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Research article

INVESTIGATING THE EFFECTS OF BORON AND ZINC ON CORN SEED SET IN MAZANDARAN IRAN

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ABSTRACT: In some corn fields, in different parts of Iran, the phenomenon of partly grain free ear is observed. This phenomenon can severely decreases corn yield. Although most researchers, mention that this phenomenon is the result of moisture and heat stresses at the time of pollination, but some other researches believed that it is due to the nutritional factors, especially boron and zinc nutritional elements. In order to examine the effect of zinc and boron application on corn grain production, an experiment was conducted at Qarakheil Agricultural research station in Qaemshahr during the 2003-2005. The experiment was factorial and conducted in the field as a Randomized Complete Block Design, with 20 treatments, and 3 replications. The treatments were composed of five level of zinc (O, 8, 16 and 24 $kg.ha^{-1}$ in soil and foliar application of $ZnSO_4$ with 0.5 percent concentration) and four levels of Boron (0, 20 and 40 $kg.ha^{-1}$ of boric acid in soil and foliar application of boric acid with 0.3 percent concentration), and finally their means were compared. The result from Mazandaran experiment, showed that application of zinc caused a significant increased in grain yield (α = 5%), but application of Boron individually or zinc in combination with boron, had not significant effect on grain yield. The maximum grain yield (10380 $kg.ha^{-1}$) was obtained due to application of 120 kg. ha^{-1} $ZnS0_4$ and 40 kg. ha^{-1} Boric Acid, which produced more yield (1415 kg. ha^{-1}) to chek (B=0 and ZN=0) . The application of zinc individually had only a significant effect on the length of corn ear and plant height, but application of Zn + B had significant effect on length and diameter of corn ear percent of partly grain free and their effect on other studied parameters were not significant.
Keywords: Boron, corn, seed set, Zinc.

INTRODUCTION

Maize (*Zea mays* L.) is an important cereal crop of the world and has great economic value in livestock and poultry production [9] and processed for several industrial products for human con sumption [19 ,14]. Soil tests and efficiency symptoms are not conclusive. The regions with Zn-deficient soils are also the regions where Zn deficiency in human beings is widespread, for example in India, Pakistan, China, Iran and Turkey [1,10].

In a global soil survey study, Sillanpaa [22] found that 50% of the soil samples collected in 25countries were Zn deficient. Nearly 50% of the cereal grown areas in the world have soils with low plant availability of Zn [4, 7]. Zinc deficiency is an increasingly important risk factor to the global agriculture and human health. This is so because Zn is an essential micronutrient, which is equally important for all forms of life i.e., for plants, animals and human beings [1]. Globally about 2 billion people are considered to be Zn deficient [15]. This situation is more alarming in developing countries where Zn deficiency is the fifth important factor causing ailments especially in children and women [24]. Several strategies are being used worldwide i.e. supplementation, food fortification and food diversification [11] but all these approaches have certain limitations in their use [6]. Recently a more beneficial approach, the biofortication of food that implicates increasing the mineral nutrient contents in staple food crops has been introduced [17,5]. Biofortication of edible plant parts may be done either through fertilization, plant breeding or genetic engineering [2].Breeding cultivars with increased mineral contents is a long term strategy [5]. Crop species/varieties vary in their nutrient requirement and utilization [13,18]. Hence the selection of those genotypes having maximum nutrient content in their edible parts is a promising approach. However fertilization of staple food crops to increase the mineral nutrient contents is easier. Keeping in view the above scenario, a field experiment was conducted with the objective to evaluate the effect of supra-optimal rates of Zn application on Zn partitioning in and grain yield in hybrid and synthetic maize cultivars.

The event of partly grain- free ear is a crucial problem which can result in severe reductions in corn yield. While some researchers believe that, water and heat stresses during the pollination process are the main causes of the event, others notify that nutritional disorders are noticeably involved in the incidence of this difficulty. Among micronutrients, boron (B) and zinc (Zn) play a key role in pollination and seed set processes; so that their deficiency can cause decrease in seed formation and subsequent yield reduction. Vitosh et al., [23] expressed that B is involved in carbohydrates metabolism and it is essentially necessary for protein synthesis, pollen germination and seed and cell wall formation. Rehem et al [20] stated that B plays a key role in water and nutrients transportation from root to shoot. They believe that boron shortage causes barren stalks and small, twisted ears. Since many factors can cause small, twisted ears of corn; they suggest having both soil and corn plant samples analyzed for boron before confirming a deficiency. Sometimes water stress and B deficiency are in companion with each other. For example B deficiency is intensified by water stress. According to a review reported by Marschner [12], B is relatively immobile in plant tissues and its transportation is further hindered under water stress circumstances. Similarly Zn supply is considered as an important factor in reproduction process. According to Brown et al [3] formation of male and female reproductive organs and pollination process are disturbed in Zn deficiency which may be attributed to the reduction of Indol acetic acid (IAA) synthesis. Marschner [12] declared that following Zn deficiency, reduction in RNA-polymerase activity and increase in RNA destruction can severely reduce the seed protein content. Studies have revealed that, B and Zn are interestingly related with each other. Graham et al., [7] reported that low Zn treatment did not affect plant growth.

MATERIALS AND METHODS

An experiment was conducted at Qarakheil Agricultural research station in Mazandaran Iran during the 2003-2005. The experiment was laid out in factorial on the basis of randomized completely block design, with 20 treatments, and 3 replications. The treatments were composed of five level of zinc (0, 8, 16 and 24 $kg.ha^{-1}$ in soil and foliar application of $ZnSO_4$ with 0.5 percent concentration) and four levels of Boron (0, 20 and 40 $kg.ha^{-1}$ of boric acid in soil and foliar application of boric acid with 0.3 percent concentration). NPK fertilizers were applied according to yield potentials and soil test level to the site. Fertilizers used as N. P. K (200-100-100) were made from urea, triple super phosphate and potassium sulfate. Hand weeding was introduced to control weeds. Plants from each plot harvested in an area of 9 m2 and the moisture content was adjusted to 14%. Cultivar corn was a single cross hybrid (*Z. mays* L. cv. singel cross 704) that was popular among growers in Iran. Plots were seeded on 31st of May. The site was irrigated with water using a sprinkler irrigation system. Plants were cut at the surface from the central of the four middle rows in the plots (area of 9 m2). All plots were harvested, on 3rd October, 2011. Ears were separated, weighed and the plant dry weights of forage were measured, grain corn moisture content was also determined. Data were analyzed using the MSTAT-C procedure to develop the ANOVA for a factorial design. The LSD procedure was used to make tests of simple and interaction effects by MSTAT-C, all differences reported are significant at $P\leq0.05$ unless otherwise stated.

RESULTS AND DISCUSSIN

Corn yield

Results of combinend analysis variance (3 years) showed that there was no significant difference on Zn effects on corn yield (Table 2).But means comparison with LSD procedure showed that apply of 24 net Zn had 534 kg increased in yield (Table 3). Application of B also was 117kg increased (Table2and4), The maximum grain yield (10380 $kg.ha^{-1}$) was obtained due to application of 120 kg. ha^{-1} $ZnSO_4$ and 40 kg. ha^{-1} Boric Acid, which produced more yield (1415 kg. ha-1) to checked (B=0 and ZN=0) (Table3). This experiment showed that, the increase of yield was du to for the effects of this treatment on, 1000 seeds weight, Num of grain in Row, Ear length and Ear diameter.

According to Brown et al., [3] formation of male and female reproductive organs and pollination process are disturbed in Zn deficiency, which in result causes a sever reduction in plant yield. They attribute this event to the reduction of Indol acetic acid (IAA) synthesis. Rehem et al., [20] stated that B plays a key role in water and nutrients transportation from root to shoot. They believe that boron shortage can cause barren stalks and small, twisted ears. Vitosh et al., [23] reported that B is initially necessary for pollen germination and growth of pollen tube. They believe that B uptake is negligible in calcareous soils with high pH, so that disturbance in pollination process and abortive plants are the common features of such circumstances.

1000seeds weight

Application of Zinc and B0rn individually had not significant effects on 1000seeds weight, but application of Zn + Born had significant effects. Apply Zn or Born individually increased in mean 9gr (Table 3) but application of Zn + Born increased 16gr to check. [21] Had the same report.

Table1. Soil physical and chemical analysis

P mg/kg	Zn mg/kg	B mg/kg	K mg/kg	Clay %	Silt %	Sand %	O.C %	O.M %	N %	T.N.V	pH	EC Ds/m	Depth of soil-cm
5	0.9	0.8	99	26	44	30	2.12	3.65	0.17	34	7.7	0.85	30

Table-2. Combined analysis of variance (factorial) for studied traits (3years)

Sources of variation	DF	Plant height	Grain free ear	Num of grain in Row	Ear diametr	Ear length	1000seeds weight	Grain yield
Replication	2	10.65**	4.18**	4.76**	9.84**	10.65**	1.66ns	11.29**
Zn levels	4	5.42**	0.70ns	2.09ns	1.37ns	5.42**	1.52ns	1.69ns
Boron levels	3	0.93ns	2.90*	0.17ns	0.28ns	0.93ns	2.22ns	0.66ns
Zn*B	12	1.38ns	1.84*	1.07ns	2.7**	1.38ns	0.74ns	0.79ns
Year	2	146.14**	15.55**	51.5**	0.15ns	146.15**	32.35**	56.51**
Zn*Y	8	2.88**	0.85ns	1.07ns	1.56ns	2.88ns	1.22ns	2.21ns
B*Y	6	0.31ns	0.60ns	0.85ns	0.44ns	0.31ns	1.02ns	0.36ns
Y*Zn*B	24	0.61ns	0.37ns	0.86ns	0.61ns	0.61ns	0.39ns	0.50ns
C.V %		3.6	36.9	7.4	2.7	5.0	10.6	13.0

*,**and ns significant at the 5%,1%and non significant respectively.

Table-3. Mean comprision of different amount of $ZnSO_4$ on some traits (3 years)

Treatment	Plant height (cm)	Grain free in ear%	Num. of grain in Row	Ear diametr (cm)	Ear length (cm)	1000seeds weight(g)	Grain yield (kg.ha^{-1})
Zn0	250.3bc	7.44a	41ab	4.45a	18.3ab	342.3a	9466ab
Zn10	251.9c	7.75a	39.9b	4.44a	19.28a	343a	9512ab
Zn20	256.7a	7.76a	40.5ab	4.48a	19.6ab	336.3a	9793ab
Zn30	252.6ab	7.28a	41.5a	4.5a	19.41a	337.5a	10000a
Zn f (Foliar)	246.9c	8.22a	39.8b	4.45a	18.79b	328.5a	9331b
Lsd 5%	4.28	1.33	1.4	0.06	.45	16.7	584

Different letteres in each colum shows significant difference at 5% probability.

Table-4. Mean comprision of different amount of B on some traits (3 years)

Treatment	1000seeds weight(g)	Grain/Cob%	Grain yield (kg.ha^{-1})	Plant height (cm)
B0	334.9ab	80	9685a	251.7a
B3	338.6ab	78.8	9520a	253.5a
B6	343.6a	79.9	9802a	250.3a
(Foliar) Bf	324.9b	79.2	9475a	251.4a
Lsd 5%	14.9	0.22	522	3.83

Different letteres in each colum shows significant difference at 5% probability (LSD).

Table-5. Mean comprision of different amount of B on some traits (3 years)

Treatment	Num.of Row per Ear	Grain free ear%	Ear length (without kernel)	Num. of grain in Row	Ear diametr (cm)	Ear lenght (cm)
B0	14.09a	80a	1.74a	40.5a	4.47a	19.18a
B3	14.13a	78.8a	1.45a	40.3a	4.45a	19.12a
B6	14.27a	79.9a	1.59a	40.6a	4.48a	19.06a
(Foliar) Bf	14.40a	79.2a	1.51a	40.7a	4.46a	19.08a
Lsd 5%	0.36	1.22	0.36	1.26	0.05	0.40

Different letteres in each colum shows significant difference at 5% probability (LSD).

Num of grain in Row

Application of Zinc and Born individually and together had not significant effects on Num of grain in Row (Table 2), but application of Zn + Born (Zn30B6) had Maximum effects on Num of grain in Row.

Ear diametr

Application of Zinc and Born together had significant effects ($p<0.0$) on Ear diameter. Application of 24 Zn and 40 kg. B had maximum Ear diameter. The check medum was 14 seed (Table 4) and application of Zn and B had shown 0.5(Table5) and B 0.2 (Table 5) respectively increase in seed to the check.

Table-5. Mean comprision of different amount of Z and B on some traits (3 years)

Treatment	Plant height (cm)	Ear diametr (cm)	Ear lenght (cm)	Num. of grain in Row	Num.of Row per Ear	1000seeds weight	Grain yield
Zn0B0	250.8bcd	4.43ab	18.91abc	40.9abc	14.22a	334.6ab	8965a
Zn0B3	249.3bcd	4.44b	18.8abc	40.7abc	14.00a	352.7ab	9661a
Zn0B6	247.3bcd	4.41bc	19.31abc	41.2abc	14.22a	336.3ab	9275a
Zn0Bf	253.8abc	4.51ab	18.71abc	41.2abc	14.44a	335.6ab	9964a
Zn10B0	248.7bcd	4.47ab	18.98abc	39.6abc	14.00a	325.7b	9413a
Zn10B3	254.8abc	4.31c	19.68a	40.2abc	14.67a	343.9ab	9491a
Zn10B6	253.8abc	4.54ab	19.32abc	40.3abc	14.00	368.7a	9828a
Zn20Bf	250.6bcd	4.46b	19.12abc	39.3abc	14.44a	333.7ab	9315a
Zn20B0	262.3a	4.44b	19.11abc	40.1abc	14.00a	338.1ab	10180a
Zn20B3	254.7abc	4.49ab	19.6a	40.3abc	14.00a	338.1ab	9336a
Zn20B6	253.3abc	4.48ab	18.97abc	41.2abc	14.67a	350.6ab	10130a
Zn20Bf	256.4ab	4.49ab	18.96abc	40.2abc	14.22a	318.2b	9529a
Zn30B0	248.7bcd	4.5ab	19.43abc	40.3abc	14.22a	330.2ab	10039a
Zn30B3	255.9ab	4.59a	19.18abc	41.9a	14.00a	327.9b	97783a
Zn30B6	252.2abcd	4.47ab	19.31abc	42.0a	14.00a	338.1ab	10380a
Zn30Bf	253.7abc	4.44bc	19.71a	41.8a	14.44a	313.7b	9443a
ZnfB0	247/9bcd	4.49ab	19.47ab	41.7ab	14.00a	336.0ab	9472a
ZnfB3	252.7abc	4.43bc	18.36c	38.3bc	14.00	330.3ab	9327a
ZnfB6	244.8cd	4.48ab	18.41bc	38.2c	14.44a	324.4b	9398a
ZnfBf	242.3d	4.41bc	18.91abc	41.1abc	14.44a	323.3b	9125a
Lsd 5%	8.6	0.11	0.89	2.81	0.81	33.3	1168

Different letteres in each colum shows significant difference at 5% probability.

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