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Effect of combination between potassium fertilizer levels and zinc foliar application on growth, yield and some chemical constituents of groundnut

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ABSTRACT

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 summer seasons of 2012 and 2013 to investigate the effect of combination between potassium fertilizer levels and zinc foliar application on growth, yield, yield attributes and some chemical constituents of groundnut. The results clear that different treatments show significant differences in both growth samples however, 90 K_2O kg/ha +1000 mg/L Zn surpassed in most studied characters with no significant difference between this treatment and treatment 90 K_2O kg/ha+500mg/L Zn in most studied characters, except stems dry weight/plant in both samples. Increasing foliar zinc application from 0 to 1000mg/L significantly increased all yield and yield attributes with the potassium fertilizer levels however, the treatment 90 K_2O kg/ha +1000 mg/L Zn records the highest values of studied character. Significant differences between treatments in seed protein content, NPK seed and straw concentration.

Key words: Groundnut, Potassium, Zinc, Yield and yield attributes, Chemical constituents

1. INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is one of the most important summer legumes in Egypt, more than half of the national production is consumed directly without oil extraction and remaining exported, because its high price in the international commodity market. It contains oil 50%, protein 25-30%, carbohydrate 20 % and fiber and ash 5%, which make a substantial contribution to human nutrition (Fageria et al., 1997). Recently, groundnut has been given great attention from Government as well as from the Scientific Institutes due to its importance for the new sandy areas but, the sandy soils face many problems like low content of potassium as well as high loss of it by leaching. Therefore, groundnut needs more attention for fertilization and their methods to improve pods production and its quality.

Potassium is a multifunctional versatile nutrient, indispensable for plants. In plants, the function of K has several roles, such as enzyme activation, stimulation of assimilation and transport of assimilate, anion/cation balance as well as water regulation through control of stomata (Krauss and Jin Jiyun, 2000). The positive effect of applying potassium was reported by many researchers Ali and Mowafy (2003) indicated that adding potassium fertilizer significantly increased each of number of branches and pods/plant, weight of pods and seeds/plant, 100-seed weight, pod and seed yields/faddan and oil yield/faddan. Moreover, Mohamed and Gobarah (2005) showed that increasing K levels up to 48 kg K_2O/faddan significantly increased

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number of branches and pods/plant, weight of pods and seeds/plant, 100-seed weight as well as pod, seed, oil and protein yields/faddan. On contrarily, the oil percentage is the only character that is negatively responded to increasing the K level.

Zinc is an important micronutrient, plant response to Zn deficiency occurs in terms of decrease in membrane integrity, susceptibility to heat stress, decreased synthesis of carbohydrates, cytochromes, nucleotide, auxin and chlorophyll. Further, Zn-containing enzymes are also inhibited, which include alcohol dehydrogenase, carbonic anhydrase, copper-zinc superoxide dismutase, alkaline phoshatase, phosphosipase, carboxypeptidase and RNA polymerase (Marschner, 1993). Some investigators reported that foliar spraying with zinc could correct zinc deficiency improve growth, yield and seed quality of groundnut. Foliar spraying with zinc had a significant effect on groundnut growth, yield and its components as well as seed quality (Gobarah et al., 2006). Soil and/or foliar applications of Zn may also increase grain Zn concentration and thus contribute to grain nutritional quality for human beings. Higher grain Zn concentration is also important for better seedling vigor and field establishment, particularly on Zn deficient soils (Cakmak, 2008). Use of Zn foliar application either at flowering or seed filling stages significantly increased number of pods/plant, weight of pods/plant, number of seed/plant, weight of seeds/plant, 100-pod weight, 100-seed weight, pod, seed and straw yield/faddan (El-Habbasha et al., 2013a). Application of enriched $ZnSO_4$ as a basal was found to be economically viable and sustainable. In case of severe deficiency of zinc foliar application of $ZnSO_4$ at 0.2 to 0.5% is recommended to temporarily arrest the deficiency (Arunachalam et al., 2013). Increasing foliar zinc application from (0 to 1000mg/L) significantly increased all yield and yield attributes with the two nitrogen rates, 60 and 120 N kg/ha (El Habbasha, 2015). Therefore, the objective of the present study was to investigate the effect of combination between potassium fertilizer levels and zinc foliar application on growth, yield, yield attributes and some chemical constituents of groundnut.

2. MATERIALS 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 summer seasons of 2012 and 2013 to investigate the effect of combination between potassium fertilizer levels and zinc foliar application on growth, yield, yield attributes and some chemical constituents of groundnut. The soil sample (0-30 depth) of the experimental area was subjected to laboratory analysis to determine some of its physical and chemical properties according to the method described by Chapman and Pratt(1978) as follows: sand 91.2%, silt 3.7%, clay 5.1%, pH 7.3 organic matter 0.3 %, $CaCO_3$ 1.4%, EC 0.3 dS/m, soluble N 8.1 ppm, available P 3.2 ppm and available K 0.3 ppm. The treatments were arranged in a factorial experiment based on Randomized Complete Block Design (RCBD) with three replications, concentrations of zinc foliar application (water sprayed, 500 and 1000 mg/L $ZnSO_4$ $7H_2O$) were done at 45 and 60 days after sowing (DAS) and three levels of potassium fertilizer as potassium sulfate 48% K_2O (30, 60 and 90 K_2O kg/ha) were added during the seed bed preparation. The following treatments were studied.

T_0: 30K_2O kg/ha + water spraying
T_1: 30K_2O kg/ha +500 mg/L $ZnSO_4$ $7H_2O$
T_2: 30K_2O kg/ha + 1000 mg/L $ZnSO_4$ $7H_2O$
T_3: 60K_2O kg/ha + water spraying
T_4: 60K_2O kg/ha +500 mg/L $ZnSO_4$ $7H_2O$
T_5: 60K_2O kg/ha +1000 mg/L $ZnSO_4$ $7H_2O$
T_6: 90K_2O kg/ha + water spraying
T_7: 90K_2O kg/ha +500 mg/L $ZnSO_4$ $7H_2O$
T_8: 90K_2O kg/ha +1000 mg/L $ZnSO_4$ $7H_2O$

The experimental unit area was 10.5 m^2 consisting of five rows (3.5m long and 60 cm between rows). Seeds were sown on May 5th and 12th in the first and second seasons, respectively. The seeds (Giza 6 cultivar) were coated just before sowing with the bacteria inoculants, using Arabic gum (40%) as adhesive agent and were sown in hills 10 cm apart. Phosphorus fertilizer, as calcium superphosphate (15.5 % P_2O_5) was added during the seed bed preparation at 70 P_2O_5 kg/ha and nitrogen fertilizer has been added at level of 90 N kg/ha as ammonium sulfate (20.6 %N) in four equal doses weekly

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starting from 15 days after. Sprinkler irrigation was applied as plants needed. The proceeding winter crop was wheat in the both seasons. The normal cultural practices for groundnut were followed. Groundnut was manually harvested on September 10^{th} and 14^{th} in the first and second season, respectively. Two samples of five plants were taken at random from the middle area of each plot to measure dry weight of leaves, stems, total top and pods/plant at 75and 90 days after sowing. At harvest, a random sample of ten plants were taken from each plot to determine number and weight of pods/plant, number and weight of seeds/plant, 100-pod weight and 100-seed weight. Plants on the middle two rows in each plot were harvested and dried to calculate, pods, seed and straw yield/ha. Oil %, NPK in seed and straw were determined according to the method described by A.O.A.C (1995) and the seed protein content was calculated by multiplying total nitrogen concentration by 6.25. Data were analyzed using an ANOVA randomized complete block design (MSTAT-C. MSTAT-C 1988). Since the trend was similar in both seasons, Bartlett's test was applied and the combined analysis of the two growing seasons was done. LSD ($P<0.05$) was used to compare means.

3. RESULTS AND DISCUSSION

Effect of combination between potassium fertilizer levels and zinc foliar application on some growth characters

Data presented in Table (1) shows the effect of combination between potassium fertilizer levels and zinc foliar application treatments on the growth characters of groundnut. Regarding to 30K_2O kg/ha+ water spraying, 60K_2O kg/ha+ water spraying and 90K_2O kg/ha+ water spraying, proving that increasing potassium fertilizer levels from 30 to 90 K kg/ha without foliar zinc application, positive increase in dry weight of leaves, stems, total top and pods/plant at 75 and 90 days after sowing. Such beneficial effect of K fertilizer could be attributed to its essential role in growth and establishment of groundnut plants in addition to its activity in the function of enzymes for the biological processes in plants. K application is known to improve such physiological characteristics as stomatal resistance, RWC, NRA, chlorophyll and proline contents which might improve the overall plant water status and metabolism (Beringer 1982, Umar et al., 1990). Application of potassium improves Relative water content of plants under normal as well as water stress conditions. The maintenance of plant water economy by K application in terms of a high Relative water content could be ascribed to the supposed role of K in stomatal resistance, water use efficiency and lowered transpiration rate (Umar and Moinuddin, 2002).

Regarding treatments 60K_2O kg/ha+ water spraying, 60K_2O kg/ha+500 mg/L Zn and 60K_2O kg/ha+1000 mg/L Zn, found that increasing of foliar zinc application from 500 to 1000mg/L show significant differences in most studied characters in both growth samples, except dry weight pods/plant at 90 days after sowing. Foliar spraying with zinc encouraged the vegetative growth and increased the plant capacity for building metabolites. Such response may be due to that zinc is known to play an activator of several enzymes in plants and is directly involved in the biosynthesis of growth substances such as auxin which produces more plant cells and more dry matter (Cakmak, 2008). The results were supported by Ali and Mowafy (2003) and, Mohamed and Gobarah (2005).

Data shows a significant positive effect of fertilization treatments on the following characters: dry weight of leaves, stems, total top and pods/plant at 75 and 90 days after sowing, with a superiority for 90 K_2O kg/ha +1000 mg/L $ZnSO_4$ 7H_2O. This gave the greater increase percentages reaching 31.9%, 35.2%, 33.5% and 68.5 % over the treatment 30K_2O kg/ha, for dry weight of leaves, stems, total top and pods plant^{-1} in first sample, respectively, at 90 DAS the increment in dry weight of leaves, stems, total top and pods/plant reach to 33.3%, 35.4%, 34.25% and 37.97%, respectively, over the treatment 30K_2O kg/ha. With respecting to the significant combination between different levels of potassium fertilizer and foliar spraying with zinc on growth characters .These results it can be indicated that foliar nutrition of groundnut plants with Zn may increase the efficiency of potassium utilization in enhancing. This increment in vegetative of groundnut plants may be due to the physiological fact that potassium involved in plant metabolism as well as large number of enzymes that are activated by potassium and foliar spray with zinc encouraged the vegetative growth and increased the plant capacity building metabolites (Marschner, 1995).

Table 1. Effect of combination between potassium fertilizer levels and foliar zinc application on dry matter (DM) accumulation in leaves, stems and pods/plant at75 and 90 days after sowing (DAS) of groundnut (combined data of 2012 and 2013 seasons)

Characters / Fertilizer	75 DAS				90 DAS			
	Leaves dry wt./plant (g)	Stems dry wt./plant (g)	Total top dry wt./plant (g)	Pods dry wt./plant (g)	Leaves dry wt./plant (g)	Stems dry wt./plant (g)	Total top dry wt./plant (g)	Pods dry wt./plant (g)
$30K_2O$ kg/ha+ water spraying	35.10	32.99	68.09	14.59	62.52	56.06	118.58	30.23
$30K_2O$ kg/ha+500 mg/L Zn	35.41	33.61	69.02	15.28	63.25	56.56	119.81	31.65
$30K_2O$ kg/ha+ 1000 mg/L Zn	37.16	35.36	72.52	15.61	66.55	59.59	126.13	32.72
$60K_2O$ kg/ha+ water spraying	38.06	35.77	73.83	15.27	68.51	60.82	129.33	31.29
$60K_2O$ kg/ha+500 mg/L Zn	37.62	35.73	73.35	16.98	67.71	60.77	128.48	35.80
$60K_2O$ kg/ha+1000 mg/L Zn	40.83	38.37	79.20	19.24	73.48	65.25	138.73	38.43
$90K_2O$ kg/ha+ water spraying	45.36	42.22	87.59	21.94	81.66	71.80	153.45	40.31
$90K_2O$ kg/ha+500 mg/L Zn	45.27	42.77	88.04	23.58	81.49	72.72	154.21	41.34
$90K_2O$ kg/ha+1000 mg/L Zn	46.30	44.62	90.92	24.58	83.34	75.86	159.20	41.71
LSD 5%	2.06	1.97	3.69	1.84	3.69	3.12	6.47	2.76

Effect of combination between potassium fertilizer levels and zinc foliar application on yield and yield components:-

Data presented in Table (2) illustrate the effect of combination between potassium fertilizer levels and zinc foliar application treatments on number and weight of pods/plant, number and weight of seeds/plant, 100-pod weight, 100-seed weight, pod, seed and straw yield/ha. Concerning the treatments $30K_2O$ kg/ha+ water spraying, $60K_2O$ kg/ha+ water spraying and $90K_2O$ kg/ha+ water spraying, resulted that increasing of potassium fertilizer from 30 to 90 K_2O kg/ha show significant differences in the studied characters. This increase reach to 37.5, 28.01, 32.1, 30.5, 21.8, 28.5, 30.9, 28.03 and 25.15 % for number and weight of pods/plant, number and weight of seeds/plant, 100-pod weight, 100-seed weight, pod, seed and straw yield/ha, respectively over 30 K_2O kg/ha. The beneficial effect of potassium on the mentioned characters might be attributed to its important role plays in many enzymatic systems, photosynthesis, and synthesis of proteins and carbohydrates (Marschner, 1995). Moreover, K enhances translocation from leaves to capsules and seeds. This is indicative of a positive role of potassium in hydration and organization of cell protoplasm and, thereby, in maintenance of turgor and growth of the plant (Sinclair and Ludlow, 1989; Khanna-Chopra et al., 1994). It also helps in maintaining a balance between osmotic potential of the plant and its surroundings. Plants have evolved hydraulic stomatal optimization mechanism to ensure that water loss does not exceed its uptake by the roots. It is the concentration of potassium ions moving through the xylem that influence the hydraulic conductivity of the transport pathway, perhaps by affecting the nature of pit membranes within xylem vessels, such that a root-sourced chemical signal can influence the properties of the water-transport pathways through the root and therefore, influence the hydraulic signaling between the root and shoot. These findings are in harmony with those obtained by Ali and Mowafy (2003), Mohamed and Gobarah (2005), Thalooth, et al. (2006) and Gashti, et al. (2012).

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Regarding the treatments 60K_2O kg/ha+ water spraying, 60K_2O kg/ha+500 mg/L Zn and 60K_2O kg/ha+1000 mg/L Zn, the increase in the studied character reach to 13.09, 6.27, 9.33, 8.16, 9.08, 8.44, 9.77, 8.27, 8.94 % for number and weight of pods/plant, number and weight of seeds/plant, 100-pod weight, 100-seed weight, pod, seed and straw yield/ha, respectively. While, the treatments 90K_2O kg/ha+ water spraying, 90K_2O kg/ha+500 mg/L Zn and 90K_2O kg/ha+1000 mg/L Zn, increasing foliar zinc application shows significant differences in most of studied characters, except number of pods/plant and 100-seed weight, this increase reach to 10.05, 12.05, 11.15, 11.47, 11.23, 2.25, 10.49, 12.21 and 11.30 % for number and weight of pods/plant, number and weight of seeds/plant, 100-pod weight, 100-seed weight, pod, seed and straw yield/ha, respectively. Such increase in seed groundnut yield/ha with zinc spraying might be due to the increase in weight of pods/plant, number and weight of seeds/plant as well as 100-pod weight. The beneficial effect of zinc fertilizer could be attributed to its vital role activity in the function of enzymes for the biological processes in plants which lead to increase in yield components. Similar result was obtained by Thalooth, et al., (2006) Gobarah, et al. (2006), Esmail et al. (2010) El-Habbasha et al. (2013b) and El-Habbasha (2015). These results are in full agreement with those obtained by Ali and Mowafy (2003) concluded that increasing the level of potassium fertilization to 72 kg k/faddan and foliar spraying with zinc had a favorable effect on enhancing growth and yield of peanut plants grow under sandy condition.

Table 2. Effect of combination between potassium fertilizer levels and foliar zinc application on yield and yield attributes of groundnut (combined data of 2012 and 2013 seasons)

Characters / Fertilizer	No. Pod/ plant	Wt. pod/ Plant (g)	No. of seeds/ plant	Wt. of seeds/ Plant (g)	100-pods wt.(g)	100-seed wt.(g)	Seed yield (ton/ha)	Pods yield (ton/ha)	Straw yield (ton/ ha)
30K_2O kg/ha+ water spraying	24.01	31.63	51.04	30.50	134.91	63.81	2.33	3.71	8.27
30K_2O kg/ha+500 mg/L Zn	24.89	34.36	54.36	32.74	138.72	64.35	2.43	3.89	8.60
30K_2O kg/ha+ 1000 mg/L Zn	26.81	35.13	56.82	33.92	138.80	67.35	2.52	4.05	8.84
60K_2O kg/ha+ water spraying	28.94	35.67	59.27	35.03	144.45	73.38	2.66	4.23	9.28
60K_2O kg/ha+500 mg/L Zn	31.17	37.14	62.67	36.82	152.55	76.51	2.78	4.44	9.77
60K_2O kg/ha+1000 mg/L Zn	32.73	37.91	64.80	37.89	157.57	79.58	2.92	4.58	10.11
90K_2O kg/ha+ water spraying	33.02	40.49	67.44	39.82	164.33	82.01	3.05	4.75	10.35
90K_2O kg/ha+500 mg/L Zn	34.89	42.32	70.83	41.75	172.56	83.08	3.19	4.94	10.97
90K_2O kg/ha+1000 mg/L Zn	36.34	45.36	74.95	44.39	182.80	83.86	3.37	5.17	11.52
LSD 5%	2.45	1.58	2.68	1.40	6.00	1.94	0.14	0.15	0.38

Effect of combination between potassium fertilizer levels and zinc foliar application on some chemical constituents

Chemical composition i.e., seed oil and protein content, nitrogen, phosphorus and potassium seed content and nitrogen, phosphorus and potassium straw content were affected by combination between potassium fertilizer levels (30, 60 and 90 K2O kg/ha) and zinc foliar application (water spraying, 500 and 1000 mg/L Zn) (Table 3), where it shows significant differences in most studied characters, except seed oil content. Where, the highest protein content, nitrogen and phosphorus seed content and nitrogen and phosphorus straw content were recorded in 90K_2O kg/ha+1000 mg/L Zn. This means that the combination between potassium fertilizer and foliar spray with zinc may enhance plant utilization of nutrients and water which was reflected in a good growth and biological yield. Zn is required for integrity of cellular membranes to preserve the structural orientation of macromolecules and ion transport systems. Its interaction with phospholipids and sulphydryl groups of membrane proteins contributes for the maintenance of membranes (Dang et al., 2010; Disante et al., 2010).

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Table 3. Effect of combination between potassium fertilizer levels and foliar zinc application on some chemical constituents of groundnut (combined data of 2012 and 2013 seasons)

Characters / Fertilizer	Oil%	Seed protein content	N %	P%	K %	N %	P%	K %
			in seed			in straw		
$30K_2O$ kg/ha+ water spraying	47.59	24.29	3.88	0.86	0.76	1.95	0.23	1.93
$30K_2O$ kg/ha+500 mg/L Zn	47.38	24.68	3.95	0.88	0.70	1.98	0.23	1.79
$30K_2O$ kg/ha+ 1000 mg/L Zn	46.70	24.62	3.93	0.88	0.75	1.98	0.23	1.89
$60K_2O$ kg/ha+ water spraying	46.73	23.76	3.80	0.84	0.81	1.91	0.22	2.07
$60K_2O$ kg/ha+500 mg/L Zn	48.74	24.58	3.93	0.87	0.85	1.97	0.23	2.15
$60K_2O$ kg/ha+1000 mg/L Zn	47.31	23.28	3.72	0.83	0.86	1.87	0.22	2.19
$90K_2O$ kg/ha+ water spraying	47.16	25.20	4.03	0.90	0.91	2.02	0.24	2.30
$90K_2O$ kg/ha+500 mg/L Zn	47.98	24.16	3.86	0.86	0.97	1.94	0.23	2.46
$90K_2O$ kg/ha+1000 mg/L Zn	46.79	25.28	4.04	0.90	0.92	2.03	0.24	2.35
LSD 5%	NS	1.41	0.23	0.05	0.07	0.11	0.01	0.17

4. CONCLUSION

Different treatments show significant differences in growth, yield and some chemical constituents. Increasing potassium fertilizer levels from 30 to 90 K_2O kg/ha with increasing foliar zinc application from 0 to 1000mg/L significantly increased all yield and yield attributes. Treatment 90 K_2O kg/ha +1000 mg/L shows significant differences in most of studied characters, except seed oil content.

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