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Foliar Application of Zinc and Potassium Mitigates the Effect of Salt Stress on Wheat

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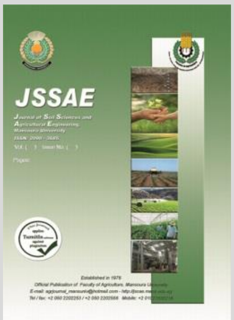

ABSTRACT

Foliar application is a promising agronomic strategy because it involves direct adsorption and loading of nutrients from the leaf surface to the phloem in a short period and in comparatively far less quantity than soil applications. Potassium and zinc are essential elements required for plant growth, metabolism and development and that plays a pivotal role in plant adaptation and tolerance to salt stress. The objective of this study was to the evaluation of foliar spray with Zn and most suitable form of K-fertilization to improve growth and yield components of wheat (*Triticum aestivum* L, var Sakha 93) under salinity conditions. The experimental design was a split-plot with three replicates, the treatments can be described as two concentrations of zinc foliar application (0 and 300 mg L^{-1} Zn-EDTA) as the main plots and the sub plots involved the five sources of K-fertilization :i.e. 1- Without spraying (control treatment) , 2- K-sulphate, 3- K-humate, 4- K-silicate and 5- mono K-phosphate as foliar spray a rate of 2 g L^{-1} . The results revealed that growth performance, chlorophyll content, yield and its component, nutrient status of wheat grains as well as total carbohydrate and protein significantly due to Zn-EDTA foliar application. Moreover, spraying with potassium silicate and humate was the most effective under saline condition to improve the mentioned parameters. Accordingly, it was concluded that foliar application with potassium silicate or potassium humate in presence of Zn-EDTA were optimum for achieving higher yield of wheat under conditions of salt stress.

Keywords **:** Foliar application, zinc, potassium fertilization and salt stress

INTRODUCTION

Wheat is the most important winter grain in the world, and the qualities of its grain make it the most important cereal for human consumption (Salim and Raza, 2020). Wheat plants are the most important grain crops in Egypt. The Egyptian government's strategy calls for cultivating 3.6-3.7 million acres of wheat plants in the 2020/2021 season, up from 3.4 million acres in the previous season (Agric. Res. Ins. of Economy, 2021). In Egypt, overall wheat output is insufficient to meet local demand, necessitating the immediate maximization of wheat crop production because local production is insufficient to meet annual requirements (Kasim *et al.*, 2020). Furthermore, according to the Economic Affairs Annual Report (2017), total wheat consumption is increasing dramatically due to overall population growth of around 2.5 % per year.

Zinc deficiency, along with vitamin A and iron (Fe) deficiency, is the most common nutritional disorder (Welch and Graham, 2005). According to studies, 17.3 % of the world's population is at danger of Zn deficiency (Wessels and Brown, 2012). Zinc is a crucial plant micronutrient that is found in the structure of tens of proteins and acts as a cofactor for a variety of enzymes involved in a variety of physiological processes including as chlorophyll synthesis, glucose metabolism, protein synthesis, and biological membrane maintenance (Alloway, 2009). Plants absorb zinc from the soil, and soil zinc deficiency is a very important abiotic stress factor, affecting more than 50% of cultivated land worldwide (Alloway, 2009). Zinc deficiency adversely affects plant growth and, in severe cases, causes short internodes of dysgenesis, small leaves, leaf bleaching, delayed maturation and necrotic tissue death (Hacisalihoglu, 2020). Furthermore, synthetic fertilizers are frequently insufficient to address soil Zn deficiencies. Wheat, in comparison to other field crops, is more resistant to zinc shortage. However, its continued cultivation on Zn-deficient soils has resulted in widespread Zn insufficiency in grains, hampered agricultural production, and caused a shortage of Zn for humans (Ning *et al*. 2019). Zn loss owing to intensive cropping methods, decreased use of organic manures, phosphorus-induced Zn insufficiency due to greater use of phosphatic fertilizers, and irrigation water of poor quality are all factors for increased Zn deficit (Akram *et al*. 2017). As a result, boosting the Zn content of wheat grains and other cereal crops is a primary research priority (Chattha *et al*., 2017). According to Mathpal *et al.* (2015), deficiencies in nitrogen, phosphorus, and zinc have a significant impact on average wheat yields.

Zn supplementation reduced ROS production and protected cells from ROS damage. Zn deficiency can lead to high levels of ROS production and cell damage (Cakmak, 2000). So, under salinity condition have suggested that Zn increased the tolerance against salt stress, due to this element playing an important role in antioxidant metabolism as a cofactor of main enzymes (Weisany *et al.*, 2014). Sattar *et al.*, (2022) found that foliar application of zinc improves morpho-physiological and antioxidant defense mechanisms, and agronomic grain biofortification of wheat (*Triticum aestivum* L.) under water stress

Potassium is a significant element that plays an important role in plant growth and agricultural output (Bukshs *et al.*, 2012). The K is involved in a variety of

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physiological functions, including regulating stomatal conductance, maintaining turgor pressure, increasing photosynthetic rate, and improving cell expansion (Mengel and Kirkby, 1987). El-Lethy *et al*,. (2013) mentioned that potassium plays a positive function in plant growth under saline environments due to its role in alleviation of injury of wheat irrigated with salinized water depend on the level of salinity (El-Agrodi *et al*., 2016). It is essential for the activation of over 60 enzymes involved in the synthesis and growth of plants (Hasanuzzaman *et al*., 2018), sugar and starch creation, protein synthesis and cell division, as well as maintaining the water condition within plant tissues (Pandey and Mahiwal, 2020). Mohamed (2017) resulted that application of 48 kg K_2O /fed. on wheat scored the highest values of chlorophyl content, plant height, plant dry weight/m^2, LAI, flag leaf area, number of spikes/m^2, spike length, number of grains/spikes, grain and straw yield (ton/ fed), weight of 1000-grain, harvest index and content of protein in grain. Ghazi *et al.,* (2021) revealed that the rate of 1500 mg L^{-1} K_2SiO_3 possessed the best performance of wheat plant parameters as plant height, chlorophyll content, spike weight (g), No. of grain/ spike^{-1}, 1000 grain weight (g) and grain yield (Mg h^{-1}) as well as N, P, K, protein and carbohydrates contents.

However, the purpose of this study is to reveal the compensation of Zinc deficiency by foliar spray and influence of various sources of K-fertilization on growth performance, yield and quality of wheat plant under salinity condition.

MATERIALS AND METHODS

A two-year field research trail was executed successfully during winter consecutive growing seasons of 2020/2021 and 2021/2022 at Tag El-Ezz Experimental Farm, Temi El-Amdid District, El-Dakahlia Governorate, Egypt. The study was pertaining to evaluation of two levels of zinc fertilizer as foliar spray and various sources of K-fertilization on the growth, yield and quality of wheat. Pre-sowing soil analysis values for two years of experiment depicted that texture of experimental soil was clay with pH 7.92 and electrical conductivity (EC) 5.67 dSm^{-1}, total soil organic matter (1.33%), available N, P, K and Zn was (39.46, 7.48, 215.34 and 1.74 mg kg^{-1}). Haluschak (2006) methods were used to determine the mechanical analysis. Reeuwijk (2002) was used to determine the amount of available N, P, K and Zn.

The experimental design was split-plot with three replicates, the treatments can be described as two concentrations of zinc foliar application (0, 300 mg L^{-1} Zn-EDETA12%) as the main plots and the sub plots involved the five sources of K-fertilization at the rate of i.e. 1- Without spraying (control treatment) , 2- K-sulphate (K_2SO_4), 3- K-humate, 4- K-silicate (K_2O_3Si) and 5- mono K-phosphate (KH_2PO_4) as foliar spray a rate of 2 g L^{-1} . The permanent field was prepared by ploughed twice and divided into plots of 12 m^2 (3X4 m). Each plot of the experimental site was fertilized by the rate of 150 kg fed^{-1} in the form of calcium super phosphate (6.76% P) during the preparation of soil. Nitrogen fertilizer in the form of ammonium nitrate at the rate of 100 kg fed^{-1} (33.5 % N) was applied in two equal doses at the first irrigation and the last at the second irrigation. The potassium fertilizer was sprayed in the different form of potassium in three times after 20, 40 and 60 days from planting. Zn was sprayed twice during 40 and 75 days (both of tillering and elongation growth stages).

In both growing seasons, grains of wheat plants (Triticum aestivum L, var Sakha 93) were obtained from the Ministry of Agriculture and Land Reclamation and sowed at a rate of 145 kg ha-1 in Mid of November and harvest in Mid of April.

Random samples of 10 wheat plants were taken after 90 days from wheat sowing from each sub-plot to determine the following parameters: plant height (cm), fresh and dry weight g plant^{-1}, and chlorophyll content (SPAD, value).

At harvest stage, from each sub-plot, random samples of ten wheat plants were taken to estimate wheat yield, its components and some qualitative traits as follows:

1. Yield and its components: No. of grain spike^{-1}, spike weight, weight of 1000 grains, grain yield, straw yield, biological yield ton h^{-1} and harvest index was computed as a ratio of grain yield to biological yield and given in percentage.
2. Nutrient status of wheat grains: the oven-dried wheat grains were ground then wet digested by a mixture of sulfuric, and perchloric acids (1:1) then the flowed nutrient was determined as N, P and K contents by using kjeldahl, spectrophotometer and flam photometer apparatus, respectively according to Mertens, (2005) while zinc determined by using Atomic absorption according to Khazaei *et al*., (2017).
3. Qualitative parameters of wheat grains: protein content in wheat grain was calculated by using the following formula: total carbohydrates (%) in wheat grain were determined according to (A.O.A.C, 2000), while protein % = (N) × 5.75 as described by (Anonymous, 1990).

Data of contributing parameters were recorded and statistically analyzed with the help of CoSTATE Computer Software according to Gomez and Gomez, (1984).

RESULTS AND DISCUSSION

Growth performance and chlorophyll content after 70 days from sowing:

Foliar application of zinc and variouse sources of K-fertilization affectd on plant height, fresh, dry weight and chlorophyll contenet as well as their interaction are presented at Table (1) after 70 days from sowing wheat plant during seasons of 2020-2021 and 2021-2022 under salinity condition.

The wheat plant sprayed with 300 mg L^{-1} Zn-EDTA significantly increased the plant height (cm), fresh and dry weight g plant^{-1}, and chlorophyll content (SPAD) over the untreated plants. The rate of increase over the control was (3.52, 9.84, 14.69, 6.93%) in the 1st season and (3.67, 9.79, 15.60 and 6.76%) in the second season for plant height (cm), fresh and dry weight g plant^{-1}, and chlorophyll content (SPAD), respectively.

Foliar application of different sources of potassium fertilization results a significant increase in plant height (cm), fresh and dry weight g plant^{-1}, and chlorophyll content (SPAD) during both seasons of the experiments in comparing to the untreated plants. The form of potassium humate was the best for increasing mentioned parameters with no significant effect with potassium silicate for plant height in the first season followed by foliar application with potassium silicate for other parameters during both seasons.

The interaction between foliar application with Zn and K-fertilization had significant effect on mentioned parameters in both seasons (Table 1). The highest mean values was indicated with tretamnt of 300 mg L^{-1} Zn-EDTA and 2 g L^{-1} potaasium humate.

The fact that Zn is known to have a vital role as a metal component of enzymes or as a functional, structural, or regulatory co-factor of a wide range of enzymes could explain the increase in growth characteristics of wheat plant under study as a result of Zn foliar spraying (Hotz and Braun, 2004). Zinc has a vital role in the generation of biomass wheat cultivar Sakha 94, according to (El-Dahshouri *et al.,* 2017).

Table 1. Effect of foliar application with Zn and different forms of K-fertilization on growth parameters and chlorophyll content of wheat during 2020-2021 and 2021-2022.

Treatments		Plant highet g/plant		Fresh weight g/plant		Dry weight g/plant		Chorophyll SPAD	
		2020-2021	2021-2022	2020-2021	2021-2022	2020-2021	2021-2022	2020-2021	2021-2022
Zinc levels									
No application		67.14b	71.06b	35.08b	37.40b	10.28b	10.83b	36.22b	37.42b
300 mg L^{-1} Zn-EDTA		69.51a	73.67a	38.53a	41.06a	11.79a	12.52a	38.73a	39.95a
LSD at 5%		0.18	0.11	0.58	0.13	0.12	0.18	0.60	0.61
K- ferilization sources (2 g L^{-1})									
Without		65.59c	69.16d	32.82e	35.09e	9.32e	9.85e	34.45e	35.59e
K-sulphate		68.03b	72.39c	36.27d	38.71d	10.81d	11.51d	37.13d	38.34d
K-humate		69.92a	73.98a	39.36a	41.73a	12.11a	12.83a	39.33a	40.61a
K-silicate		69.39a	73.50ab	38.25b	40.79b	11.68b	12.41b	38.57b	39.87b
Mono K-phosphate		68.69ab	72.82bc	37.33c	39.84c	11.26c	11.78c	37.90c	39.02c
LSD at 5%		1.23	1.02	0.63	0.73	0.15	0.24	0.63	0.65
Interaction									
No application	Without	65.18h	68.64f	32.27j	34.51g	9.08j	9.57i	34.09i	35.27h
	K-sulphate	66.71fgh	70.99de	34.27h	36.65f	9.94h	10.59g	35.64gh	36.90g
	K-humate	68.57cde	72.32cd	37.35e	39.55d	11.22e	11.86e	37.87de	39.15de
	K-silicate	67.95def	71.96d	36.21f	38.51e	10.83f	11.49f	37.09ef	38.31ef
	Mono K-phosphate	67.29efg	71.41de	35.30g	37.80e	10.35g	10.66g	36.41fg	37.46fg
300 mg L^{-1} Zn-EDTA	Without	65.99gh	69.67ef	33.37i	35.67f	9.57i	10.13h	34.81hi	35.92h
	K-sulphate	69.35bcd	73.78bc	38.27d	40.78c	11.68d	12.44d	38.61cd	39.78cd
	K-humate	71.28a	75.64a	41.38a	43.90a	12.99a	13.79a	40.78a	42.06a
	K-silicate	70.82ab	75.04ab	40.28b	43.08a	12.53b	13.34b	40.06ab	41.42ab
	Mono K-phosphate	70.09abc	74.23ab	39.35c	41.89b	12.16c	12.89c	39.39bc	40.57bc
LSD at 5%		1.75	1.75	0.89	1.03	0.21	0.34	0.89	0.92

The application of potassium humate and potassiume silicate were the most effective on growth parameters and chlorophyll content, this could be due to the role of potassium in plant tissue is crucial to the proper functioning of several important biochemical and physiological processes that directly determine crop productivity, including improved nutrient mobilization, increased nitrogen metabolism, carbohydrates metabolism, enzyme activity, tissue growth, and then improved translocation of assimilates and thus improved crop productivity (Mohamed, 2017). Also, the fact that humic compounds may have anti-stress properties under abiotic stress circumstances, allowing them to promote nutrient uptake while reducing toxic element uptake, resulting in improved wheat plant growth. Under moderate salinity circumstances, the protective impact of humic compounds was attributed to an increase in cell membrane permeability, oxygen, photosynthesis, respiration and phosphorus uptake, as well as supplying root cell proliferation (Pizzeghello *et al*., 2013). Additionaaly the increase in chlorophyll due to K-humate may be attributed to the role of humic acid as a growth regulator that promotes plant development processes as indicated by Salem *et al*., (2017) on wheat plant under salinity condition. Furthermore, silicon's enhancing effect could be linked to the antioxidant defence system's activation or their protective effect on photosynthetic pigments in salt-stressed plants (Ashraf *et al*,. 2010).

Yield and its components:

1.No. of grain spike^{-1}, spike weight and weight of 1000 grain of wheat:

Data presented in Table 2 show the effect of zinc and variouse source of K-fertilization in foliar way as well as their interaction on No. of grain spike^{-1}, spike weight and weight of 1000 grain during seasons of 2020-2021 and 2021-2022 under salinity condition.

Data of Tables 2 show that wheat plants sprayed with 300 mg L-1 Zn-EDTA possesed the heighest values of No. of grain spike-1, spike weight and weight of 1000 grain over the untreated plants during both seasons of the experiments.

Regarding the foliar application with different forms of potassium fertilization at the rate of 2 g L^{-1} in Tables 2 on wheat plant (No. of grain spike^{-1}, spike weight and weight of 1000 grain). The form of potassium silicate was the best for recording an increase in No. of grain spike^{-1}, spike weight and weight of 1000 grain followed by potassium humate in both seasons.

The interaction effect of foliar application with Zn and different forms of potassium on wheat plant significantly affected the No. of grain spike^{-1}, spike weight and weight of 1000 grain. All forms of potassium under Zn as foliar application increased the mentioned parameters and only foliar spray of Zn-EDTA and form of potassium silicate recorded the highest values of No. of grain spike^{-1}, spike weight and weight of 1000 grain during both seasons.

2.Grain yield, straw yield, biological yield ton h^{-1} and harvest index of wheat:

The response of yield criteria of wheat (grain yield, straw yield, biological yield ton h^{-1} and harvest index) at harvest to the foliar application of zinc and variouse source of K-fertilization as well as thier interaction shown in Table 3.

The data regarding grain yield, straw yield, biological yield ton h^{-1} and harvest index (Table 3) indicated a significant difference between treatments of Zn foliar application. The presence of Zn foliar application at 300 mg L^{-1} Zn-EDTA increased grain yield, straw yield, biological yield ton h^{-1} and harvest index comparing to the absence of foliar application with Zn (control).

Table 2. Effect of foliar application with Zn and different forms of K-fertilization on No. of grain spike^{-1}, spike weight and weight of 1000 grain of wheat during 2020-2021 and 2021-2022.

Treatments		No. of grain/spike		Spike weight g		Weight of 1000 grain g	
		2020-2021	2021-2022	2020-2021	2021-2022	2020-2021	2021-2022
		Zinc levels					
No application		42.13b	44.07b	3.90b	4.13b	37.90b	39.04b
300 mg L^{-1} Zn-EDTA		49.87a	51.20a	4.94a	5.25a	40.34a	41.76a
LSD $_{at\ 5\%}$		4.23	5.98	0.33	0.01	0.41	0.13
		K- ferilization sources (2 g L^{-1})					
Without		36.50d	38.17c	3.46c	3.64e	36.19e	37.40e
K-sulphate		44.83c	46.67b	4.39b	4.69d	38.77d	40.09d
K-humate		49.83ab	51.67a	4.53b	4.78c	40.27b	41.51b
K-silicate		51.50a	53.33a	5.11a	5.43a	40.90a	42.28a
Mono K-phosphate		47.33bc	48.33b	4.61c	4.89b	39.47c	40.73c
LSD $_{at\ 5\%}$		2.63	2.19	0.24a	0.08	0.54	0.22
		Interaction					
No application	Without	34.67h	36.33g	3.27g	3.43i	35.80g	36.94j
	K-sulphate	40.00fg	42.33ef	3.86ef	4.13g	37.28ef	38.37h
	K-humate	45.67e	47.67cd	3.69f	3.88h	38.88d	40.02f
	K-silicate	47.00de	49.33bc	4.60d	4.88e	39.49d	40.78e
	Mono K-phosphate	43.33ef	44.67de	4.06e	4.32f	38.03e	39.10g
300 mg L^{-1} Zn-EDTA	Without	38.33gh	40.00f	3.64f	3.85h	36.57f	37.85i
	K-sulphate	49.67cd	51.00b	4.93cd	5.25d	40.26c	41.80d
	K-humate	54.00ab	55.67a	5.36ab	5.68b	41.66ab	43.00b
	K-silicate	56.00a	57.33a	5.63a	5.99a	42.31a	43.78a
	Mono K-phosphate	51.33bc	52.00b	5.16bc	5.46c	40.90bc	42.36c
LSD $_{at\ 5\%}$		3.73	3.10	0.34	0.11	0.76	0.31

Data presented in the same table indicated that all foliar fertilizer spraying with potassium fertilization forms significantly increased grain yield, straw yield, biological yield ton h^{-1} and harvest index. Data also show that foliar application with potassium silicate followed by potassium humate gave the greatest mean values for all the above-mentioned characters, meanwhile untreated plants gave the lowest one. The same trend was true during both seasons.

Statistical analysis of data in Table 3 shows the interaction effect between treatments of K-fertilization forms under absence and presence of Zn application in foliar way. The present study indicated that under foliar application of zinc with foliar spray with different form of potassium fertilization a significant increase was happened in grain yield, straw yield, biological yield ton h^{-1} and harvest index, in this respect the highest mean values of parameters realized with foliar application of potassium silicate followed by potassium humate in presence in Zn-EDTA comparing to the untreated plant in both seasons.

The response of wheat crop to foliar application of zinc, in terms of No. of grain spike^{-1}, spike weight, weight of 1000 grain, grain yield, straw yield, biological yield ton h^{-1} and harvest index seems to be positive. Zn has a role in a variety of metabolic processes, including glucose metabolism, chlorophyll production, and ribosomal activity (Zulfiqar *et al*., 2020). On the other hand, foliar Zn is quickly absorbed by the leaf epidermis, remobilized, and subsequently translocated into the grain via phloem with the help of Zn-regulating transporter proteins (Li *et al*,. 2014). Foliar application of zinc increased grain wheat yield, which improved productivity. The increased grain yield is due to enhanced plant physiology with the addition of Zn, which corrects the efficiency of various enzymes, chlorophyll content, IAA hormone, thermo-tolerance and water use efficiency and nitrate conversion to ammonia in the plant, resulting in higher yields (Firdous *et al.,* 2018).

The results obtained in the present investigation concerning the effect of K-fertilization application in foliar way in various forms a significant increase on No. of grain spike^{-1}, spike weight, weight of 1000 grain, grain yield, straw yield, biological yield ton h^{-1} and harvest index especially with foliar application by potassium silicate followed by potassium humate under salinity condition. This could be due to the rapid chemical potassium uptake by wheat leaves, as well as the role of potassium in seed development, nitrogen metabolism, carbohydrates metabolism, enzyme activity, translocation of photosynthates and sugar, tissue growth, protein synthesis, crop quality, and improved vegetative growth in wheat plants, all of which contribute to increased yield and its components (Mohamed, 2017). The beneficial effects of potassium silicate as a foliar spray application may be attributed to its ability to increase leaf water potential, nutrient bioavailability, antioxidant levels, elevated growth hormones and regulators, increase photosynthesis, reduce transpiration, increase energy compound, improve cell membrane stability, and encourage cell division and elongation. Potassium silicate ensures a high nutritional content, which results in high levels of gibberellic Acid (GA3) and indole acetic acid (IAA), which promote cell division and elongation of the panicle axel, resulting in a lengthy panicle. Furthermore, silica stimulates the release of copious abscisic acid (ABA), which reduces panicle peduncle elongation and division, inhibiting panicle exertion. Silica may increase IAA and GA3 production while decreasing ABA production. The current findings are in a good agreement with those reported by Wissa (2017) and Aurangzaib *et al*., (2021). The results also obtained in the present investigation concerning the effect of K-humate, the favorable effects of humic acids on yield components could be attributed to increased amounts of endogenous cytokinin and auxins, which would likely lead to higher yields (Salem *et al.*, 2017).

Table 3. Effect of foliar application with Zn and different forms of K-fertilization on grain yield, straw yield, biological yield ton h^{-1} and harvest index of wheat during 2020-2021 and 2021-2022.

Treatments		Grain yield (ton/hectare)		straw yield (ton/hectare)		Biological yield (ton/hectare)		Harvest index %	
		2020-2021	2021-2022	2020-2021	2021-2022	2020-2021	2021-2022	2020-2021	2021-2022
				Zinc levels					
No application		4.73b	4.87b	7.94b	8.18b	12.67b	13.05b	37.27b	37.26b
300 mg L^{-1} Zn-EDTA		5.40a	5.59a	8.48a	8.78a	13.88a	14.36a	38.82a	38.81a
LSD at 5%		0.04	0.02	0.24	0.04	0.28	0.05	0.44	0.06
				K- ferilization sources (2 g L^{-1})					
Without		4.31e	4.45e	7.61e	7.85d	11.91e	12.30e	36.17d	36.14e
K-sulphate		4.96d	5.13d	8.14d	8.43c	13.11d	13.56d	37.82c	37.79d
K-humate		5.33b	5.49b	8.42b	8.68b	13.76b	14.17b	38.73b	38.73b
K-silicate		5.55a	5.73a	8.59a	8.87a	14.14a	14.60a	39.23a	39.22a
Mono K-phosphate		5.15c	5.33c	8.29c	8.57bc	13.45c	13.89c	38.27bc	38.28c
LSD at 5%		0.09	0.10	0.11	0.16	0.15	0.26	0.47	0.02
				Interaction					
No application	Without	4.21j	4.33i	7.51h	7.74g	11.72j	12.08h	35.91i	35.88j
	K-sulphate	4.58h	4.71g	7.81fg	8.05ef	12.39h	12.75fg	36.94gh	36.90h
	K-humate	4.94f	5.08e	8.12e	8.35cd	13.05f	13.43e	37.82ef	37.82f
	K-silicate	5.17e	5.33d	8.30d	8.56c	13.47e	13.89d	38.40de	38.40e
	Mono K-phosphate	4.74g	4.88f	7.97ef	8.20de	12.71g	13.07ef	37.29fg	37.29g
300 mg L^{-1} Zn-EDTA	Without	4.41i	4.56h	7.70g	7.96fg	12.11i	12.52g	36.42hi	36.40i
	K-sulphate	5.35d	5.56c	8.48c	8.81b	13.83d	14.36c	38.70cd	38.68d
	K-humate	5.73b	5.91b	8.73ab	9.00ab	14.46b	14.91b	39.65ab	39.64b
	K-silicate	5.93a	6.13a	8.88a	9.18a	14.81a	15.31a	40.05a	40.04a
	Mono K-phosphate	5.57c	5.78b	8.61bc	8.94b	14.18c	14.71bc	39.26bc	39.26c
LSD at 5%		0.12	0.14	0.16	0.23	0.22	0.36	0.67	0.03

Nutrient status of wheat grains:

Nutrient status of wheat grain as N, P, K% and Zn ppm in relation with foliar application of Zn and different forms of potassium fertilization as well as their interaction under salinity conditions are presented in Table 4 during 2020/2021 and 2021/2022.

It is clear from the data in Table 4 that N, P, K% and Zn ppm in wheat grain gradually significantly affected by the foliar spray with Zn at the rate of 300 mg L^{-1} Zn-EDTA comparing in absence of Zn in untreated plants in the two seasons.

As for the effect of foliar application with different form of potassium on N, P, K% and Zn ppm in wheat grain, it was found a significant increase under all forms of potassium comparing to the control. The highest mean values of N, P, K% and Zn ppm in wheat grain was associated with foliar application by potassium silicate followed by potassium humate at the rate of 2 g L^{-1}. The same trend was true during both seasons.

Regarding the interaction effect of Zn and forms of K-fertilization on nutrient status of wheat grain as N, P, K% and Zn ppm, the obtained results in table 4 reveal that, all forms of potassium fertilization significantly increased the values of N, P, K% and Zn ppm in wheat grain. Additionally, foliar application of Zn increases the nutrient values. In this respect it was found that foliar application with potassium silicate in presence of Zn-EDTA scored the highest value of N, P, K% and Zn ppm in wheat grain.

Because micronutrients can improve macronutrient usage efficiency and result in sub-optimal nutrient use efficiency, Zn application is linked to plant tissue levels and mineral consumption (Brown *et al.*, 1993). The contents of N, P, K% and Zn ppm of the wheat grains may be increased due to the role of Zn in plant enzymes. It is also considered an essential element since it is found in a functional structural or regulatory cofactor in many enzymes and is required for protein synthesis, photosynthesis, auxin synthesis, and cell division. Zinc is also essential for the production of proteins, DNA and RNA. Firdous *et al.* (2018) reported that the use of a Zn foliar spray at the start of panicle development resulted in a two-fold increase in whole grain Zn content. Additionally, the highest Zn content was reported in wheat grains under foliar application of Zn (Mathpal *et al.*, 2015).

The increment in nutrient status of wheat grain as N, P, K% and Zn ppm as a result of potassium silicate as mentioned by Barker and Pilbeam (2007) illustrated that K+ is required to stimulate the ATPase plasmalemma, which creates the circumstances for metabolites such as amino acids and sucrose to exist. The use of potassium silicate affects the absorption and translocation of a variety of macronutrients (Das *et al*., 2017), as well as the osmotic adjustment, antioxidant enzyme (SOD and/or CAT) activities, and decreased H_2O_2 concentration in leaves, as well as the maintenance of the photosynthetic apparatus (Pilon *et al*., 2014). One of the most critical nutrients for plant growth is potassium. Many physiological activities rely on it, including photosynthesis, regulation of plant stomata and transpiration, control of ionic balance, activation of plant enzymes, and many more (Thompson, 2010). This could also point to the involvement of Si in improving nutrient absorption and metal ion compartmentation within plants (Liang *et al.*, 2007), as well as activating antioxidant enzymes (GPX, SOD, APX, GR and DHAR) in the leaves, which leads to the production of more metabolites (Zhu *et al*., 2004). Foliar feeding with varied nutrients improves root growth and nutrient transfer from leaves to roots and vice versa, promoting root absorption of the same components or nutrients through the spray (El-Fouly and El-Sayed, 1997). Ali *et al*., (2019) that K application influenced the yield attributes and grain content of K (Abd El-Hady *et al.*, 2021).

Table 4. Effect of foliar application with Zn and different forms of K-fertilization on nutrient status of wheat grains during 2020-2021 and 2021-2022.

Treatments		N%		P%		K%		Zn ppm	
		2020-2021	2021-2022	2020-2021	2021-2022	2020-2021	2021-2022	2020-2021	2021-2022
Zinc levels									
No application		2.01b	2.08b	0.195b	0.201	2.27b	2.49b	43.72b	45.17b
300 mg L^{-1} Zn-EDTA		2.19a	2.26a	0.217a	0.225	2.47a	2.71a	48.81a	50.36a
LSD $_{at\ 5\%}$		0.04	0.04	0.002	0.001	0.09	0.04	0.44	0.17
K- ferilization sources (2 g L^{-1})									
Without		1.91d	1.98d	0.179e	0.185d	2.12e	2.33e	40.12e	41.45e
K-sulphate		2.08c	2.15c	0.203d	0.210c	2.34d	2.57d	45.45d	46.94d
K-humate		2.15b	2.22b	0.216b	0.222b	2.46b	2.69b	48.60b	50.18b
K-silicate		2.22a	2.30a	0.223a	0.230a	2.52a	2.77a	50.12a	51.80a
Mono K-phosphate		2.14b	2.20b	0.211c	0.218b	2.40c	2.64c	47.06c	48.45c
LSD $_{at\ 5\%}$		0.04	0.04	0.004	0.004	0.04	0.04	0.79	0.88
Interaction									
No application	Without	1.89h	1.96h	0.175g	0.181g	2.08g	2.29g	39.39j	40.75j
	K-sulphate	1.98fg	2.04fg	0.190f	0.195f	2.23e	2.46e	42.47h	43.97h
	K-humate	2.03ef	2.10e	0.203de	0.208e	2.34d	2.56d	45.62f	47.16f
	K-silicate	2.13d	2.20d	0.210cd	0.216d	2.41c	2.64c	47.09e	48.64e
	Mono K-phosphate	2.04e	2.10ef	0.198e	0.204e	2.28e	2.51de	44.04g	45.32g
300 mg L^{-1} Zn-EDTA	Without	1.94gh	2.00gh	0.183f	0.190f	2.16f	2.38f	40.85i	42.14i
	K-sulphate	2.19c	2.26c	0.216c	0.224c	2.46c	2.69c	48.43d	49.90d
	K-humate	2.27ab	2.34ab	0.229b	0.236b	2.57b	2.82b	51.57b	53.19b
	K-silicate	2.31a	2.39a	0.236a	0.244a	2.63a	2.90a	53.14a	54.96a
	Mono K-phosphate	2.24bc	2.31bc	0.224b	0.232b	2.53b	2.77b	50.07c	51.58c
LSD $_{at\ 5\%}$		0.06	0.05	0.006	0.006	0.05	0.06	1.12	1.25

Qualitative parameters of wheat grains:

Total carbohydrate and protein % in wheat grain as affected by foliar application of Zn and different forms of potassium fertilization as well as their interaction under salinity conditions are presented in Table 5 during 2020/2021 and 2021/2022.

Table 5. Effect of foliar application with Zn and different forms of K-fertilization on total carbohydrate and protein% of wheat grains during 2020-2021 and 2021-2022.

Treatments		Total carbohydrates %		Protein %	
		2020-2021	2021-2022	2020-2021	2021-2022
Zinc levels					
No application		62.06b	64.21b	11.57b	11.96b
300 mg L^{-1} Zn-EDTA		64.88a	66.96a	12.58a	12.98a
LSD $_{at\ 5\%}$		2.61	0.49	0.23	0.23
K- ferilization sources (2 g L^{-1})					
Without		60.15d	62.36e	11.00d	11.37d
K-sulphate		63.01c	65.08d	11.98c	12.37c
K-humate		64.77a	66.91b	12.35b	12.77b
K-silicate		65.51a	67.75a	12.76a	13.20a
Mono K-phosphate		63.91b	65.84c	12.29b	12.66b
LSD $_{at\ 5\%}$		0.85	0.37	0.24	0.22
Interaction					
No application	Without	59.70i	62.18i	10.85h	11.25h
	K-sulphate	61.36gh	63.49h	11.37fg	11.75fg
	K-humate	63.22ef	65.34f	11.67ef	12.09e
	K-silicate	63.85de	66.02e	12.23d	12.67d
	Mono K-phosphate	62.16fg	64.03g	11.71e	12.06ef
300 mg L^{-1} Zn-EDTA	Without	60.61hi	62.54i	11.16gh	11.48gh
	K-sulphate	64.66cd	66.66d	12.59c	13.00c
	K-humate	66.33ab	68.47b	13.03ab	13.46ab
	K-silicate	67.16a	69.49a	13.28a	13.72a
	Mono K-phosphate	65.65bc	67.65c	12.86bc	13.26bc
LSD $_{at\ 5\%}$		1.20	0.52	0.33	0.31

The effect of Zn as foliar spray on concentration of total carbohydrate and protein of wheat grain are presented in Table 5. Application of Zn-EDTA significantly increased the content of total carbohydrate and protein in wheat grain.

The highest mean values indicated with presence of Zn-EDTA at the rate of 300 mg L^{-1} comparing to the absence of Zn (untreated plants) during two seasons.

Total carbohydrate and protein content in wheat grain in relation to the different forms of K-fertilization in foliar way was illustrated in Table 5. All forms of K-fertilization increased content of total carbohydrate and protein% comparing to the untreated plants, however the highest mean values recorded with foliar application by potassium silicate followed by potassium humate with no significant effect in the first season in content of carbohydrate during both seasons.

The results in the same table show the interaction effect between all treatments under investigation. Generally, the forms of K-fertilization increased content of total carbohydrate and protein% in presence of Zn-EDTA comparing with the forms in absence of Zn. The highest mean values associated with foliar application of potassium silicate under Zn-EDTA at 300 mg L^{-1}.

Zn is an essential nutrient for N metabolism because of its catalytic influence on multiple enzyme systems and biochemical activities involved in nitrate reduction and protein synthesis (Akram *et al.,* 2017, Hasan *et al.,* 2017) they discovered a high link between N and Zn. Zinc foliar spray increased nitrogen uptake and protein quality, which improved the crop's development and yield components, according to (Shehla and Atif, 2019).

Under controlled settings, a significant increase in total carbohydrate and protein content of wheat grain was attained when it was treated with K-silicate followed by K-humate at a rate of 2 g L^{-1} as a foliar application under saline conditions. These findings could be due to potassium's ability to improve nitrogen compound translocation to grains, which has a positive impact on grain protein. Additionally, potassium activates a number of enzymes involved in carbohydrate metabolism, protein synthesis, particularly protein and sugar production, as well as photosynthesis, which aids in the translocation of carbohydrates from leaves to grains as mentioned by Mohamed (2017). Natural humic acids, which have been found to enhance protein synthesis and activity, can be used as an ecological alternative to increase plant drought resistance (Muscolo *et al.,* 2007). Humic acids fulfil this role in plants via a phytohormonal mechanism, and several studies have shown that it can significantly increase H+ATPase activity (Dobbs *et al.,* 2010). Similar results were also reported by Salem *et al.* (2017).

CONCLUSION

The majority of the important outcomes in the current wheat experiment found enhance the growth parameters, chemical content, yield and its component were obtained with presence of Zn-EDTA and foliar application with various K-fertilization counteracted the adverse effect of Zn deficiency soil salinity and on the yield, especially at later stages of growth and help the plants grow successfully under Abiotic Stress . According to the results of the experiment, foliar application with both of potassium silicate and potassium humate at the rate of 2 g L^{-1} in presence of Zn-EDTA at the rate of 300 mg L^{-1} gave the best grain yield compared to all other treatments

REFERENCE

A.O.A.C. (2000) “Official methods of Analysis” Twelfth Ed. Published by the Association of Official Analytical chemists,Benjamin, France line station,Washington. Dc.

Abd El-Hady, M. A. M.; S. M. A. Doklega and S. F. Abo El-Ezz (2021). Influence of organic and potassium fertilization on potato yield and quality. Plant Archives Vol. 21, Supplement 1: 560-568

Agricultural Research Institute of Economy. (2021). Personal communication. General administration of Agricultural sense, Agric. Res. Center - Ministry of Agric. Egypt.

Akram, M. A.; Depar, N. and Memon, M. Y. (2017). Synergistic use of nitrogen and zinc to bio-fortify zinc in wheat grains. Eurasian Journal of Soil Science,6 (4): 319-326. DOI: https://doi.org/ 10.18393/ejss. 306698Ali, I.:

Alloway, B.J. (2009). Soil factors associated with zinc deficiency in crops and humans. Environmental geochemistry and health, 31(5), 537-548.

Anonymous, (1990). "Official Methods of Analysis of the Association of Official Analytical Chemists". 15th Ed. Vol. 11. Helrich (Ed.) Assoc. off. Ana. Chemists. Inc., Virginia, USA.

Ashraf, M.; Afzal, R. M.; Ahmed, R.; Mujeed, F.; Sarwar, A. and Ali, L. (2010). Alleviation of determintal effects of NaCl by silicon nutrition in salt-sensitive and salt-tolerant genotypes of sugarcane (*Saccharum officinarum* L.). Plant and Soil, 326(1), 381-391.

Aurangzaib, M.; Ahmad, Z.; Jalil, M. I.; Nawaz, M. F.; Shaheen, M. R.; Ahmad, M.; Hussain, A.; Ejaz, M. K. and Tabassum, M. A. (2021). Exogenous application of silicon can help augment drought tolerance in wheat (*Triticum aestivum* L.) by enhancing morpho-physiological and antioxidant potential. Research square, 1-21. DOI: https:// doi.org/ 10.21203/rs.3.rs-276853/v1.

Barker, A. V and Pilbeam, D. I. (2007). Handbook of Plant Nutrition. by Taylor & Francis Group, LLC CRC Press is an imprint of Taylor & Francis Group, an Informa business pp: 244.

Brown, P. H.; Cakmak, I. and Zhang, Q. (1993). Form and function of zinc plants. In Zinc in soils and plants (pp. 93-106). Springer, Dordrecht.

Bukshs, M.A.; Ahmad, R.; Iqbal, J.; Maqbool, M.; Ali, A. and Ishaque, M. (2012). Nutritional and physiological significance of potassium application in maize hybrid crop production. Pakistan Journal of Nutrition, 11 (2): 187- 202.

Cakmak, I. (2000). Tansley Review No. 111 Possible roles of zinc in protecting plant cells from damage by reactive oxygen species. *The New Phytologist*, *146*(2), 185-205.

Chattha, M. U.; Hassan, M. U.; Khan, I.; Chattha, M. B.; Mahmood, A.; Chattha, M. U.; Nawaz, M.; Subhani, M. N.; Kharal, M. and Khan, S. (2017). Biofortification of wheat cultivars to combat zinc deficiency. Frontiers in Plant Science. 8:281. DOI:http: //doi: 10.3389/fpls. 00281.

Das, K. K.; Swamy, G. S.; Biswas, D. and Chnaniya, K. K. (2017). Response of soil application of diatomaceous earth as a source of silicon on leaf nutrient status of guava. Int. J. Curr. Microbiol. App. Sci., 6 (4): 1394- 1399.

Dobbs, L.; Canellas, L. P.; Olivares, F. L.; Aguiar, N. O.; Peres, L. E. P.; Spaccini, R. and Piccolo, A. (2010). Bioactivity of chemically transformed humic matter from vermicompost on plant root growth. Journal of Agricultural and Food Chemistry, 58(6), 3681-3688. DOI:https://doi.org/10.1021/jf904385c. Economic Affairs Sector (2017). Area, yield and production of winter crops. Ministry of Agricultural, Egypt.

El-Agrodi, M., EL-Shebiny, G., Mosa, A., & El-sherpiny, M. (2016). Maize tolerance to different levels of boron and salinity in irrigation water. *Journal of Soil Sciences and Agricultural Engineering*, *7*(1), 35-44.

El-Dahshouri. M. F.; El-Fouly, M. M.; Khalifa R. Kh. M. and Abd El-Ghany, H. M. (2017). Effect of zinc foliar application at different physiological growth stages on yield and quality of wheat under sandy soil conditions. Agricultural Engineering International: CIGR Journal, 193-200.

El-Fouly, M. M. and El-Sayed, A. A. (1997). Foliar fertilization: An environmentally friendly application of fertilizers. In Dahlia Greidinger International Symposium on" Fertilization and Environment (pp. 24-27).

El-Lethy, Safaa R.; Abdelhamid, M. T. and Reda, Fatma (2013). Effect of potassium application on wheat (*Triticum aestivum* L.) cultivars grown under salinity stress. World Applied Sciences Journal 26 (7): 840-850. DOI: 10.5829/idosi.wasj.2013.26.07.13527

Firdous, S.; Agarwal, B. K. and Chhabra, V. (2018). Zinc-fertilization effects on wheat yield and yield components. Journal of Pharmacognosy and Phytochemistry, 7(2): 3497-3499.

Ghazi, D. A., El-Sherpiny, M. A. and Elmahdy, S. M. (2021). Effect of Soil Amendments and Foliar Application of Potassium Silicate on Wheat Plants Grown under Sodicity Conditions. Journal of Soil Sciences and Agricultural Engineering, Mansoura Univ., 12 (6):409 – 416. DOI: 10.21608 / JSSAE.2021.177775

Gomez, K. A. and Gomez, A. A. (1984). “Statistical procedures for agricultural research”. John Wiley and Sons, Inc., New York. pp:680.

Hacisalihoglu, G. (2020). Zinc (Zn): The last nutrient in the alphabet and shedding light on Zn efficiency for the future of crop production under suboptimal Zn. Plants, 9 (11): 1471.

Haluschak, P. (2006). Laboratory Methods of Soil Analysis. Canada-Manitoba Soil Survey ,3-133..

Hasan, M. K.; Cheng, Y.; Kanwar, M. K.; Chu, X-Y.; Ahammed, G. J. and Qi, Z-Y. (2017). Responses of plant proteins to heavy metal stress—a review. Frontiers in plant science, 8:1492. DOI :https :// doi.org/10.3389/fpls.2017.01492

Hasanuzzaman, M.; Bhuyan, M. H. M. B.; Nahar, K.; Hossain, M. S.; Mahmud, J. A.; Hossen, M. S.; Moumita, A. A. C. M. and Fujitai, M. (2018). Potassium, a vital regulator of plant responses and tolerance to abiotic stresses. Agronomy, 8 (3): 31-38.

Hotz, C., and Braun, K. H. (2004). Assessment of the risk of zinc deficiency in populations and options for its control. Food and Nutrition Bulletin, 2: 194–204.

Kasim, W.; Hafez, T. M. and SaadAlla, K. M. (2020). Yeast extract and lithovit mineral fertilizer ameliorate the harmful effects of drought stress in wheat. Egyptian Journal of Botany, 60 (3): 889-903.

Khan, A. A.; Munsif, F.; He, L.; Khan, A.; Ullah, S.; Saeed, W.; Iqbal, A.; Adnan, M. and Ligeng, J. (2019). Optimizing rates and application time of potassium fertilizer for improving growth, grain nutrients content and yield of wheat crop. Open Agriculture,4 (1) : 500-508. DOI:https://doi.org/10.1515/opag-2019-0049.

Khazaei, H.; Podder, R.; Caron, C. T.; Kundu, S. S.; Diapari, M.; Vandenberg, A. and Bett, K. E. (2017). Marker–Trait Association Analysis of Iron and Zinc Concentration in Lentil (*Lens culinaris*Medik.) Seeds. The plant genome, 10(2), plantgenome2017-02. DOI: https:// doi.org/ 10.3835/ plantgenome 2017.02.0007

Li, M.; Yang, X. W.; Tian, X. H.; Wang, S. X.; Chen, Y. L. (2014). Effect of nitrogen fertilizer and foliar zinc application at different growth stages on zinc translocation and utilization efficiency in winter wheat. Cereal Research Communications, 42(1), 81-90. DOI: https://doi.org/10.1556/crc.2013.0042

Liang, Y.; Sun, W. and Christie, P. (2007). Mechanisms of silicon-mediated alleviation of abiotic stresses in higher plants: A review. Environmental pollution, 147 (2): 422-428. DOI :https:// doi.org/ 10.1016/j.envpol.2006.06.008

Mathpal, B.; Srivastava, P. C.; Shankhdhar, D. and Shankhdhar, S. C. (2015). Zinc enrichment in wheat genotypes under various methods of zinc application. Plant, Soil and Environment, 61(4): 171-175. DOI:https://doi: 10.17221/41/2015-PSE

Mengel, K. and Kirkby, E. A. (1987). Principles of Plant Nutrition. 3rd Edition. International Potash Institute, 687-695.Mertens, D., (2005). AOAC official method 922.02. Plants preparation of laboratory sample. Official methods of analysis, 18thedn. North Frederick Avenue, Gaitherburg, Maryland, pp.1-2.

Mohamed, A. A. A. (2017). Effect of potassium and nitrogen levels on productivity of seeds 12 wheat cultivar under Delta North condition. Journal of Plant Production,Mansoura Univ., 8 (2): 347 – 352. DOI: 10.21608/JPP.2017.39634

Muscolo, A.; Sidari, M.; Attiná, E.; Francois, O.; Tugnoli, V. and Nardi, S. (2007). Biological activity of humic substances is related to their chemical structure. Soil Science Society of America Journal, 71(1), 75-85. DOI:https://doi.org/10.2136/sssaj2006.0055

Ning, P.; Wang, S.; Fei, P.; Zhang, X.; Dong, J.; Shi, J. and Tian, X. (2019). Enhancing zinc accumulation and bioavailability in wheat grains by integrated zinc and pesticide application. Agronomy, 9(9), 530. DOI:https://doi.org/10.3390/agronomy9090530

Pandey, G. K and Mahiwal, S. (2020). Role of Potassium in Plants. Springer.

Pilon, C.; Soratto, R. P.; Broetto, F. and Fernandes, A. M. (2014). Foliar or Soil Applications of Silicon Alleviate Water-Deficit Stress of Potato Plants. Agronomy Journal, 106(6), 2325-2334. DOI:https://doi.org/10.2134/agronj14.0176

Pizzeghello, D.; Francioso, O.; Ertani, A.; Muscolo, A. and Nardi, S. (2013). Isopentenyladenosine and cytokinin-like activity of different humic substances. Journal of Geochemical Exploration,129: 70- 75. DOI:https://doi.org/10.1016/j.gexplo.2012.10.007

Reeuwijk, L. P. (2002). Procedures for Soil Analysis. Inter. Soil Ref. and Info. Center. Food and Agric. Organization of the United Nations.

Salem, Hanaa M.; Abo-Setta, Yossria; Aiad, M. A.; Hussein, Hebat-Allah A. and El-Awady, Rasha A. (2017). Effect of potassium humate on some metabolic products of wheat plants grown under saline conditions. Journal of Soil Sciences and Agricultural Engineering, Mansoura Univ., 8 (11): 565 – 569. DOI:https://doi.org/10.1080/01904167.2019.167690 7Salim, N and Raza, A. (2020). Nutrient use efficiency (NUE) for sustainable wheat production: a review. Journal of Plant Nutrition, 43 (2): 297-315.

Sattar, A.; Wang, X.; UlAllah, S.; Sher, A.; Ijaz, M.; Irfan, M.; Abbas, T.; Hussain, S.; Nawaz, F.; Al-Hashimi, A.; Al Munqedhi, B. M. and Skalicky, M. (2022) . Foliar application of zinc improves morpho-physiological and antioxidant defense mechanisms, and agronomic grain biofortification of wheat (*Triticum aestivum* L.) under water stress. Saudi Journal of Biological Sciences, 29 (3): 1699-1706. DOI:https://doi.org/10.1016/j.sjbs.2021.10.061

Shehla, N. and Atif, K. (2019). Foliar application of zinc sulphate to improve yield and grain zinc content in wheat (*Triticum aestivum* L.). African Journal of Agricultural Research, 14 (20): 867-876. DOI: 10.5897/AJAR2018.13593

Thompson, B. (2010). Efficient fertilizer Use-Potassium (1st edition Ed.). New York: John Willy and sons.

Weisany, W.; Sohrabi, Y.; Heidari, G.; Siosemardeh, A. and Badakhshan, H. (2014). Effects of zinc application on growth, absorption and distribution of mineral nutrients under salinity stress in soybean (Glycine max L.). *Journal of plant nutrition*, *37*(14), 2255-2269. DOI: https :// doi.org/ 10.1080/ 01904167 .2014.920386

Welch, R. M., and Graham, R. D. (2005). Agriculture: the real nexus for enhancing bioavailable micronutrients in food crops. Journal of Trace Elements in Medicine and Biology, 18(4): 299-307. DOI :https: //doi.org /10.1371/journal.pone.0050568

Wessels, K. R.; Brown, K. H. (2012). Estimating the global prevalence of zinc deficiency: Results based on zinc availability in national foods supplies and prevalence of stunting. PloS one, 7(11), e50568. DOI :https:/ /doi.org/10.1371/journal.pone.0050568 Wissa, Mariam T. (2017). Impact of potassium silicate compound as foliar application on the growth, yield and grains quality of GIZA 179 Rice Cultivar. *Journal of Plant Production*, Mansoura Univ., 8 (11): 1077 – 1083. DOI : 10.21608/ JPP.2017.41115

Zhu, Z.; Wei, G.; LI, J.; Qian, Q. and Yu, J. (2004). Silicon alleviates salt stress and increases antioxidant enzymes activity in leaves of salt-stressed cucumber (*Cucumis sativus* L.). Plant Science,167 (3): 527-533. https://doi.org/10.1016/j.plantsci.2004.04.020

Zulfiqar, U.; Hussain, S.; Ishfaq, M.; Matloob, A.; Ali, N.; Ahmad, M.; Alyemeni, M. N. and Ahmad, P. (2020). Zinc-induced effects on productivity, zinc use efficiency, and grain biofortification of bread wheat under different tillage permutations. Agronomy, 10 (10): 1566. DOI:https:// doi.org/ 10.3390 / agronomy10101566

الإضافات الخارجيه للزنك و البوتاسيوم لتخفيف التأثير الملحى على نبات القمح

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معهد بحوث الأراضى والمياه و البيئه – قسم تغذية النبات – مركز البحوث الزراعيه – الجيزه

الملخص

يعتبر الرش الورقي إستراتيجية زراعية محتملة لأنها تتضمن الامتصاص المباشر وتحميل العناصر الغذائية من سطح الورقة إلى اللحاء في فترة زمنية قصيرة وبكمية أقل نسبيا من التطبيقات الأرضية. البوتاسيوم والزنك عنصران أساسيان لازمان لنمو النبات، التمثيل الغذائي وتطوره واللذان يلعبان دورا محوريا في تكيف النبات وتحمل الاجهاد الملحي. الهدف من الدراسة هو تقييم تأثير الرش الورقى بالزنك و الصوره المناسبه من التسميد البوتاسي على تحسين النمو و مكونات المحصول لنبات القمح صنف سخا 93 تحت ظروف الملوحه. يمكن وصف المعاملات كالتالى الرش الورقى لتركيزين من الزنك (بدون، 300 ملجم/لتر زنك ايديتا) كقطع رئيسيه، والقطع تحت الرئيسية تتضمن خمسة مصادر مختلفه من التسميد البوتاسي وهم : 1- بدون رش (معاملة الكنترول) ، 2- كبريتات بوتاسيوم، 3-هيومات بوتاسيوم، 4-سليكات بوتاسيوم، 5- فوسفات أحادي البوتاسيوم)كرش ورقي. أظهرت النتائج أن أداء النمو ومحتوى الكلوروفيل والمحصول ومكوناته والحالة الغذائية لحبوب القمح وكذلك الكربوهيدرات الكلية والبروتين معنوية والسبب الرش الورقى بالزنك فى صوره إيديتا. علاوة علي ذلك، وجد أن الرش الورقى بسليكات البوتاسيوم و هيومات البوتاسيوم كانت أكثر الصور فاعليه فى زياده الصفات المذكورة تحت ظروف ملوحة التربه. وبناءا علي ذلك، تم التوصل بأن الرش الورقى بسليكات أو هيومات البوتاسيوم فى وجود الزنك كان أفضل المعاملات لتحقيق محصول أعلى من القمح تحت الاجهاد الملحي.