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ORIGINAL ARTICLE

EFFECT OF NITROGEN FERTILIZATION AND FOLIAR APPLICATION OF ZINC IN GROWTH AND YIELD OF MAIZE (*ZEA MAYS* L.)

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Abstract: Macronutrients and micronutrients are one of the factors affecting the production of field crops, especially in soils that are deficient or have problems in its nutrient's availability or absorption by the plant. Thus, two field experiments were carried out during the spring and autumn seasons of 2016 in Basrah governorate, in a silty clay soil with an electrical conductivity of 7.5 dS m^{-1} and soil acidity 7.6. Nitrogen was studied as one of the macronutrients added to soil at levels 50, 100, 150 or 200 kg N ha^{-1} and one of the micronutrients (zinc) at levels 0, 50, 100, or 150 mg Zn l^{-1} added as foliar spraying. The results showed that nitrogen significantly affected the plant height (for the autumn season only), number of grains in the ear, weight of 500 grains (for the spring season only) and total yield. Plants fertilized by 150 kg N ha^{-1} gave the highest grain yield in the spring season attained 5974.0 kg ha^{-1}, while the nitrogen level 200 kg ha^{-1} recorded the highest grain yield (7882.8 kg ha^{-1}) in the autumn season. Spraying of zinc significantly affected the height of the plant, leaf area index, number of grains in ear, weight of 500 grains, and the grain yield (in the autumn season only) by using 100 mg Zn l^{-1}, which gave 7583.4 kg ha^{-1}. Interaction between N and Zn caused significant differences in some parameters. The highest grain yield obtained attained (6425.2 kg ha^{-1}) by using 150 kg N ha^{-1} +100 mg Zn l^{-1} in the spring season, while the interaction (200 kg N ha^{-1} + 100 mg Zn l^{-1}) gave the highest grain yield in the autumn season (8867.5 kg ha^{-1}).

***Key words*:** Nitrogen fertilization, Zinc spraying, *Zea mays* L., Yield components.

Cite this article

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1. Introduction

Maize (*Zea mays* L.) is an important multipurpose crop, used for human and animal feeding, as grain or fodder. It is nutritional, forage and oil crops, with a wide environmental range, comes after wheat and rice according to the economic importance, but the productivity rate per unit area in Iraq is still low, which attained 3326 Kg ha^{-1} [Ministry of Agriculture (2018)], as compared to world productivity which attained 5650 kg.ha^{-1} to the same year [USDA (2018)]. Maize is considered as a depleted crop, which needs and absorbs a large amount of nutrients during the growing season. Therefore, the application of essential nutrients in optimum and balanced quantity will enhance and sustain maize productivity [Marschner (2012)]. One of these nutrients is nitrogen, which is an essential and major nutrient, act an important role in the formation, size and distribution of roots, as well as in the contribution of proteins, chlorophyll and nucleic acids synthesis and improving the yield and crop quality [Majid *et al.* (2017)]. Many studies indicated that nitrogen is the most effective nutrient in the growth and yield of maize [Kandil *et al.* (2016)]. The lack of nitrogen delaying plant growth and development and reduces grain yield [Asif *et al.* (2013)]. Majid *et al.* (2017) found that highest grains yield of maize was obtained by using 345 kg N ha^{-1}.

Micronutrients can increase grain yield, as well as increase macronutrients use efficiency. Among the

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micronutrients, zinc is an important and essential nutrient for the satisfactory growth and development of plants. It is considered as a main limiting factors for growth and yield, due to its catalytic action in metabolism of maize. The deficiency of Zn in soil becomes a problem in arid and semi-arid regions of the world and it is a common phenomenon of crops especially in soil with high pH [Marschner (2012)]. Many previous investigations showed that maize is sensitive to zinc deficiency [Ehsanullah *et al*. (2015)]. Zinc influences on many vital processes, such as nitrogen metabolism, protein synthesis, formation of enzymes and auxins, resistant to biotic and abiotic stresses, appropriate root development and for oxidation and reduction reactions, synthesis of some essential hormones and amino acids, and the efficiency and its impact reflected on the crop productivity and quality [Potarzycki and Grzebisz (2009), Iqbal *et al*. (2016)]. It was found that application of $ZnSO_4$ significantly increased the maize yield [Iqbal *et al*. (2016)]. It was also observed that maize responded significantly to zinc foliar application, spatially in the range from 1.0 to 1.5 kg Zn ha^{-1} [Potarzycki and Grzebisz (2009)]. Ehsanullah *et al*. (2015) showed that spraying of zinc lead to an increase in maize yield by 38%, while soil application increases the yield by 23.7% compared to control.

Most studies have focused on the interaction between zinc and the macronutrients and its effect on the growth and yield of many different crops. It has been shown that the nitrogen fertilization have an encouraging effect in increasing the concentration of zinc in leaves and stems, therefore, nitrogen fertilization may increase plant resistance to zinc deficiency or increase zinc efficiency, which is defined as the ability or portability of the plant to growth and gave a good yield in the poor zinc soil.

Fertilizers of zinc were used as foliar application, especially in the arid and semi-arid soils (like Iraqi soils) which distinguished as alkaline with high amount of $CaCO_3$ and low amount of available zinc. This study was aimed to investigate the effect of different levels of nitrogen fertilization and spraying with zinc and their interaction on some growth and yield components of maize planted in a salted and alkaline soil in southern of Iraq.

2. Materials and Methods

A field experiments were conducted in Al-Basrah city in the autumn and spring sowing seasons of 2018 to study the response of the maize crop (*Zea mays* L.) cv. Bohooth 106, to nitrogen fertilization and zinc foliar spraying, by measuring some growth characteristics and yield and its components. A factorial experiment was carried out according to Randomized complete block design with three replicates. Nitrogen fertilization was added to the soil in four levels: 50, 100, 150 or 200 kg N ha^{-1}, using urea fertilizer (46% N). Zinc was sprayed on the vegetative part with four concentration which were 0, 50, 100 or 150 mg l^{-1}, by using $ZnSO_4.7H_2O$ (24.3% Zn). The plants were sprayed at the early morning by two batches, the first at 6 leaves stage and the second before tasseling, using **tween** 20 to reduce the surface tension to increase the efficiency of the spraying solution. A combined sample was taken from the field soil before sowing to determine some physical and chemical characters during the two seasons (Table 1).

After performing the soil service operation as leveling and soften, the planting operation was conducted on 1 march and 15 July for the two seasons, Spring and Autumn, respectively. Super Phosphate Fertilizer was added at rate 200 kg P_2O_5 ha^{-1} and potassium fertilizer at rate 120 kg K ha^{-1} as $K_2SO_4.7H_2O$ (26% K), applied as one batch at planting. Nitrogen fertilizer was divided into three equal batches, the first batch was applied at planting, the second batch after 30 days and the third batch was added at tasseling stage. The experimental unit (5×3 m^2), included four furrows with a length of 5 meters and 0.75 m between, the distance between the plants was 0.25 m. After the plants arrived at the 50% tasseling, ten plants were randomly selected from the middle furrows of each experimental unit to determine plant height, leaf area. When the field reached full maturity, 10 plants were

Table 1: Some physical and chemical characters of the field soil.

Soil characters		**E.C.e**	**pH**	**Organic matter**	**$CaCO_3$**	**Irrigation water salinity**	**Texture**
Unit	ds m^{-1}		g kg^{-1}	g kg^{-1}	ds m^{-1}		
Sowing season	Spring	7.89	7.54	11.2	250	1.53-1.75	Silty clay
	Autumn	8.64	7.61	10.7	254	1.41-1.82	Silty clay

harvested to calculate the number of grains per ear and weight of 500 grains. Grains yield (kg ha^{-1}) was calculated after harvesting the plants of two middle furrow of each experimental unit plus the yield of ten plants.

3. Results and Discussion

3.1 The plant height

The results of the statistical analysis and the data in Table 2 showed that the nitrogen level 200 kg ha^{-1} gave the highest value of plant height attained 137.6 cm, with an increase by 13.7% compared to 50 kg N ha^{-1}, which gave the lowest value attained 121.0 cm for the autumn season, while the increasing was little and insignificant in the spring season. The reason may be due to the increase in uptake of nitrogen, which led to increased cell division and elongation. This is agreed with what was found by Zeidan and Amany (2006).

Regarding to the effect of the zinc foliar spraying, the results in Table 2 showed that there were significant differences at the two seasons, where the spraying level 100 mg Zn l^{-1} gave the highest value for the plant height attained 134.0 and 140.8 cm for the spring and autumn seasons respectively, as compared to control, which gave the lowest mean of the plant height attained 110.5 and 107.5 cm, with an increasing rate by 31% and 21% at the two seasons, respectively. The reason may be due to the direct role of the zinc in enhancing the tryptophan (amino acid) synthesis, which is considering the basic of IAA hormone synthesis, which is very necessary in the cells elongation and then reflected on plant height. This result is agreed with Aref (2011).

3.2 Leaf area index

The different levels of nitrogen fertilization did not significantly affect on the leaf area index of maize (Table 2), while at zinc spraying, a significant differences were shown, where the highest value of leaf area index attained 3.24 and 3.45 for the spring and autumn seasons, respectively by using 150 mg Zn l^{-1}, with an increasing percentage by 21% and 13% compared to control (no zinc application), which gave the lowest values attained 2.86 and 2.84 for the two seasons, respectively. The reason may be due to the role of the Zinc in the synthesis of tryptophan as mentioned above, as well as the role of zinc in building many metabolic and storage compounds, which are entering in the growth and expansion of cells and forming new cells and thus increases the leaf area index. This result is agreed with what mentioned by Konuskan and Gozubenli (2004).

Table 2: Effect of nitrogen and zinc on the plant height (cm) and leaf area index of maize.

Nitrogen (kg ha^{-1})	Plant height (cm)		Leaf area index	
	Season		Season	
	Spring	Autumn	Spring	Autumn
50	120.0	121.0	2.98	3.14
100	121.6	126.8	3.14	3.21
150	128.4	133.3	3.09	3.22
200	128.0	137.6	3.10	3.41
$LSD_{0.05}$	**N.S.**	**11.2**	**N.S.**	**N.S.**
Zn (mg l^{-1})				
0	110.5	107.5	2.86	2.84
50	123.3	134.3	3.15	3.33
100	134.0	140.8	3.05	3.37
150	130.2	136.0	3.24	3.45
$LSD_{0.05}$	**9.8**	**11.2**	**0.27**	**0.31**

Table 3: Effect of nitrogen and zinc on number of grains in the ear and weight of 500 grains (gm) of maize.

Nitrogen (kg ha^{-1})	Number of grains in the ear		Weight of 500 grains	
	Season		Season	
	Spring	Autumn	Spring	Autumn
50	306	382	120.4	127.3
100	318	416	127.3	128.0
150	388	463	132.5	130.2
200	354	490	135.7	133.2
$LSD_{0.05}$	45.3	42.6	**7.04**	**N.S.**
Zn (mg l^{-1})				
0	325	372	128.4	123.0
50	337	458	128.7	131.1
100	357	482	132.7	132.8
150	344	439	126.1	131.8
$LSD_{0.05}$	N.S.	42.6	**N.S.**	**6.14**

3.3 Number of grains in the ear

The results in Table 3 showed significant differences in the number of grains in ear resulted in differences of nitrogen fertilization levels. The maximum number of grains in ear (388) was obtained by using the fertilizer level 150 kg N ha^{-1} during the spring season, with an increase by 27% compared to control treatment. The fertilizer level 200 kg N ha^{-1} achieved the highest value attained 490 grains in the ear during the autumn season, by increasing rate attained 28% compared to control. This effect achieved possibly due to more availability of nitrogen, which led to increase the efficiency of photosynthesis by increasing the height of plant with no effect on the leaf area (Table 2), which allowed to the best exposure of light and this reflected positively on biological processes that are beneficial to ear ontogeny. Increase in total number of grains in ear resulted in increasing of the number of rows in the ear and number of grains in the row. This result is agreed with Zeidan and Amany (2006).

The data given in Table 3 revealed that spraying of zinc on the leaves did not affect the number of grains in ear during the spring season. In the autumn season, spraying zinc had significant effect on the number of grains in the ear. The highest value attained (482) grains by spraying 100 mg Zn l^{-1}, which did not differ significantly from 50 and 150 mg Zn l^{-1}. This increase may be due to the role of zinc in enhancing the efficiency of photosynthesis and increasing the accumulation of manufactured substances in the plant and decrease the rate of atrophied grains [Konuskan and Gozubenli (2004)]. This is agreed with Al-Muhammadi (2005).

The interaction between nitrogen fertilization and zinc foliar spraying (Table 4) showed a significant effect on this parameter. Application of 200 kg N^{-1} with 100 mg Zn l^{-1} gave the highest number attained 554 grains in the ear. The lowest number was recorded (325 grains per ear) by using 50 kg N ha^{-1} without zinc spraying. This may be due to the role of nitrogen in combination with zinc in the synthesis and activation of many enzymes and their role in many biological processes, in addition to their roles in the production of chlorophyll, contributing on the pollination process and what resulting from it as emergence of grains initials that contribute to increase grains number in the ear [Zeidan and Amany (2006)].

3.4 Weight of 500 grains

The data in Table 3 indicated that there were no significant differences in the weight of 500 grain due to the nitrogen application during the autumn season. In the spring season, the level 200 kg N ha^{-1} gave the highest value of this attribute attained 135.7 gm, while the level 50 kg N ha^{-1} gave 120.4 gm with an increase by 12.7%. The reason of this increasing may be due to the effect of nitrogen in extended the effective duration of grain filling and provide an efficient source during that period by increasing the leaf area and delay aging [Kandil *et al*. (2016)]. It is also noted that spraying of 100 mg Zn ha^{-1} recorded the highest mean of this attribute in the autumn season (132.8 gm) with an increase by 8% compared to the non-spraying (control), which gave the lowest value attained 123.0 gm, while there were no significant differences in spring season. As shown in Table 5, the interaction between nitrogen and zinc showed a significant effect in this parameter, where the combination 200 kg N ha^{-1} and 50 mg Zn l^{-1} gave the highest value attained 139.8 gm as compared with 50 kg N ha^{-1} and 50 mg Zn ha^{-1}, which gave the lowest mean 117.0, with an increase by 19.4%. The increase in the weight of grain at these levels of nitrogen and zinc may be due to the role of nitrogen in enhancing the efficiency of the source size by increasing the accumulation of dry matter in the grains, which interacted with the effect of zinc in enhancing of leaf area and later the efficiency of photosynthesis [Dahmardeh (2012)]. This result is agreed with what found by Iqbal *et al*. (2016).

Table 4: Effect of interaction between nitrogen and zinc on the number of grains in ear at the autumn season.

Nitrogen (kg ha^{-1})	Zinc (mg l^{-1})			
	0	50	100	150
50	325	385	430	388
100	336	432	458	438
150	388	483	486	495
200	439	532	554	435
$LSD_{0.05}$	85.2			

Table 5: Effect of interaction between nitrogen and zinc on the weight of 500 grain (gm) at the spring season.

Nitrogen (kg ha^{-1})	Levels of zinc (mg l^{-1})			
	0	50	100	150
50	118.2	117.0	123.4	122.8
100	126.3	126.8	130.0	126.1
150	130.8	131.2	134.9	130.1
200	138.3	139.8	139.3	125.4
$LSD_{0.05}$	14.08			

3.5 Grains yield (kg ha^{-1})

Data in Table 6 indicated that nitrogen fertilizer at the level 150 kg N ha^{-1} gave the highest value of grain yield reached to 5974.0 kg ha^{-1}, with an increase by 34.7% compared to 50 kg N ha^{-1}, which gave the lowest (4437.2 kg ha^{-1}) in the spring season. In the autumn season, the nitrogen level 200 kg ha^{-1} was exceeded and gave the highest mean attained 7882.7 kg ha^{-1}, while the lowest value recorded by using 50 kg N ha^{-1}(6042.7

Table 6: Effect of nitrogen and zinc and their interaction on grains yield (kg ha^{-1}) of maize.

Spring season

The adding Nitrogen (Kg N h^{-1})	Zinc (mg L^{-1})				Nitrogen mean
	0	50	100	150	
50	4315.4	4361.3	4717.3	4355.2	**4437.2**
100	4622.6	4718.3	5133.9	5016.4	**4872.8**
150	5689.1	5811.6	6425.2	5970.1	**5974.0**
200	5274.1	5529.6	6175.6	5472.3	**5612.8**
Zinc mean	**4975.3**	**5105.2**	**5613.0**	**5203.5**	**Grand mean 5224.2**
$LSD_{0.05}$	N = 419.1		Zn=N.S.		N*Zn = 838.2

Autumn season

Nitrogen (Kg N h^{-1})	Zinc (mg L^{-1})				Nitrogen mean
	0	50	100	150	
50	4932.4	6136.8	6814.4	6287.1	**6042.7**
100	5221.1	6908.2	7133.5	6856.2	**6529.8**
150	5903.3	7535.9	7518.3	7785.5	**7185.8**
200	6942.0	8160.7	8867.5	7560.6	**7882.7**
Zinc mean	**5749.5**	**7185.4**	**7583.4**	**7122.4**	**Grand mean 6910.2**
$LSD_{0.05}$	N = 536.4		Zn = 536.4		N*Zn = 1072.8

kg ha^{-1}). This increase may be due to the role of nitrogen in increasing the growth parameters *viz*. plant height and the leaf area index, which positively reflected in enhancing photosynthesis, which led to increased distribution of photosynthetic products to the stock organs (grains), in addition to the role of nitrogen in increasing the root system, which positively increases the activity of the plant to absorb more water and nutrients from the soil. These processes led to increase the components of the yield (number of grains in the ear and the weight of grain), which reflected in the total yield of grains. This result is agreed with what noted by Iqbal *et al*. (2016). Regarding to the effect of zinc on grains yield the spraying treatment (100 mg Zn l^{-1}) significantly exceeded in the autumn season only and gave the highest value attained 7583.4 kg ha^{-1} with increasing percentage reached to 31.9% compared to the non-zinc foliar application, which gave the lowest mean attained 5749.5 kg ha^{-1}. The reason may be resulted from increasing the growth parameters which were positively reflected in the total yield. This result is agreed with what found by Asif *et al*. (2013). The interaction between nitrogen application and spraying with zinc significantly affected the grains yield. Interaction between 150 kg N ha^{-1} and 100 mg Zn l^{-1} gave the highest value attained 6425.2 kg ha^{-1} in the spring season. The combinations 200 kg N ha^{-1} and 100 mg Zn l^{-1} exceeded in the autumn season and gave grains yield attained 8867.5 kg ha^{-1}, while 50 kg N ha^{-1} and **0** mg Zn l^{-1} gave the lowest mean attained 4315.4 and 4932.4 kg ha^{-1} of the two seasons, respectively.

The two means of the grains yield at the two seasons (spring and autumn) were compared by using t-test. It was found a significant difference between them (t = 4.32**). In the autumn season, the grains yield recorded 6910.2 kg ha^{-1} as compared to 5224.2 kg grains ha^{-1} in the spring season. This may be due to the environmental conditions in the region in the spring season. During the pollination stage in spring, the plants focused and attached a high temperature, led to a death of the pollen, which negatively affect the grains yield.

4. Conclusion

From what was mentioned above, we can conclude that the growth and yield of maize crop were positively affected by application of nitrogen and generally recorded the highest value by using 200 kg N ha^{-1}, whereas it is affected by spraying with zinc sulfate (100 mg Zn l^{-1}). So, we suggest that maize should be planted during the autumn season under the conditions of the southern region of Iraq with using the above two levels of nitrogen and zinc.

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