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EFFECTS OF N, B, MN AND ZN NUTRIENTS FOLIAR APPLICATION ON SOME PHYSIOLOGICAL CHARACTERISTICS OF MAIZE (*Zea mays* L.) IN DIFFERENT GROWTH STAGES

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ABSTRACT

In order to investigate the Effects of N, B, Mn and Zn nutrients foliar application on some physiological characteristics of maize single cross 704 (*Zea mays* L.) in different growth stages an experiment was conducted in factorial form based on randomized complete block design (RCBD) with three replications at the Research Station of Saatlo, Urmia, north-western Iran, during growing seasons of 2013-2014. Treatments were five levels of foliar application include (N (Urea), Mn sulfate ($MnSO_4.H_2O$), Zn sulfate (Zn SO_4), boric acid (H3BO3), control and three growth stages include (the 8-10 leaves stage, the tasseling stage and the grain-filling stage. The analysis of the data showed significant effect of interaction between growth stage and foliar application on 100-grain weight and number of grain at the probability level of 5 and 1% respectively. Also foliar application had significant effect on grain yield per plant ($p<0.05$), 100- grain yield, number of grain and harvest index (HI), ($p<0.01$). Based on the results, the 100-grain weight showed an average 5 times more than control due Zn spraying in tasseling stage. Besides, the results also proved that N-foliar application had the highest effect on grain yield and harvest index. This treatment had 54% and 17% more grain yield and HI compared with control.

Keywords: corn, foliar application, nutrients.

INTRODUCTION

Maize (*Zea mays* L.) is an important crop worldwide [21]. Its grain is a rich source of many important nutrients and used for multipurpose. But yield of maize crop is alarmingly affected due to deficiency of plant nutrients in Iran. One of the most important issues about increase of crop yield and improving the quality of agricultural products is balanced plant nutrition [14]. Foliar application often is effective and economic method for quality improvement of nutrients in the plants [17]. Other advantages are quick compensation of nutrient deficiency and application of lesser rates and thus, reducing toxicity arises from excessive accumulation of elements and preventing nutrients fixation in the soil [10]. Foliar-applied N can be up to seven times more efficient than soil applied N [6]. Other benefits of foliar applied N include lower application rates (higher efficiency), plus the relative ease of obtaining timely, uniform applications [1]. Zinc (Zn) is an essential nutrient for the standard and healthy growth and development of plants [18]. Generally, zinc affects the synthesis of protein in plants hence is considered to be the most critical micronutrient [3]. Zn is also crucial in taking part in plant development due to its catalytic action in metabolism for all crops especially maize [5]. Manganese (Mn) is involved in many biochemical functions. It primarily acts as an activator of enzymes, involved in respiration, amino acid and lignin synthesis and hormone concentrations [8]. It is an important activator of enzymes acting in the Krebs cycle and, together with chlorine, acts on breaking the water molecule in the photosystem II [2]. A primary function of boron (B) is related to cell wall formation, so boron-deficient plants may be stunted. Sugar transport in plants, flower retention and pollen formation and germination also are affected by boron [9].

Foliar application Zn and Mn in small amounts had significant positive effect on morpho-physiological characteristics of safflower [13], maize [7] and growth of rice [20]. Foliar spray of micro power, containing Zn, B, Fe and Mn, also significantly increased plant height of Gerbera [11].

In arid and semiarid areas of Iran, the absorption of micronutrients is low due to a high pH level of the soil. In order to use chemical fertilizers efficiently, it is essential that fertilizer is applied by foliar-applications. The aim of this study was to investigate the N, B, Mn and Zn nutrients foliar application on maize and its physiological traits in 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 Saatlo, Urmia, north-western Iran, during the 2014 - 2015. Soil samples from various blocks of field were collected to determine the physicochemical properties and fertility of the soil (Table-1).

Table-1. Soil physical and chemical analysis.

Clay (%)	**Silt** (%)	**Sand** (%)	**K** (ava) (ppm)	**B** (ava) (ppm)	**Zn** (ava) (ppm)	**N** (%)	**Ec × 10^3**
43	43	16	425	0/93	0/4	0/12	1/57

The first factor was nutrients foliar application in five levels: a_1: N (Urea), a_2: Mn sulfate ($MnSO_4.H_2O$), a_3: Zn sulfate ($ZnSo_4$) and a_4: boric acid (H_3BO_3). The second factor was growth stages in three levels: b_1: 8-10 leaves, b_2: tasseling and, b_3: seed-filling stages. Mineral concentrations of foliar applications were determined in ratios of 5 to 1000 (for Zn, B and Mn) and 5 to 100 (For N). Considering the size of the plots, applications were made with a hand sprayer to facilitate effective foliar application in terms of precision and delicacy. Spraying was done thoroughly until foliar dropped from the plants. Furthermore, Tween80 was used as a surfactant to enable the leaves to absorb nutrient minerals. The control plots were water sprayed consistently to avoid the effects of foliar application used for experimental plots. Each plot consisted of 4 rows, with 70 cm between rows and 20 cm plant intervals. Initially, 2-5 seeds were planted together; thinning was done at the 3-leaf stage to obtain a plant density of 7 plants per m^2. Ten plants were randomly selected from each treatment for recording of the data. Grain yield was measured from two middle rows at the centre of each plot. Harvested ears were threshed and grain yield was expressed in g $plant^{-2}$. To determine the 100-grain weight, 100-grain in four replicates were counted and the weights were measured using a scale. Harvest index (HI) was described by the following model:

Grain yield = biomass yield × HI

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 DISCUSSIONS

The analysis of variance presented in Table-2 showed significant effect of interaction between growth stage and foliar application on 100-grain weight and number of grain at the probability level of 5 and 1% respectively. Also foliar application had significant effect on grain yield per plant ($p<0.05$), 100- grain yield, number of grain and harvest index (HI), ($p<0.01$).

100-grain weight

The mean comparison of data showed that Zn-foliar application in tasseling stage had the highest (100/4) and control in grain filling stage had the lowest (17/88) 100-grain weight (tab 4). Based on the results, this treatment showed an increase of 5 times due urea spraying compared with the control. Increase in 100-grain weight might be attributed to the increased in cob length and diameter which ultimately produced healthy and heavier grains. Tahir *et al.,* [19] also reported increased in the cob length (cm), cob diameter and 100-grains weight with foliar application of Zn over the control treatment.

Number of grain

Highest (590/8) and lowest (383) number of grain were observed for B-foliar application and N-foliar application in grain filling stage, respectively. This treatment had 54% more number of grain than N-foliar application in grain filling stage (tab.4). Our results are not supported by the Costa *et al.,* [4] who reported that the application of nitrogen did not affect the number of kernels per cobs.

Grain yield

Comparative look to the calculated mean showed that N-foliar application had the highest effect (115/9 g) whereas control showed the lowest effect (99 g) on grain yield in plant. Foliar application with N produced 17% more grain yield than control treatment (tab 5). Foliar urea applications have increased grain yield, particularly when applied before flag leaf emergence and when N availability was limiting [15]. Applications of N near flowering increased post flowering N uptake, grain protein content, and grain protein concentration. A supplemental dose of 7 kg N ha^{-1} as urea spray significantly increased maize grain yield (Singh *et al.,* 2005). Shirvani Sarakhsi *et al.,* [17] indicated that N foliar application increased grain yield in wheat. Zeidan *et al.,* [22] and Lawrence *et al.,* [12] reported that grain yield increased with increasing nitrogen rates.

Harvest Index (HI)

The physiological efficiency and ability of a crop for converting the total dry matter into economic yield is known as harvest index (HI). The comparison of mean showed that the foliar application with N had the highest effect (45/76 %) on harvest index while control had the lowest effect (32/47 %), (Table-5). The increased in harvest index might be due to the increased grain, while control treatment showed minimum harvest index. Lawrence [12] reported that harvest index in corn increases when nitrogen rates increases. Similar results have been reported by Zeidar *et al.,* [22].

Table-2. Analysis of variance of measured traits.

S.O.V	df	Grain yield	100-grain weight	Number of grain	HI
Rep	2	1345 *	20/82 ns	1880 ns	76/78 *
Growth Stage	2	194 ns	35/9 ns	3847 ns	8/83 ns
Foliar application	4	433 *	15643 **	14546 **	307/9 **
Stage × Foliar	8	308 ns	14/601 *	12485 **	16/69 ns
Error	28	135	5/912	2229	13/82
CV	-	7/5	3/48	10/03	9/61

* and **significant at 5% &1% respectively

Table-3. Mean comparison of interaction between foliar application and growth stage among understudy traits.

Nutrients foliar application	Growth stage	100-grain weight	Number of grain
Mn	8-10 leaves	95/83 bc	476 bcd
	Tasseling	97/3 abc	451 b-e
	Grain filling	94/38 c	476 bcd
Zn	8-10 leaves	99/43 ab	431 de
	Tasseling	95/95 bc	444 cde
	Grain filling	95/35 bc	427 de
B	8-10 leaves	97/1 abc	445 cde
	Tasseling	99/76 ab	581 a
	Grain filling	100/4 a	590 a
N	8-10 leaves	24/81 d	540 ab
	Tasseling	21/66 de	454 b-e
	Grain filling	17/92 e	383 e
Control	8-10 leaves	23/99 d	527 abc
	Tasseling	20/94 de	445 cde
	Grain filling	17/82 e	387 de

Table-4. Mean comparison of nutrients foliar application on measured traits.

Nutrients foliar application	Grain yield (g plant $^{-1}$)	Harvest index (%)
Mn	104 ab	34/93 b
Zn	113/9 a	36/33 b
B	111/4 a	44/03 a
N	115/9 a	45/76 a
Control	99/15 b	32/47 b

CONCLUSIONS

Results obtained from this study indicate that the foliar application composition in the various stages of the growth had a significant effect on 100-grain weight and number of grain. Foliar application with Zn in tasseling stage had the highest 100-grain weight. Moreover, B-foliar application in grain filling stage had the highest effect on number of grain. Also, foliar application with N had the highest and control had the lowest grain yield and harvest index.

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