zinc sulphate soil and foliar application on grain yield of sweet corn Var. Chalenger.

Grain yield

Grain yield per square meter in treatment zinc sulphate soil using and foliar application in 6-8 leaves, tasseling and grain filling stages (A+B+C+D) with average of 1586.57g. had maximum amount of this trait and together with treatment of soil using and foliar application in grain filling stage (A+D) (1549.11g/m^2) were in class A. Levels of zinc sulfate application in soil (A) and foliar application in 6-8 leaves and tasseling (B+C), respectively with averages of 1041.87g. and 1020.24g. per square meter had the lowest grain yield per square meter and were placed in class H together with treatments of foliar application at stages of plants with 6-8 leaves and foliar application at stages of 6-8 leaves and grain filling stages. Zinc sulphate soil using and foliar application in 6-8 leaves, tasseling and grain filling stages (A+B+C+D), soil using and foliar application in grain filling stage (A+D), foliar application in 6-8 leaves, tasseling and grain filling stages (B+C+D) caused to significant increment in grain yield per square meter with rates of 32.01%, 28.89% and 21.36% respectively, as compared with non-use of this fertilizer (Fig. 2). Carsky and Reid (1990) declared that by using zinc fertilizer over four years except in one year maize yield increased about 20%.

Conclusions

Based on results of this survey, zinc sulphate soil using and foliar application in 6-8 leaves, tasseling and grain filling stages (A+B+C+D) also soil using and foliar application in grain filling stage (A+D) increased grain yield with amounts of 24.24g. and 22.42 g., respectively in comparison with control treatment. Zinc sulphate soil using and foliar application in 6-8 leaves, tasseling and grain filling stages (A+B+C+D) also soil using and foliar application in grain filling stage (A+D) augmented grain yield with rates of 34.33g. and 32.74g., respectively as compared with treatment of zinc sulfate application in soil.

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