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The Effect of Zinc Sulfate Spraying on Yield and Yield Components of CornHybrids

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Elnaz Samadzade Ghalejoghi, Shahram Lack, Mojtaba Alavi Fazel:The Effect of Zinc Sulfate Spraying on Yield and Yield Components of Corn hybrids

ABSTRACT

In order to study effects of zinc sulfate spraying on yield and yield components of corn hybrids, an experiment was conducted during the summer of 2011- 2012 agronomic year, in a farm located in Ahvaz. This experiment was conducted in split plot based on the Randomized Completely Block Design (RCBD) with three replications. The treatments were including Main factor was zinc Sulfate spraying in four levels (without spraying, spraying at the level of 8 leaves,spraying at the level of 12 leaves and simultaneous spraying on both eight and twelve leaves) and corn hybrids (K.S.C701 corn hybrid and K.S.C704 corn hybrid). The results indicated that zinc Sulfate spraying had significant effect on traitof biological yield. For all of the traits except 1000-grain weight and harvest index, the maximum amount belonged to in K.S.C701 corn hybrid while zinc sulfate spraying at the level of 8 and 12 leaves, and the minimum amount was in K.S.C704 corn hybrid while treatment without spraying. There was a significant difference between under experiment hybrids according to the number of grain rows per ear, number of grains per row, number of grains per ear, grain yield, biologic yield and the harvest index. Mutual effect of zinc sulfate and hybrid was not significant in any traits. The results of this research indicated that, the reaction of different hybrids to different treatments such as zinc sulfate is distinct, and this status is dependent on differences between hybrids.

***Key words*:** Corn, Zinc sulfate spraying, Hybrid, Yield and Yield components.

Introduction

Nearly 40% of the world population faces a shortage of micronutrient elements specially zinc, and high share of cereals such as corn in diet was known as the main reason for zinc shortage in the human communities. Zinc is among necessary elements lowly used by plants, animals and human and corn is of the plants most sensitive to zinc shortage. If other nutrient elements except zinc are supplied at the extent required by cultivated plant, the cultivated plant will not be able to produce its full potential yield. Zinc shortage in plants has had a global extension, and it is estimated that about 30% of the lands under cultivation in the world face zinc shortage [1]. Effects of zinc shortage in soil are tangible in decreased agricultural productions, particularly in cereals such as corn [11].

Due to its special climate condition, Khouzestan province has an excellent potential for producing corn. One of the problems of cultivating this product is noncompliance of growth period of late ripening varieties such as K.S.C704 with a growth period of about 125 days with the existing cultivation opportunity because immediately after wheat harvest, corn can be cultivated because its fertilization and pollination stages face high temperature of 40ºC. Due to the vulnerability of this growth stage to heat, corn cultivation is inevitably delayed, and it is cultivated in the late July. If some late ripening varieties are used for cultivation, their physiological examination stage coincides with rainfall in the second half of fall. Because of high yield of late ripening varieties such as K.S.C704, farmers are very interested in cultivating these varieties, and it is necessary the effect of zinc sulfate spraying on new corn hybrid in the late ripening group such as K.S.C701 to be compared to the cultivar of the region, e.g. K.S.C704, in terms of yield and yield components in Ahvaz climate conditions. SheykhBaglooet *al*.,[15] stated that use of zinc sulfate and chelated zinc spraying increased 1000 grain weight, number of grains per ear, number of ears in ear, protein percentage and grain oil percentage. In the study of effect of low-used element spraying on qualitative and quantitative properties of silage corn K.S.C704 in the city of Khoy, Khalil Mahalehet *al*.,[7] recommended spraying of three micronutrient elements of iron, zinc, and manganese in two stemming and tasselling stages to increase the yield and improve qualitative properties of corn hybrid 704 in Khoy. Gastro [4] reported that increase in new varieties of corn may be caused by increased biological yield (total dry material over soil surface)

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or harvest index (economic yield to biological yield ratio) or both of them. Shaw and Ling [14] reported that in all crops, as the use of zinc increases, its concentration in aerial organs increases as well. They stated that effect of zinc on grain yield is more than straw. In the study of effect of different micronutrient elements on yield and yield components in the varieties of corn 700 and 704, Taher *et al*.,[17] concluded that type of the element used had significant effect on grain yield, harvest index, and 1000-grain weight. Carsky and Reid [2] stated that by using zinc fertilizer during four years, corn yield increased up to 20%. Mohammad *et al*.,[13] reported that use of zinc in different ways increases grain yield compared to the cultivar significantly. Soleimani [16] reported that soil use and spraying with a concentration of three per thousand increases zinc concentration 46% and 36%, respectively, compared to zinc sulfate-off treatment.

Material and Methods

This research was conducted on a farm during the summer 2011. The soil texture of the farm was of silty clay type. The experiment was conducted in split plot based on the Randomized Completely Block Design (RCBD) with three replications. The main factor included four levels of zinc sulfate spraying (without spraying (F_1), spraying at the level of eight leaves (F_2), spraying at the level of twelve leaves (F_3), and simultaneous spraying on both eight and twelve leaves (F_4)). The sub factor included two corn hybrids (K.S.C701 (H_1) and K.S.C704 (H_2)). In order to evaluate grain yield, harvest in the final examination stage was done from third and fifth lines by considering one meter margin upwards and one meter margin downwards to the extent of 6 meters length (area of $6m^2$) from each plot. After transferring the ears to the laboratory and separating and weighing the grains, grain yield was calculated according to kilogram per hectare. In order to study and analyze plant growth under different treatments during the growth season, the farm was sampled every seven days, and five samples were harvested from each plot, followed by the samples put inside plastic bags, labeled, and transferred to the laboratory to measure the related factors such as number of grain rows per ear, number of grains per row, number of grains per ear, 1000-grain weight, grain yield, biological yield, and harvest index.

To statistically analysis, SAS software was used and to correlate the factors, MSTATC software was used. In addition, for the average comparisons, Duncan's test was used. Graphs and histograms were drawn by Excel software.

The number of grain rows per ear:

The results of variance analysis regarding the number of grain rows per ear showed that none of the factors of zinc sulfate solution spray, the hybrid, and their reciprocal effect on this component were not significant and all of the means were belonged to the same statistical group (table 1). The highest number of grain rows as 15.75 was related to solution spray in the stage of 8 and 12 leaves and the least number as 15.08 rows was related to solution spray with control treatment (no solution spray); and the difference between the highest and the lowest value was 4.26 percent, although this difference was not statistically significant. Mehrabadi*et al*.,[10] stated that the number of grain rows is a high stability genetic attribute and is less affected by environmental and managerial circumstances. Perhaps for this reason solution spray didn't have significant effect on the number of grain rows in corn. Despite the insignificance of the difference between hybrids, the highest number of grain rows as 15.45 rows was related to Single Cross 701 variety (table 2). The mean comparison between reciprocal effect of solution spray and hybrid showed that the highest number of the number of grain rows as 16.33 rows was related to F_4H_1treatment (solution spray in 8 and 12 leaves stages with hybrid 701); although the difference between this treatment and the other treatments was not statistically significant (table3).

The number of grains per row:

The factors of zinc sulfate solution spray and reciprocal effect of solution spray and hybrid was not statistically significant for this component but the difference between the hybrids was significant concerning this by the 5 percent approximation level (table 1). Despite the effect of different levels of solution spray being not significant, the highest number of grains per row as 42.10 grains was related to the 8 and 12 leaves stage (table 2). The mean comparison also showed that the highest grain number was 42.05 grains, relating to Single Cross 701 (table 2). The Single Cross 701 hybrid has higher grain number in row due to more corn length and number of inseminated grains compared to the Single Cross 704 hybrid. HashemiDezfuli and Herbert [5] reported that the cause of increase in corn grains and the number of grain in row is the extension of the gap between pollination and kernel appearance in corn. This study was correspondent to the findings of Chogan*et al*.,[3]. The mean comparison of the reciprocal effect of zinc sulfate solution spray and hybrid showed that the highest number of grain per row as 16.33 grains was related to F_4H_1 treatment (solution spray at the 8 and 12 leaves stage and 701 hybrid (table 3)).

The number of grains per ear:

The results of variance analysis of the grain number implied that the effect of zinc sulfate solution spray and the reciprocal effect of zinc

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sulfate solution spray and hybrid on this component were not statistically significant, but the difference between the hybrids concerning this effect was significant at 5 percent probability level (table 1). The highest number of grains per ear as 664.02 was related to solution spray at the 8 and 12 leaves stages, although the difference of this treatment with other treatments was not significant and all the means were in a same statistical group (table 2). The mean comparison also showed that the highest number of grains per ear as 653.89 grains was related to Single Cross 701 and the lowest number was 9.65 percent (table 2). The number of grains per ear depends on the number of grain rows and the number of grains in every row, so as a result, the Single Cross 701 hybrid was superior to Single Cross 704 hybrid due to having higher number of grain rows and the number of grains in every row concerning the number of grains per ear attribute (table2). This study was correspondent to the findings of Masji Bahoush *et al*.,[9]. The mean comparison of the reciprocal effect of zinc sulfate solution spray and hybrid showed that the highest number of the grain per ear as 712.80 was related to F_4H_1 treatment (solution spray was at the 8 and 12 leaves stages and 701 hybrid (table 3)).

Table 1: The results of variance analysis for Number of grain rows per ear, Number of grains per row, number of grains per ear, 1000 grain weight, Grain yield, Biologic yield and Harvest index in which the mean-squares have been indicated in them.

Variable sources	degree of freedom	Mean- squares						
		Number of grain rows per ear	Number of grains per row	Number of grains per ear	1000 grain weight	Grain yield	Biologic yield	Harvest index
Block	2	0.42	7.42	962.59	345.76	139951.43	516973.99	1.21
Zinc sulfate spraying	3	$0.45^{n.s}$	$11.44^{n.s}$	$6469.56^{n.s}$	$108.36^{n.s}$	$1001167.41^{n.s}$	3257289.31^{**}	$0.91^{n.s}$
Error (block* spraying)	6	0.49	4.45	2256.97	288.54	280632.70	529063.40	1.27
Hybrid	1	$0.51^{n.s}$	66.33^{*}	23883.35^{*}	$137.76^{n.s}$	3667658.05^{**}	27975027.93^{**}	10.27^{*}
Mutual effect (spraying* hybrid)	3	$0.59^{n.s}$	$0.047^{n.s}$	$937.67^{n.s}$	$202.21^{n.s}$	$82925.71^{n.s}$	$142805.11^{n.s}$	$0.73^{n.s}$
Error	8	0.29	3.78	1420.38	110.84	89389.13	149756.35	0.67
Variation coefficient (percentage)		3.51	4.82	6.06	4.64	3.04	1.90	1.69

$^{n.s}$,*and ** relatively in significance at the levels 5 & 1 percent n.s. have no significant difference

Table 2: Comparing average Number of grain rows per ear, Number of grains per row, number of grains per ear, 1000 grain weight, Grain yield, Biologic yield and Harvest index affected by zinc sulfate and hybrid, by means of Duncan test.

Treatment	Number of grain rows per ear	Number of grains per row	number of grains per ear	1000 grain weight	Grain yield	Biologic yield	Harvest index
	(number)		(g/m^2)	(g)	(kg/h)		(%)
Zinc sulfate							
(without spraying)	15.08a	38.73b	583.70b	229.40a	9354b	19340b	48.38a
The level of 8 leaves	15.42a	40.20ab	620.48ab	231.51a	10020ab	20620a	48.57a
The level of 12 leaves	15.33a	40.52ab	621.18ab	224.10a	9717ab	20260ab	48.02a
The level of 8 & 12 leaves	15.75a	42.10a	664.02a	222.57a	10310a	21070a	48.95a
Hybrid							
k.s.c701	15.54a	42.05a	653.89a	224.50a	10240a	21400a	47.83b
k.s.c704	15.25a	38.72b	590.80b	229.29a	9458b	19240b	49.13a

According to Duncan's Multi-domain test, in each column the averages with similar letters are not significant in 5 percent possibility of Error

Table 3: Comparing average mutual effects of zinc sulfate and hybrid on Number of grain rows per ear, Number of grains per row, number of grains per ear, 1000 grain weight, Grain yield, Biologic yield and Harvest index, by means of Duncan test.

Mutual effects (F×H)	Number of grain rows per ear	Number of grains per row	number of grains per ear	1000 grain weight	Grain yield	Biologic yield	Harvest index
	(number)		(g/m^2)	(g)	(kg/h)		(%)
F_1H_1	15a	40.43a	605.16a	228.47a	9673a	20250a	47.73a
F_1H_2	15.17a	37.03a	562.23a	230.33a	9036a	18420a	49.03
F_2H_1	15.33a	41.93a	643.73a	235.70a	10580a	21850a	48.40a
F_2H_2	15.50a	38.47a	597.23a	227.33a	9458a	19400a	48.73a
F_3H_1	15.50a	42.20a	653.87a	221.10a	10100a	21460a	47.07a
F_3H_2	15.17a	38.83a	588.50a	227.10a	9333a	19060a	48.97a
F_4H_1	16.33a	43.63a	712.80a	212.73a	10610a	22050a	48.10a
F_4H_2	15.17a	40.57a	615.23a	232.40a	10010a	20090a	49.80a

According to Duncan's Multi-domain test, in each column the difference between averages with a common letter, has not been significant in 5 percent possibility of Error.

H_1:k.S.C 701 H_2:K.S.C 704

F_1: without spraying F_3: spraying at the level of 12 leaves

F_2: spraying at the level of 8 leaves F_4: spraying at the level of 8 & 12 leaves

The 1000 grain weight:

The results of variance analysis of the 1000-grain weight showed that none of the studied factors and their reciprocal effects had not significant effect on this component and all the means were in a same group (table 1). Despite the insignificance of the effect of solution spray on this attribute, the highest weight of 1000-grain weight with the mean of 231.51 g was related to solution spray in the 8 leaves stage (table 2). The increase in the 1000-grain weight in the 8 leaves stage due to the usage of zinc was a result of an increase in the reserved material and decrease in supply limitation that resulted in more transmission of propagated material towards the grain. HashemiDezfuli[6] showed that the 1000-grain weight in corn is mainly affected by genetic factors and less effected by environmental factors. Although the difference between hybrids was not significant from this viewpoint, the highest weight of 1000-grains as 229.3 g was related to Single Cross 704 hybrid (table 2). Perhaps Single Cross 704 hybrid was superior to Single Cross 701 hybrid concerning the transportation speed and distribution of assimilate materials. The mean comparison of the reciprocal effect of zinc sulfate solution spray and hybrid

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showed that the highest 1000-grain weight as 235.70 was related to F_4H_1 treatment (solution spray at the 8 leaves stage and 701 hybrid although the difference between the means was not significant (table3).

Grain Yield:

The results of variance analysis of the grain yield showed that the effect of zinc sulfate solution spray and the reciprocal effect of zinc sulfate solution spray and hybrid on this component were not statistically significant, but the difference between the hybrids was significant concerning this (table 1). Despite the insignificance of the effect of solution spray on this component, the highest grain yield 10310 kg/ha was related to solution spray at the 8 and 12 leaves stage with Single Cross 701 hybrid as, and the lowest value as 9458 kg/ha was related to Single Cross 704 hybrid and the difference between these two values was 7.64 percent (table 2). Refusal and maintaining the effective green leaf area are among the important attributes in increasing the grain yield of the late-maturing corn hybrids until the end of the quarter. In summer cultivation of corn, due to sufficient time for growth and also suitability of environmental circumstances for corn growth, the late-maturing varieties have more yields as a result of having more growth and production potential compared to early-maturing varieties. The results of this study were correspondent to the findings of Soleimani [16], Majidi and Malakouti [8]. The mean comparison of the reciprocal effect of zinc sulfate solution spray and hybrid showed that the highest biologic yield as 10610 kg/ha was related to F_4H_1 treatment (solution spray at the 8 and 12 leaves stage and 701 hybrid (table 3)).

Biological yield:

The results of variance analysis of the biological yield showed that the effect of zinc sulfate solution spray on biologic yield was statistically significant at 1 percent probability level, but the reciprocal effect of these factors on this component was not significant (table 1). The highest biological yield as 21070 kg/ha was related to solution spray at the 8 and 12 leaves stage, and the lowest value as 19340 kg/ha was related to solution spray with control treatment and the difference between these two values was 8.22 percent (table 2). The mean comparison showed that the highest biological yield as 21400 kg/ha was related to Single Cross 701 hybrid and the lowest value as 19240 kg/ha was related to Single Cross 704 hybrid and the difference between these two values was 8.89 percent (table 2). The study of the relationship between yield and yield components showed that the corn yield in K.S.C701 hybrid is higher than Single Cross 704 hybrid due to its higher grain number per row. It appears that although the K.S.C701 hybrid is to some extent more pre-maturing than K.S.C704, it has more production potential in Khouzestan district environment. This hybrid is comparable to high potential hybrids in the area as a matter of yield potential and its components. The results of this study were correspondent to the findings of Gastora [4]. The mean comparison of the reciprocal effect of zinc sulfate solution spray and hybrid showed that the highest biological yield as 22050 kg/ha was related to F_4H_1 treatment (solution spray at the 8 and 12 leaves stage and 701 hybrid) and the least value as 18420 kg/ha was related to F_1H_2 (solution spray with control treatment and 704 hybrid), although the difference between these two values was not statistically significant (table 3).

Harvest Index:

The results of variance analysis of the harvest index showed that the factors of zinc sulfate solution spray and the reciprocal effect of solution spray and hybrid on this component was not statistically significant, but the difference between the hybrids was significant concerning grain yield (table 1). The mean comparison showed that the highest harvest index as 48.95 percent was related to the 8 and 12 leaves stage, although the difference between these two values was not statistically significant (table 2). The Single Cross 704 hybrid with mean harvest index of 49.13 percent was superior to Single Cross 701 hybrid with mean harvest index of 47.83 percent (table 2). The harvest index shows the transmission scale of photosynthetic materials from the photosynthetic levels to grain. It is evident that the treatments that have a greater harvest index have more carbohydrate transmission from green parts of the plant to the grain. The results of this study were correspondent to the findings of Mobser*et al*.,[1]. The mean comparison of the reciprocal effect of zinc sulfate solution spray and hybrid showed that the highest harvest index as 49.80 percent was related to F4H1 treatment (solution spray at the 8 and 12 leaves stage and 704 hybrid) although the difference between the means was not significant (table 3)).

Conclusion:

Regarding the gained results and analyzing the studied attributes, among the used hybrids, the Single Cross 701 had more appropriate grain yield potential. Regarding the positive effect of zinc sulfate solution spray and corn grain enrichment, solution spray of this element with the concentration of 2.5 gr/1000 cc water at the 8 and 12 leaves stages (conjugative) had the highest grain yield. The results of variance analysis showed that zinc sulfate solution spray had a significant effect on biological yield. For all the attributes except the weight of 1000-grain weight and harvest index attributes, the highest and lowest value was related to F4 treatment (solution spray was at the

8 and 12 leaves stages) and H_1 hybrid (Single Cross 701), respectively. Among the studied hybrids a significant difference concerning the number of grain per ear row, the number of grain per row, number of grains per ear,grain yield, biological yield and harvest index was observed, but the reciprocal effect of zinc sulfate solution spray and hybrid was non-significant for all the attributes.

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