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RESPONSE OF MAIZE PLANTS TO DIFFERENT NITROGEN RATES AND ZINC APPLICATION METHODS

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Abstract

Two field experiments were carried out during the two successive seasons of 2017/2018 and 2018/2019, at Agricultural Experimental of Suez Canal University, Ismiailia Governorate Egypt, to define the effect of nitrogen rates (100, 120 and 140 kg/ fed) and zinc application method (soil, foliar) at 0.5 g/L on maize production.

The obtained results could be summarized in the following:-

* Increasing nitrogen fertilizer rate significantly increase all the studied growth and yield parameters, nutritional stats and chemical constituents of maize (white maize, single cross 10).

* Zinc significantly increase maize growth, yield and its component compared with control (nitrogen rates alone).

* Zinc foliar application recorded the highest values of the studied maize parameters compared with its soil application with all rates of nitrogen fertilizer.

* Nitrogen rate 140 kg per feddan with foliar zinc application recorded the superior growth, grains yield quantity and quality.

Key words: Maize production -Nitrogen- zinc.

Introduction

Maize (*Zea mays* L.) is great important crop for both human and animal nutrition. It ranks the third position among sereal crops. In Egypt, it is very important to increase production of maize to cover the gab between production and consumption. The highest maize yield production depended on many factors such as cultivars, nitrogen and micronutrients fertilization. Therefore, through proper fertilization. Maize hybrids differed in its productivity as well as its response to nitrogen fertilization.

Zinc element is essential to the growth and yield of maize plants. Nitrogen is the most limiting factor in maize production. It plays a vital role in maize production for vegetative growth, grain filling, protein content and minerals composition (Darwish, 2003).

Many investigators reported that the increasing nitrogen rates up to 120 kg/fed or 150 kg/fed led to a signification increase in grain yield and its components (El-Bana and Gomaa, 2000 ans El-Douby *et al.*, 2001). El-Aref *et al.*, (2004) found that, increasing nitrogen fertilization levels led to a significant increase in plant hight, ear leaf area, ear length, number of kernel/ rows, ear weight and grains yield.

Zinc is very important micronutrient for increasing maize grain yield as well as sorghum, spinach and onion. Zinc plays key role in pollination and seed set processes so that its deficiency can cause in grain formation and subsequent yield reduction (Ziaeyan and Rajaie, 2009). Under stress conditions (Salinity, drought, Cold, etc.,) zinc has a positive interaction with potassium, increases the resistance of plant stress and it's necessary for chlorophyll and carbohydrate synthesis (El-Hadidi and Mansour, 2008).

Zinc has a role in starch metabolism in plants as well as formation of male and female reproductive organs and pollination process are disturbed in zinc deficiency, which may be attributed to the reduction of indole acetic acid (IAA) synthesis. Marschner, (1995) declared that following zinc deficiency, severely reduce the seed protein content in higher plants.

El-Douby *et al.,* (2001) who stated that nitrogen is usually the most limiting factor in maize production.

El-Metwally *et al.,* (2018) response of peanut to different foliar applications of nano- iron, manganese and zinc under sandy soil conditions.

The aim of present investigation is to study the effect

Table 1: Some physical and chemical properties of Ismailia soil.

Physical properties							
Particle size distribution %				**Soil moisture constant %**			
Sand	**Silt**	**Clay**	**Soil texture**	**Saturation**	**FC**	**WP**	**AW**
887.4	7.7	4.9	Sandy	35.0	20.2	6.1	14.1

				Soluble cations ($meq^{-1}L$)				**Soluble anions ($meq^{-1}L$)**			
pH 1:2.5	**EC ($dS\ m^{-1}$)**	**$CaCO_3$ %**	**OM %**	**Ca^{++}**	**Mg++**	**K+**	**Na+**	**HCO_3-**	**CO_3**	**Cl-**	**SO4=**
8.17	1.08	6.30	6.30	2.70	10.00	5.12	14.00	0.4	-	1.8	0.4

Zinc			**Total**		**Available**	**Available micronutrients**			
ppm			**mg 100 g^{-1} soil**			**ppm**			
Soluble	Available	Total	N	P	K	Fe	Mn	Zn	Cu
0.44	4.19	8.92	14.00	0.51	5.12	1.13	0.15	0.24	0.23

FC (Field capacity), WP (Welting point), AW (Available water).

of different nitrogen rates and zinc application methods on maize growth, yield and its components as well as grains quality.

Materials and Methods

Soil analysis

Physical and chemical properties of Ismailia soil were determined and particle size distributions along with soil moisture were determined as described by Blackmore, (1972). Soil pH, EC, cations and anions, organic matter, $CaCO_3$, total nitrogen and available P, K, Fe, Mn, Zn, Cu were run according to Black *et al*., (1982). The moisture constant Some physical and chemical properties of Ismailia soil are shown in table 1.

Experimental works

Tow field experiments were conducted to evaluate the effect of nitrogen levels and methods of zinc application on the growth, yield and its components of maize plants as well as grains quality. Experiments were carried out at the Agricultural Experimental of Suez Canal University, Ismiailia Governorate, during two successive seasons of 2017/2018 and 2018/2019 under drip irrigation system. The experimental design was split plot in randomized complete blocks. Each experiment consisting of nine plots. Each plot area was 10.5 m^2. Each plot consisting of four rows. Each row length 5 meter and 60 cm between rows. Each row consisting ten plants. Grains of white maize (Zea maize, single cross 10) were sown in the 15^{th} May, 17^{th} May 2017 and 2018 seasons.

Maize plants were fertilized with the Agriculture Ministry recommended doses of calcium superphosphate fertilizer (15% P_2O_5) was added during grain bed preparation at the rate of 30 kg P_2O_5) per faddan. Potassium sulphate (48% K_2O at 24 kg per feddan was added before the first irrigation. Nitrogen fertilizer as ammonium sulphate (20.6%N) was splitted into three doses (100, 120 and 140 kg/ fed) applied at planting, 21 and 35 days from planting.

The method of zinc application was as follows:

1. Without zinc
2. Soil irrigated with Zn-EDTA solution (0.5 g/L).
3. Foliar application of Zn-EDTA solution (0.5 g/L).

were performed towice, at 45 and 75 days from sowing.

Measurement Maize growth parameters

After 80 days from sowing, the growth parameters such as plant hight, leaves number, leaf area, shoot fresh and dry weights were recorded according to FAO, (1980).

Measurement Maize yield parameters and its components

After 120 days from sowing, all yield parameters and its components such as Ear length, Ear diameter, Ear weight as well as grain ear weight, number of grains per row, 100 grains weight, grains yield per feddan and strow yield per feddan were recorded according to Gabal *et al*., (1984).

Measurement mineral composition

Macronutrients (N,P and K) along with Micronutrients (Fe, Mn, Cu and Zn) were determined according to Black *et al*., (1982).

Measurement Chemical constituents

Total proteins (%) Total carbohydrates (%), starch (%), oil (%) and oil yield (kg/fed) were determined according to A.O.A.C., (1995).

Statistical analysis

The obtained data were statistically analyzed of variance procedure outlined by SAS, (1996) computer program and means compared by LSD method to Snedecor and Cochran, (1980).

Results and Discussion

1. Vegetative Growth

Table 2: Effect of nitrogen fertilizer rates and zinc application method on vegetative growth of maize.

Nitrogen. Kg/fed	Zinc addition method	Plant hight(Cm)	Leaves no. per plant	Leaf area (Cm^3)	Shoot fresh w. (g)	Shoot dry weight/ plant (g)
100	Without Zn	286	5	2146	881	236
	Soil appl.	291	5	2156	895	241
	Foliar appl.	296	6	2557	923	252
	Mean	**291**	**5.33**	**2286**	**900**	**246**
120	Without Zn	293	7	3014	890	258
	Soil appl.	301	7	3082	911	266
	Foliar appl.	308	8	3344	932	275
	Mean	**301**	**7.33**	**3014**	**911**	**266**
140	Without Zn	319	8	3370	904	271
	Soil appl.	326	9	2616	923	276
	Foliar appl.	335	9	2712	939	281
	Mean	**327**	**8.67**	**2099**	**922**	**276**
Average of Zn Treatments	Without Zn	239	6.67	2843	892	255
	Soil appl.	306	7.00	2618	910	262
	Foliar appl.	313	7.67	2871	931	269
LSD at 5%						
N		6.76	1.0	55.8	1.2	12.4
Zn		4.55	1.0	1.31	11.0	3.67
N × Zn		30.8	1.0	73.1	13.2	45.5

1.1. Effect of nitrogen:

Data in table 2 show that with the increasing of nitrogen dose, all growth parameters of maize such as plant highest, leaves number per plant, leaf area, shoot fresh and dry weights per plant significantly increased. It might be due to activation of photosynthesis process, which enhanced the amount of metabolites necessary for building plant organs. Also nitrogen plays a vital contribution in several processes related to plant growth. These data are in harmony with those obtained by Darwish, (2003) who found that many investigators reported that increasing nitrogen levels led to a significant increase maize plant growth.

El- Bana and Gomaa, (2000) added that increasing nitrogen fertilization rated led to a significant increase plant hight, leaf area and shoot weight, ear length, number of kernel per rows, ear weight and grains yield of maize.

1.2. Effect of zinc:

Present data in table 2 show that, both soil and foliar application of zinc significantly increased maize growth parameters compared with control (nitrogen levels alone). Zinc foliar application has the promotive growth parameters with all nitrogen levels compared with its soil application.

Zinc foliar application with 140 kg/ faddan nitrogen fertilizer recorded the

Table 3: Effect of nitrogen fertilizer rates and zinc application method on maize grains yield..

Nitrogen. Kg/fed	Zinc addition method	Plant hight (Cm)	Ear length (cm)	Ear diameter (Cm)	Ear weight (g)
100	Without Zn	291	18.6	3.69	216
	Soil appl.	296	18.9	3.78	224
	Foliar appl.	304	19.2	3.92	247
	Mean	**297**	**18.9**	**3.80**	**229**
120	Without Zn	298	19.7	4.14	236
	Soil appl.	306	20.5	4.25	252
	Foliar appl.	312	20.9	4.41	273
	Mean	**305**	**20.4**	**4.27**	**254**
140	Without Zn	324	22.3	4.85	304
	Soil appl.	331	22.9	4.97	326
	Foliar appl.	340	23.4	5.19	341
	Mean	**332**	**22.8**	**5.00**	**324**
Average of Zn Treatments	Without Zn	304	20.2	4.23	252
	Soil appl.	311	20.8	4.33	267
	Foliar appl.	319	21.2	4.51	287
LSD at 5%					
N		6.57	1.1	0.71	19.2
Zn		1.89	0.4	0.16	1.39
N × Zn		12.4	1.54	0.114	37.1

Table 4: Effect of nitrogen fertilizer rates and zinc application method on the component of maize yield.

Nitrogen. Kg/fed	Zinc addition method	Grain Ear weight (g)	No. of grain per plant	100 grains weight (g)	Grain yield (Ton/fed)	Straw yield (Ton /fed)
100	Without Zn	179	37.8	30.56	4.507	3.231
	Soil appl.	184	38.5	32.77	4.615	4.319
	Foliar appl.	202	40.6	34.42	5.067	4.388
	Mean	**188**	**39.0**	**22.58**	**4.730**	**3.98**
120	Without Zn	198	40.6	33.70	5.128	4.171
	Soil appl.	210	41.3	35.91	5.361	4.378
	Foliar appl.	232	43.0	37.22	6.119	4.091
	Mean	**213**	**41.6**	**35.61**	**5.536**	**4.213**
140	Without Zn	221	42.1	36.08	5.801	4.691
	Soil appl.	242	43.8	38.19	6.305	4.932
	Foliar appl.	257	44.4	40.58	6.425	5.126
	Mean	**240**	**43.43**	**38.28**	**6.77**	**4.916**
Average of Zn Treatments	Without Zn	199	40.2	33.45	5.145	3.698
	Soil appl.	212	41.2	35.62	5.427	4.543
	Foliar appl.	230	43.6	37.41	5.870	4.535
LSD at 5%						
N		10.5	1.5	3.14	0.67	0.514
Zn		7.44	1.3	1.4	0.13	0.90
N × Zn		78.1	1.95	4.4	0.09	0.46

greatest maize growth parameters flowed by with 120kg N / faddan followed by with 100 kg N/faddan. While the control (nitrogen levels alone) gave the lowes growth values. These results are agree with those obtained by Ziaegan and Rajaie, (2009) who show that zinc significantly increase the growth parameters of maize, sourghum, spinach and onion.

2. Yield characteristics

2.1. Effect of nitrogen:

Data in table 3 indicate that, the studied yield parameters of maize such as ear length (cm), ear diameter (cm) and ear weight significantly, increased with all nitrogen levels. Nitrogen at 140 kg/ feddan recorded the highest maize grains yield followed by the 120 kg/ feddan while the level of 100 kg N/feddan gave the lowest ones. These results are clear that nitrogen significant enhance maize grains yield. Confirm these results El-Douby *et al.,* (2001) who stated that nitrogen is usually the most limiting factor in maize production.

2.2. Effect of zinc:

Data in table 3 show that zinc significantly increase maize grains yield with all nitrogen rates compared with control (nitrogen levels alone). Foliar zinc application recorded the highest grains yield of maize compared with soil ones. with nitrogen at 140 kg/ feddan, zinc recorded the greatest grains yield while the level of 100 kg/feddan recorded the lowest ones. These observation are consistent with previous reports obtained by Fecenko and Lozek, (1998) who pointed out that zinc application significantly increase the grains yield of maize. This result may to due to the role of zinc as a co-factor in the enzymatic reactions of the anabolic pathway in plant growth and yield of maize.

3. Maize yield components

3.1. Effect of nitrogen rates:

Data presented in table 4 reveal that, when increasing nitrogen rate, all maize yield components are increase. Nitrogen at 140 kg per feddan has a highest values of grain ear weight, number of grain per row, 100 grains weight, grains yield as well as straw yield followed by the rate of 120 kg/per feddan followed by 100 kg per feddan. These results are agree with those obtained by Peter *et al.*, (2002) who found that, the increase grains yield fed^{-1} may by attributed to the stimulating effect of nitrogen on the vigar of vegetative growth and accumulation of photosynthesis products and their assimilation, which stimulate maize plants to produce high grains yield. Confirm these results El-Nagar, (2003).

3.2. Effect of nitrogen rates:

Zinc application as foliar gave the highest values of grains ear weight, number of grains per row, 100 grains weight, grains yield and straw yields per faddan. Such values were surpassed than those obtained by added zinc as soil ones. These explanations are in accordance with those declared by Ziaeyan and Rajaie, (2009) who stated that zinc is an essential components of various enzyme

Table 5: Effect of nitrogen fertilizer rates and zinc application method on the nutritional status of maize grains.

Nitrogen rates Kg/fed	Zinc addition method	Macronutrients (%)			Micronutrients (ppm)			
		N	P	K	Fe	Mg	Cu	Zn
100	Without Zn	0.98	0.211	1.79	7.06	3.46	3.66	0.08
	Soil appl.	1.02	0.216	1.83	7.11	3.50	3.71	15.9
	Foliar appl.	1.06	0.220	1.87	7.16	3.56	3.76	18.6
	Mean	**1.02**	**0.216**	**1.83**	**7.11**	**2.35**	**3.71**	**11.53**
120	Without Zn	1.10	0.232	1.91	7.14	3.59	3.70	0.14
	Soil appl.	1.14	0.239	1.94	7.19	3.63	3.75	17.8
	Foliar appl.	1.19	2.244	1.99	7.24	3.68	3.79	21.2
	Mean	**1.14**	**0.238**	**1.95**	**7.19**	**3.63**	**3.75**	**13.03**
140	Without Zn	1.13	0.238	1.97	7.19	3.71	3.79	0.21
	Soil appl.	1.18	0.246	2.03	7.24	3.76	3.81	20.1
	Foliar appl.	1.22	0.253	2.13	7.31	3.79	3.86	22.7
	Mean	**1.17**	**0.246**	**2.10**	**724**	**3.75**	**3.81**	**14.34**
Average of Zn Treatments	Without Zn	1.07	0.227	1.89	7.13	3.59	3.71	0.10
	Soil appl.	1.11	0.234	1.94	7.18	3.63	3.76	17.9
	Foliar appl.	1.16	0.239	2.00	7.24	3.70	3.80	20.8
LSD at 5%								
N		0.3	0.6	0.6	0.5	0.6	0.4	0.6
Zn		0.5	0.2	0.4	0.3	0.3	1.7	1.1
N × Zn		0.15	0.12	0.24	0.15	0.18	0.68	0.66

system, for energy production and is very important micronutrient for increasing grains yield and its component of maize. Zinc as foliar with 140 kg/ feddan nitrogen recorded the greatest values of maize grains yield and its components. These results are in harmony with those obtained by El-Aref *et al.*, (2004) who stated that the highest grains yield was obtained with 150 kg per faddan with zinc as foliar could be suitable for the enhancement of photosynthesis and resulted in a significant increase grains yield and its component of maize.

4. Nutritional status

4.1. Effect of nitrogen rates:

Data presented in table 5 show that, as increasing nitrogen fertilizer rate, nitrogen content in maize grains significantly increase. Also, data in table 5 reveal that, increasing rates of nitrogen fertilization up to 140 kg N per faddan significantly increased the content of potassium and phosphorous. These results are agree with those obtained by El-Fiki, (2000). Conferm these results Marchner, (1998) who found that values of nitrogen applications rates has a significant promotive effect was obtained for the N, P and K contents of maize grains.

4.2. Effect zinc:

Data presented in table 5 show that, applying zinc significantly increase N, P and K contents in maize grains. Data also indicate that the best contents of N, P and K were achieved by applying N at the rate of 120 or 150 kg N per faddan along with zinc as a foliar. Zinc as foliar gave the highest values of N, P and K compared with zinc as soil application. These results are in harmony with those obtained by Yanai *et al.*, (1998) who found that the application of Zn either foliar or soil increased the content of nitrogen content in wheat. Hassan, (1996) show that phosphorous content in wheat grains and straw with zinc application specially, as a foliar. Although potassium content increase with both nitrogen and zinc addition (Thalooth *et al.*, 2006).

Micronutrients (Fe Mg Cu and Zn):

Data in table 5 clearly indicate that the nitrogen at 140 kg N per faddan significantly increased the contents of Mg, Fe, Cu and Zn. Increasing the rate of nitrogen in plant media significantly increased these elements content in maize.

Shams El- DIn, (1993) state that the addition of zinc either foliar or soil increase the studied micronutrients in wheat grains.

5. Chemical constituents

5.1. Effect of nitrogen:

Data presented in table 6 show that as nitrogen rates increased, chemical constituent (Total proteins, total carbohydrates, starch, oil (%) and oil /yield). significantly increased of maize grains. The highest values of chemical constituents were obtained by using 140 kg N/faddan followed by 120 kg N/fed while the rate of 100 kg N/ feddan recorded the lowest ones. These results are agree with those obtained by Said *et al.*, (1990) and Kumari

Table 6: Effect of nitrogen fertilizer and zinc application method on the chemical constituents of maize grains.

Nitrogen rates Kg/fed	Zinc addition method	Chemical constituents (%)				Oil yield kg/fad.
		Total protein	Total carbohydrates	Starch	Oil	
100	Without Zn	6.13	59.13	49.4	6.22	224
	Soil appl.	6.38	60.20	50.6	6.45	233
	Foliar appl.	6.62	62.18	51.8	6.71	237
	Mean	**6.38**	**60.50**	**50.6**	**6.46**	**231.3**
120	Without Zn	6.87	61.24	51.0	6.27	228
	Soil appl.	7.13	61.87	52.14	6.54	238
	Foliar appl.	7.43	62.69	52.78	6.86	249
	Mean	**7.14**	**61.45**	**51.97**	**6.22**	**238.3**
140	Without Zn	7.06	62.02	53.0	6.30	229
	Soil appl.	7.38	63.0	54,9	6.69	243
	Foliar appl.	7.63	65.19	56.7	6.93	252
	Mean	**7.36**	**60.4**	**54.9**	**6.64**	**241.3**
Average of Zn Treatments	Without Zn	8.69	60.80	51.13	6.26	227
	Soil appl.	6.96	61,69	52.54	6.56	238
	Foliar appl.	7.18	63.35	53.70	6.83	2.46
LSD at 5%						
N		0.7	0.38	1.6	0.3	1.00
Zn		0.5	0.31	0.64	0.2	2.00
N × Zn		0.35	0.242	1.024	0.06	2.00

and Sigaram, (1996) they stated that as nitrogen application increased, increasing reducing sugar, total sugar, crude protein, starch and total carbohydrate. This is mainly due to the effect of nitrogen on the vigor of vegetative growth and accumulation of photosythesis products and their assimilation, which stimulate maize plants to produce high grains yield and its quality. Also, the addition of nitrogen fertilizer encourages plant to absorb large amounts of N and consequently more assimilation rates in forms of amino acids, proteins, enzymes and other nitrogen substances which will be formed.

5.2. Effect of zinc:

Data in table 6 clearly indicate that zinc addition with nitrogen at 140 kg N/ feddan gave the highest chemical contents values compared with control (nitrogen levels alone). Data also reveal that zinc foliar application recorded the greatest values *i.e* total proteins, total carbohydrates, starch, oil (%) and oil yield of maize grains compared with zinc soil application.

These results are in harmony with those obtained by Alloway, (2004). Who found this effect may be due to the essential role of zinc in assimilation processe of protein synthesis and nucleic acid. Marschner, (1995) declared that zinc is essentially necessary for protein synthesis and following zinc deficiency induced reduction in RNA-polyerase activity and increase in RNA destruction and this an severely reduce grain of maize protein content. He added that zinc modifies and or regulates the activity of carbonic anhydrase, an enzyme regulates the conversion of carbon dioxide to reactive bicarbonate species for fixation to carbohydrates maize, sorghum and sugarcane. Jyung *et al.*, (1975) provided the evidence for a close relationship between zinc nutrition and starch formation. They found that, under zinc deficient condition, the starch synthetase activity and the starch content. They added that in the plants are grow in the field under in the field zinc supply.

El-Metwally *et al.*, (2018) added that zinc foliar application significantly increase oil seed yield of peanut plants.

Conclusion

Nitrogen fertilizer rate 140 kg per faddan with zinc foliar at (0.5 g/L) application recorded the greatest values of maize growth, grains yield and its components quantity and quality.

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