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Performance of Wheat Plants in Sandy Soil as Affected by Foliar Spray of Potassium and Zinc and their combination

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Abstract : Two field experiments were conducted during the two successive winter seasons of 2012/2013 and 2013/2014 in Research and Production Station, National Research Centre, Al-Nubaria District, Al Behaira Governorate, Egypt to study the effect of foliar spraying of zinc and potassium on growth, yield and yield components and some chemical constituents of wheat plants grown under sandy soil condition. This experiment includes six treatments which were control (without K and Zn), foliar spraying with K (10000 ppm), Zn (500& 1000 ppm), K (10000 ppm) + Zn(500 ppm) and foliar spray with K (10000 ppm) +Zn(1000 ppm). Results revealed that foliar spraying with either K or Zn significantly increased growth parameters, yield and yield components as well as nutrient concentration of wheat leaves, straw and grains as compared with unsprayed plants (control). However, the highest record obtained by the dual spraying of both zinc and potassium at high level of K (1000ppm) and Zn (1000 ppm).

Introduction

Wheat is cultivated in most of parts of the world. It is staple diet for majority of the population in both developed and developing countries. Wheat compares well with other important cereals in the nutritive value. It contains more protein than other cereals. Wheat plants (*Triticum aestivum,* L.) is considered the most important cereal crops in Egypt . It provides 37 % of the total calories for the people and 40 % of the protein in the Egyptian diet 1. Recently, a great attention of several investigators has been directed to increase the productivity of wheat especially in the new reclaimed sandy soil, to minimize the gap between the Egyptian production and consumption by increasing wheat production. Thus, to increase the quantity and yield per unit area a variety of factors such as proper and balanced dose of fertilization were suggested.

Potassium is a “work horse” plant nutrient because it is not bound into any plant compound. Therefore, potassium is free to move and deal within the plant almost. Thus, it can be explained that a shortage of potassium can result in loss of crop yield, quality and profitability. The role of macro nutrients K is very important for wheat production to achieve high yields[2].Potassium is effective in the synthesis and transport of carbohydrates and CO2 and is necessary for the formation of thick-walled cells. Potassium enhances product quality, and increases photosynthesis efficiency, increases plant resistance against some diseases. Potassium has essential functions in enzyme activation, regulation of clever pH, cation- anion balance, regulation of transpiration by stomata, and the transport of assimilates. It is well known that potassium has great effect on grain filling and kernel weight and in turn increase wheat yield[3].

Wheat is known to respond also to the application of several micronutrients during its growing stages and results in enhanced output in terms of yield. The studies have been shown that one of the

effective and productive way to improve cereal grains production is obtained by Zn fertilization to the soil or by foliar application. Micronutrient zinc, is essential as the major nutrients. Zinc was one of the first micronutrients, essentiality of which for plant growth has been confirmed. Zinc plays a role in nucleic acid and protein synthesis and helps in the utilization of phosphorus and nitrogen, as well as in seed formation[4]. Zinc is an important element for terrestrial life since it is required as either a structural component or reaction site in numerous proteins. Zinc (Zn) play a key role in pollination and seed set processes; so that its deficiency can cause to decrease in seed formation and subsequent yield reduction. The deficiency of Zinc may be resulted from decreasing availability of it by soil fixation. Thus, foliar spray of the micronutrients is more effective than soil application. Thereby foliar application of zinc resulted in increase in grain yield and protein percentage in the grains. Specially in wheat, improvement yield and yield components were affected by foliar application of zinc[5]. It was recently documented that zinc foliar application is a simple way for making quick correction of plant nutritional status, as reported for wheat [6].

Research studies indicate that ،K has benefit effect on Zinc nutrition7. Combination use of zinc and potash significant increase, grain yield and thousand grain weight. The positive role in enhancing the effects of zinc and K on yield and yield components of wheat reported by several investigators[8,9,10].

From the aforementioned results ,this study was carried out to study the effect of foliar nutrition of potassium and zinc on the growth, yield, yield component and grain quality of wheat under sandy soil condition.

Material and Methods:

Two field experiments were carried out at the Agricultural Production and Research Station, National Research Centre, Nubaria Province, Behaira Governorate, Egypt, during the two successive winter seasons of 2012/2013 and 2013/2014 to test the effect of foliar spray of potassium and zinc on growth and yield of wheat plants. This experiment include six treatments in three replicates which were control (without K and Zn), foliar spraying with potassium (K) (10000 ppm), as well as zinc (Zn) (500 & 1000 ppm), K (10000 ppm) + Zn (500 ppm)and K (10000 ppm) + Fe(1000 ppm).

Wheat variety Masry 1 was sown on 16th November in both seasons in sandy soil. The experimental area was subjected to laboratory analysis to determine some of its physical and chemical properties according to the method described by[11] in Table (1).

Table 1: Mechanical and chemical analyses of the experimental soil (2012/2013 and 2013/2014 seasons).

Mechanical analysis: Available K (ppm)	**2012/2013**	**2013/2014**
Sand %	92.3	90.1
Silt %	3.1	4.3
Clay %	4.6	5.6
Chemical analysis:	2012/2013	2013/2014
CaCo	1.3	1.5
Organic matter %	0.3	0.3
EC. mmhos/cm2	0.3	0.3
pH	7.4	7.2
Soluble N%	8.0	8.2
Available P (ppm)	3.0	3.4
Available K (ppm)	19.8	20.2

Thirty days after sowing each treatment were sprayed with water or one of the following aqueous solutions containing 10000 ppm K as potassium sulphate, 500 and 1000 ppm Zn as Zinc sulphate, mixture of K (10000 ppm) +Zn (500 ppm) and mixture of K (10000 ppm) +Zn (1000 ppm).

After 60 days from sowing samples of one square mater were taken at random from the middle area of each plot from the three replicates to measure plant height and fresh and dry weight of leaves and stems. Representative sample from each treatment was taken to determine the following nutrient constituents N, P, K, Fe, Ca, Mg, Fe, Mn and Zn in the leaves.

At harvest time one square meter was taken at random from each plot from the three replicates to determine plant height cm, number of spikes/m^2, dry weight of spikes g/m^2, spike length, number of grains/ spike, weight 1000 grains weight (g). In addition, grain, straw and biological yields ton/fed. Representative samples from grains and straw were taken to determine the following nutrient constituents N, P, K, Fe, Ca, Mg, Mn and Zn. Macro and micronutrients were extracted using the dry ash digestion method 0f[12] **.**

The normal agriculture practices of growing wheat were practiced till harvest as recommended.

The experimental design was split-plot in randomized complete block design with three replicates. The results were submitted to analysis of variance according to[13]**.** Differences among treatment means were determined using the LSD test at a significance level of 0.05.

Results and discussion

I-Effect of potassium and zinc application on wheat growth characteristics

Plant height (cm) :

Results presented in Table (2) show that foliar spraying of K has promoting effect on plant height. In this respect,[14] reported that application of K fertilization affected maize development, the plants became taller and greener. The same effect also reported by [15]on tomato and [16] on wheat. Such promoting effect of K on plant height may be attributed to the direct effect of K on plant growth and development[17]

Table 2: Effect of foliar application of Zinc and potassium on growth of wheat plants.

Treatment	plant length	Leaves		stems	
	cm/plant	fresh wt.	dry wt.	fresh wt.	dry wt.
		gm/plant	gm/plant	gm/plant	gm/plant
control	68.00	16.5	1.57	85.67	23.72
Zn (500 ppm)	82.00	28.0	2.50	101.50	28.38
Zn (1000 ppm)	86.00	38.5	3.32	106.70	30.11
K (10000 ppm)	88.17	41.7	3.95	134.83	34.67
K+Zn (500 ppm)	78.30	35.0	3.66	128.83	37.56
K+Zn (1000 ppm)	96.00	40.0	3.99	191.50	53.13
LSD 5%	0.49	1.00	0.14	0.95	0.22

Regarding the effect of zinc spraying on plant height the Table(2) indicated that plant length significantly increased by foliar application of both levels of Zn solutions. The highest length record obtained by plants sprayed with the high level of Zn (1000 ppm) as compared with those without Zn. Similar results reported by [18,19]. In this respect, [20] reported that with Zn application maximum increase of 4.49% was observed in plant height, over control.

As regards the interaction effect of K and Zn the results showed that plant height significantly increased by dual nutrition of both K and Zn. The highest plant height was recorded in those plots which were sprayed with mixture of K+Zn solution, while minimum record obtained by control (no spray). Such effect may be attributed to the promoting effect of K and Zn on stem length which reflected in high plant height[10,19].

Fresh and dry weight of leaves and stem:

K has a critical role in plant growth as indicated in Table (2), The data show that K significantly increased fresh and dry weight of leaves and stem. These results was supported with the findings of [21,22] on wheat who reported that K application can increase biomass production and development biomass production.[14]on maize and[15] on tomato recorded also that K had positive effects on the dry weight of leaves and application of K induce significant increase in vegetative and dry biomass of shoot.

Concerning the effect of Zn nutrition on fresh and dry weight of wheat the same table (Table 2) show that Zn has enhancing effect on both fresh and dry weight. In general, such effect was clearly obvious under high level of Zn (1000 ppm). These results were confirmed with those of [18,23] who stated that plant growth was noted to be higher when greater supply of zinc doses was applied.

Results as indicated in Table 2 also detected that more fresh and dry weights obtained by the dual application with K and Zn compared with the individual spray ones. The results also indicated that foliar spray with K (10000 ppm) + Zn (1000 ppm) surpassed of all other treatments. These coincide with those obtained by [24,22] who indicated that the higher application rates of Zn and K resulted in greater growth characteristics than at the lower treatments they added that the combined treatment of K and Zn is more effective than individual application. Such enhancement effect on growth parameters confirmed by the findings of [25]

c- Nutrient contents of the leaves:

The results of this study demonstrate that foliar application of potash fertilizer had a positive effect on most studied elements as compared with un-sprayed plants (Table 4a). Such pronounced effect of K on nutrients uptake was confirmed by the findings of [26]**.** In this respect, [27]reported that K has direct synergistic relationships with iron and manganese. [16]also added that potash fertilizer had a positive effect on zinc concentration.

Table4 (a):chemical constituents of leaves as affected by foliar application of Zn and K

Treatment	N %	P %	K %	Ca %	Mg %	Fe (ppm)	Zn (ppm)	Mn (ppm)
control	1.405	0.160	1.803	0.148	0.190	62.250	25.250	11.725
Zn (500 ppm)	1.585	0.273	2.198	0.285	0.305	103.500	37.250	12.175
Zn (1000 ppm)	1.903	0.233	2.643	0.383	0.285	93.000	53.750	12.575
K (10000 ppm)	2.610	0.295	3.740	0.305	0.360	170.000	50.000	12.775
K+Zn (500 ppm)	1.913	0.275	2.598	0.360	0.348	119.250	41.250	13.950
K+Zn (1000 ppm)	2.415	0.200	2.715	0.363	0.265	95.250	55.750	15.325
LSD 5%	0.010	0.003	0.042	0.005	0.002	0.708	0.622	0.031

As regarding the effect of zinc on nutrient content of the leaves the data presented in Table (4a) demonstrated that zinc has promoting effect on uptake of most nutrient according to the level of zinc treatment . The data show that (N,K,P,Ca, Mg, Fe, Mn, Zn) increased under both levels of Zn as compared with control plants . These results were in close agreement with those obtained by [28]**.** Such effect was more pronounced under high level of Zn. These results confirmed with those of [28,29] who reported that an increase in Zn supply resulted an increase of Ca and N levels in the stems and leaves and the amount of Zn in the leaves increased with greater Zn rates.

The interaction effect of K and Zn as shown in Table (4a) indicate that dual spraying with those elements resulted in obvious increase in most studied elements as compared with those sprayed with Zn only. These results are completely supported by the findings of [30,31] .In this respect, [10] reported that the efficiency of Zn improved when it is used in combination with other elements like N or K.

II- Effect of potassium and Zinc application on wheat yield and yield components :

Treating wheat with K resulted in a significant increase in all the studied yield and yield attributes components i.e plant height, No. of tillers, spikes character and yield of straw and biological yield per m2 and consequently per Feddan as compared with un-sprayed plants (Table 3). 1000-grain weight also increased by foliar spraying of K. Similar results were obtained by[26,16] who recorded that application of potassium increased plant height, number of tillers, number of grains per spike, grain weight, grain yield, dry matter and 1000-grain weight. [32,19] also reported that using K causes increase of grain yield, 1000-grain weight and number grain as compared with control treatment. Recently, [33] reported that foliar spraying of K increase growth and yield of plants .

This increasing in yield and yield attributes characters, could be due to the role of potassium in increasing the division, cell growth, increasing photosynthesis process, and somewhat lost storage limitations and transport of photosynthesis maters into seeds cause to grain filling, and increase the dimensions of seed and consequently, seed weight increases[34]**.** As regarding the effect of Zn the studied traits data presented in Table (3) showed that application of Zn fertilizer had positive on most studied .The obtained results in Table (4) show that foliar spraying with Zn greatly increased number of spikes/m^2, spikes weight kg/m^2, grain yield kg/m^2 and biological yield kg/m^2 and 1000-grain weight. Consequently, such effect greatly reflected by high grain yield, straw yield and biological yield kg/feddan. The data revealed also that such effect was more pronounced under high level of Zn(1000 ppm). These results were in close agreement with those obtained by[35,22,20,36]**.** In this respect,[37] indicated that grain No/ m^2 related with grain yield and consequently high grain yield. Such promoting effect of Zn in growth and yield of wheat could be attributed to the enhanced nutrient (macro & micro) use efficiency in the presence of Zn fertilizer [20].Such effect may be attributed due to increase of pollen fertility in the plant. In this respect, [38] reported that zinc application seems to avoid form weakness of stems so it lead to formation more fertile spikes. The pronounced effect of high level of Zn on wheat yield confirmed by results obtained by [20] who reported that as evidenced by the grain yield successive increase in grain yield was witnessed with incremental dose of Zn. [38] also stated that higher concentration of zinc foliar application increased spikes No/ m^2 as compared to non-sprayed plants. Recently, [39] reported that thousand grains weight and number of grains per ear were also significantly increased with increase in Zn level.

Table 3: Effect of foliar application of zinc and potassium on yield of wheat plants.

Treatment	plant length (cm)	spike length (cm)	wt. of spike (gm/spike)	wt. grains (gm/spike)	Shoot No. (No./ m2)	spikes No. (No./ m2)	spikes wt. (kg /m2)	grain yield (kg /m2)	bio. yield (kg/m2)	grain yield (kg/fed	bio. Yield (kg/fed)	straw yield (kg/fed)	wt.of 1000 grains (gm)
control	78.3	8.00	1.93	1.45	640.00	602.3	1.05	0.54	1.57	2258.2	6580.0	4321.8	42.1
Zn (500 ppm)	90.0	9.00	2.33	1.86	709.33	682.7	1.55	0.77	2.63	3242.4	11032.0	7789.6	47.1
Zn (1000 ppm)	90.7	11.00	2.55	1.90	745.33	722.7	1.73	0.88	3.19	3689.0	13412.0	9723.0	47.5
K (10000 ppm)	95.3	10.63	2.42	1.81	852.00	682.7	1.76	0.83	3.22	3465.0	13538.0	10073.0	47.7
K+Zn (500 ppm)	93.7	10.17	2.56	1.92	860.00	692.7	1.73	0.89	3.71	3742.2	15582.0	11839.8	48.0
K+Zn (1000 ppm)	93.3	11.33	2.75	2.08	872.00	880.0	1.86	0.92	3.87	3883.6	16254.0	12370.4	53.0
LSD 5%	2.16	0.40	0.13	0.08	24.76	25.90	0.07	0.03	0.20	135.80	821.90	808.00	0.07

Concerning the interaction effect of K and Zn on wheat yield and attributes the data presented in Table (3) indicate that the dual application of both elements greatly increased most yield characters per plant more than single application. Table (3) also showed significant increase in spikes No., spikes wt., grain yield and biological yield per square metre which in turn reflected in highly observed record in grain, straw and biological yield per Faddan. These results were confirmed with findings of[7] who reported that maximum emergence m-2, number of tillers m-2, plant height and number of spikes m-2 were recorded in those plots which were sprayed with 0.5% N, 0.5% K and 0.5% Zn solutions while minimum emergence m-2 , number of tillers m-2, plant height were recorded in control plots. [7,40,31]also found that application of K+Zn significantly produced the highest values of yield, yield components and protein content. In general, maximum straw yield (12370.4) and biological yield (16254.0) Kg per Faddan were reported by wheat plants foliar sprayed with (10000 ppm) K and (1000 ppm) Zn. The highest grain yield (3883.6 Kg/Feddan) as indicated Table (3) also recorded by dual application of K(1000 ppm) and Zn (1000 ppm). The results confirmed with those obtained by[7,16] who reported that maximum biological yield , and straw yield and grain yield (kg ha-1) were produced in plots under the effect of foliar spray of K + Zn solution as compared with control (no spray) plots.

It is worthy to note that K and Zn interaction resulted in more pronounced record of 1000 grain weight and the highest record obtained by the dual interaction of K and the high level of Zn (1000 ppm) (53 gm) (Table 3). The positive effect of K×Zn on 1000-grain weight might be due to many zinc dependent enzymes that are involved in carbohydrate metabolism in general and in leaves in particular, impairment of K in stomata regulation, and export of photosynthetase from source, the leaves, into sink organs, the grains [41].

Nutrient content of straw and grains of wheat plants:

a- Nutrient content of straw:

The nutrient content of wheat straw as it giving in Table (4c) indicate that foliar spray of K clearly increased most studied nutrient as compared with those unsprayed with K . These results coincide by those obtained by [26,42] who reported that increase in K application increased K and Zn content of plants. [14] added that adequate K may be required for the efficient use of both Fe and other macronutrients.

Table4 (c):chemical constituents of straw as affected by foliar application of Zn and K

Treatment	N %	P %	K %	Ca %	Mg %	Fe (ppm)	Zn (ppm)	Mn (ppm)
control	0.645	0.180	2.055	2.810	0.320	65.500	50.25	11.625
Zn (500 ppm)	0.920	0.305	2.068	3.048	0.345	82.750	62.25	12.125
Zn (1000 ppm)	0.845	0.343	2.173	3.565	0.493	94.500	90.50	12.350
K (10000 ppm)	0.940	0.373	2.365	4.920	0.433	127.750	82.75	13.700
K+Zn (500 ppm)	0.875	0.288	2.085	3.593	0.383	111.500	66.00	16.400
K+Zn (1000 ppm)	0.920	0.305	2.283	4.343	0.403	101.500	93.00	19.550
LSD 5%	0.003	0.002	0.003	0.116	0.001	0.461	0.414	0.236

Concerning the effect of Zn trait on the uptake of nutrients Table (4c) revealed that Zinc has promoting effect on most nutrient uptake by plants as compared with control plants .Generally, such enhancing effect was observed under high level of Zn. These results confirmed with the findings of [28,35]. In this respect,[39] reported that high zinc groups accumulated more mineral contents in leaf and seed.

As regards the response of nutrient uptake to fertilization with both K and Zn the data presented in Table (4 c) revealed that most studied nutrients (N,P,K,Ca,Mg,Fe, Zn and Mn) significantly increased by the dual application. Similar results obtained by [43] who stated that interaction use of K & Zn has an effects on the absorption of other nutrients in the plant tissue. [44] also added that the highest total nitrogen uptake, phosphorus uptake, potassium uptake and zinc uptake; were recorded with K and Zn application .

b- Nutrient content of wheat grains:

As indicated in Table (4b) the data show that potassium fertilization increased most the studied nutrients as compared with unsprayed plants. Such promoting effect of K on mineral uptake recorded by[22,16]**.** In this concern,[26] reported that application of potassium increased seed K, Zn, Fe, and protein contents. They added that grains K content is significantly correlated with leaf K, Zn grain and Fe contents.[27] also reported that K has direct synergistic relationships with iron and manganese.

The nutrient content of wheat straw as it giving in Table (4c) indicate that foliar spray of K clearly increased most studied nutrient as compared with those unsprayed with K. These results coincide by those obtained by [26,42] who reported that increase in K application increased K and Zn content of plants. [14] added that adequate K may be required for the efficient use of both Fe and other macronutrients.

Table 4 (b):chemical constituents of grains as affected by foliar application of Zn and K

Treatment	N %	P %	K %	Ca %	Mg %	Fe (ppm)	Zn (ppm)	Mn (ppm)
control	1.808	0.180	0.478	0.128	0.275	35.500	41.000	14.875
Zn (500 ppm)	2.668	0.378	0.593	0.243	0.415	41.250	71.750	15.825
Zn (1000 ppm)	2.655	0.380	0.578	0.285	0.403	41.500	70.250	16.900
K (10000 ppm)	2.660	0.433	0.643	0.393	0.403	57.000	71.750	23.250
K+Zn (500 ppm)	2.995	0.403	0.558	0.473	0.463	46.250	59.250	27.475
K+Zn (1000 ppm)	2.768	0.390	0.525	0.473	0.383	43.250	62.750	19.000
LSD 5%	0.026	0.004	0.009	0.220	0.001	0.602	4.347	0.327

The same table (Table 4b) also show that Zn positively affected most grain nutrients (N, P, K, Ca, Mg, Fe, Zn and Mn) at both levels of zinc. Similar results obtained by[35,20,45]. It is clearly obvious also from the same table (Table 4b) that Zn has promoting effect on nitrogen uptake. Such increase in nitrogen uptake induced by zinc application corroborates the thesis of its primary effect on main physiological processes, related to nutrients uptake[46]**.**

The interaction effect of K and Zn spray on wheat grain nutrients as presented in table (4b) show that the dual application of these elements resulted in high record of most nutrients (N, P, K, Ca, Mg, Fe and Mn) as compared with the sole application of Zn. Similar results obtained by[43] who stated that interaction use of K & Zn has an effects on the absorption of other nutrients in the plant tissue. The observed record of nitrogen uptake by wheat grains by dual application supported by[30] who reported that grain protein content increased linearly as the levels of K×Zn interaction treatments increased.

Conclusion:

From the obtained results it is clear in order to obtain an optimum production and quality crops application of zinc with other nutrients should be advised particularly for wheat cultivation. Thus, these results highlighted that Zn and K application significantly affected growth and yield components of wheat plants. Thus, foliar application of K and Zn not only increased grain yield, but they also resulted in an improvement in grain quality through the effect on concentration of grain nutrients and protein. The higher application rates of Zn and K resulted in greater yield and growth characteristics demonstrating the benefit of application of Zn and K fertilizers to wheat cultivated in these sandy soils.

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