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Yield and Yield Components of Groundnut (*Arachis hypogaea* L.) in Response to Soil and Foliar Application of Potassium

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Abstract: This study was carried out in the greenhouse of the National Research Center, Dokki, Giza, Egypt during two summer seasons 2013 and 2014 in order to investigate the effect of soil and foliar application of potassium on yield and yield components of two groundnut varieties (Giza-6 and Line-623) grown in sandy soil. The results indicated that application of soil or foliar potassium fertilizer significantly increased pods weight compared to untreated plants (control). The highest pods weight (32.44g) was produced by the treatment received K_{soil}+K_{foliar}, while the lowest (15.12g) with control plants. The results also indicated that the 100-seed weight and shelling percentage were increased by applying K_{foliar} compared to untreated plants or other two potassium treatments. The highest 100-seed weight (56.86g) and shelling percentage (76.93%) were obtained with the treatment received K_{foliar}. While, applying these treatment either soil or foliar singly, as well as in combination with them resulted in a significant increase in oil content compared to control plants. The highest oil yield (11.13g) was obtained by the treatment received K_{soil}+K_{foliar} followed by K_{soil} (8.85g) and K_{foliar} (6.58g), while the lowest (4.02g) with untreated plants. In both cultivars, application of K_{soil}+K_{foliar} as one treatment resulted in a significant increase in pods weight, seed yield per plant, number of seeds per plant, shelling % and seed oil content in comparison to untreated plants (control). However, in Giza-6 applied of K_{soil} singly increased pods weight, number of seeds per plant and oil % compared to other treatment received K_{foliar} singly. On the other hand, applied the K_{foliar} singly with Line-623 increased the pods weight per plant, number of pods and seeds per plant, shelling %, oil content and oil yield in comparison to the treatment received K_{soil} singly. Application of soil potassium fertilizer singly increased the calcium content in the seeds of Giza-6 cultivar compared to control plants or K_{foliar} and K_{soil}+K_{foliar}, while it was increased by applying K_{soil}+K_{foliar} with Line-623 in comparison to untreated plants or K_{soil} and K_{foliar}. On the other hand, the Fe, Zn and Mn contents were increased in Giza-6 cultivar by applying K_{soil}+K_{foliar} in comparison to untreated plants or K_{soil} and K_{foliar}, while in Line-623 under the same treatment Fe and Zn contents were increased in comparison to untreated plants or K_{soil} and K_{foliar}.

Key words: Groundnut · Yield · Potassium · Soil and foliar application

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is an important summer oil seed crop and food grain legume. It is a valuable cash crop planted by millions of small farmers because of its economic and nutritional value. About two thirds of world production is crushed for oil and remaining one third is consumed as food. The shelled nuts are consumed after roasting, frying, salting or boiling and in many culinary preparations and confectionery products. The high-energy value, protein content and minerals make groundnut a rich source of nutrition at a comparatively low price. Groundnut cakes obtained after oil extraction is a high protein animal feed. It contains about 50% oil, 25-30% protein, 20% carbohydrates and 5% fiber and ash which make a substantial contribution to human nutrition [1]. Crop fertilization with potassium in Egypt is altogether missing merely on the assumption that Egyptian soils are rich in potassium in Nile valley and Delta and crops do not need external potassium supply. However, under continuous cropping in most of the crops essentially deplete soil potassium reserves especially in newly reclaimed sandy soil which extended in groundnut cultivation. Balanced fertilization is essential for maximum

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yields and maintenance of soil fertility. The maximum benefit due to application of K fertilizer and even secondary nutrients is not obtained in absence of adequate quantities of available macronutrients in the soil. It has been well established that most of the plant nutrients are absorbed through the leaves and absorption would be remarkably rapid and nearly complete. Moreover, foliar feeding practice would be more useful in early maturing crops, which could be combined with regular plant protection programmes. If foliar nutrition is applied it reduces the cost of cultivation which in turn reduces the amount of fertilizer thereby reducing the loss and also economizing crop production. Foliar feeding is often effective when roots are unable to absorb sufficient nutrients from the soil. Studies carried out by Nelson *et al*. [2] have shown that both pre-plant and foliar K applications can increase soybean yields with low to medium soil K levels. Although foliar and soil application of K fertilizers have been used to maintain optimum level of nutrients [3] in crop, there is limited information on the effect of foliar and soil K fertilizer on seed composition (protein, oil, fatty acids and minerals). The positive effect of applying potassium was reported by Ali and Mowafy [4], who indicated that adding potassium fertilizer significantly increased number of branches and pods/plant, weight of pods, seeds/plant, 100-seed weight, pods, seeds and oil yield. Moreover, Mohamed and Gobarah [5] pointed that increasing soil K levels significantly increased number of branches and pods/plant, weight of pods and seeds/plant, 100-seed weight as well as pod, seed, oil and protein yields. On contrary, the oil percentage is the only character that is negatively responded to increasing the K level. Mekki *et al*. [6] and Salwau and Hassanein [7] on soybean revealed that foliar nutrition with potassium increased number of pods/plant and seed yield/plant, 100-seed weight and seed and oil yields. El-Emam *et al*. [8] indicated that 1000-seed weight and number of capsules/plant were increased by adding potassium fertilizer as soil application. Bassiem and Anton [9] on sesame and Gabr [10] on groundnut found that applying potassium as soil application increased seed yield and seed oil content. Contrarily, severe mineral nutrient deficiencies due to inadequate and imbalanced use of nutrients are one of the major factors responsible for low yield [11]. Higher yield might be due to the significant effect of nutrient potassium sprays enhancing number of pods per plant and improved pod filling and phytomass production due to increased photosynthetic activity and effective translocation of assimilates to reproductive parts resulting in higher yield [12, 13].

Recently, groundnut has been given great attention from Ministry of Agriculture, as well as from the Scientific Institutes in Egypt due to its importance for the new sandy areas, but the sandy soils faces 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 for improving pods production and seed quality. Therefore, the main objective of this study was to investigate the effect of soil and foliar application of potassium on yield and yield components of two groundnut varieties grown in sandy soil.

MATERIALS AND METHODS

A pot experiments were carried out during two summer seasons 2013 and 2014 in the greenhouse of the National Research Center, Dokki, Giza, Egypt in order to investigate the effect of soil and foliar application of potassium on yield and yield components of two groundnut varieties (Giza-6 and Line-623). The analysis of soil used was carried out following the methods described by Jackson [14]. Seeds of two groundnut varieties (Giza-6 and Line-623) mainly obtained from the Oil Crops Department, Agricultural Research Centre, Giza, Egypt were sown in earthenware pots (40 cm diameter and 40 cm depth) filled by 20 kg sandy soil in May 15 during summer seasons of 2013 and 2014. Pots were arranged in factorial experiment in complete randomized design with five replicates. Soil texture is sandy, pH 7.7, EC 0.11 dSm^{-1}, organic matter (OM) 0.50%, calcium carbonate 3.3%, total N 38.8 ppm, available P 4.4 ppm and available K 2.8 ppm. Thinning was practiced at 30 days after planting to leave one plant/pot till harvest. Phosphorus fertilizer was added before sowing at a rate of 6.0 g/pot of calcium super phosphate (15.5% P_2O_5). Nitrogen fertilizer was applied as two equal portions at a rate of 0.60 g/pot for each in the form of ammonium nitrate (33.5%N) at 30 and 60 days after planting (DAP). Soil potassium fertilizer was applied in equal two portions at 45 and 60 DAP as soil application at the rate of 115kg K/ha in the form of potassium sulfate (48-52% K_2O), while the potassium foliar application was applied twice in the form of liquid potassium (36 % K_2O) at the rate of $3cm^3$/L at the same time of soil application. At harvest time (120 DAP) the plants in all pots of the treatments used were harvested, dried under sunshine for one week. The following yield and yield components were determined such as pods weight/plant (g), number of pods/plant, number of seeds/plant, seed yield/plant (g), 100-seed weight (g) and shelling%. Seed oil content was determined by using Soxhelt unit extractor and petroleum ether (40-60°C) as solvent according to the method described by A.O.C.S [15]. Oil yield (g/plant) was calculated by multiplying the seed yield/plant (g) with oil %. Calcium content (ppm) in the seeds was determined by using Flame photometer, while Fe, Zn and Mn (mg/g DW) were determined by using atomic absorption apparatus.

Statistical Analysis: All obtained data of yield and its components were statistically analyzed by using MSTAT-C programme according to Snedecor and Cochran [16] and the combined analysis according to Steel and Torrie [17].

RESULTS AND DISSUSSION

Effect of Soil and Foliar Application of Potassium on Yield and Yield Components of Groundnut: Data presented in Table 1 indicated that the yield and its components of groundnut were significantly affected by applying soil or foliar potassium fertilizer singly and/or in combination between them in one treatment. Pods weight was increased significantly under these treatments compared to untreated plants (control), however, the differences between K_{soil} and K_{foliar} was not significant. The highest pods weight (32.44g) was produced by the treatment received K_{soil}+K_{foliar}, while the lowest (15.12g) with control plants. Hafiz and El-Bramawy [18] illustrated that foliar spraying sesame plants with 1or 2% potassium sulphate induced significant increases number of capsules/plant and seed yield/plant compared to unsprayed plants. The higher concentration (2% potassium sulphate) significantly exceeded (1%) in the aforementioned characters. Number of pods and seeds/plant, as well as seed yield per plant seems to be the same trend, the differences between K_{soil} and K_{foliar} was not significant in seed yield per plant as indicated in pods weight per plant, while the differences between the two treatments was significant in number of pods and seeds per plant. Kalaiselvan *et al.* [19] mentioned that applying 35KgK_2O/ha as a basal application and spraying with 1% potassium increased most of yield attributes in sesame. Shehu *et al*. [20] on sesame observed that number of capsules/plant and seed weight/plant were increased by adding potassium fertilization (22.5 and 45Kg K_2O/ha). The highest values of number of pods (34.17), seeds (45.83) per plant as well as seed yield per plant (22.27g) were obtained by applying K_{soil}+K_{foliar} as one treatment. Such increases in seed yield per plant by applying the treatment of K_{soil}+K_{foliar} estimated by 144.46, 40.15 and 36.88 % in comparison to control plants, K_{soil} and K_{foliar}, respectively. Potassium fertilization can be either applied to soil or as foliar spray to plants. Soil application is the standard form of application and has its own advantages unless soil pH and other factors affect the movement and uptake from soil to the plants. However, Nelson *et al.* [2] have shown that both pre-plant and foliar K applications can increase soybean yields with low to medium soil K levels. Although foliar and soil application of K fertilizers have been used to maintain optimum level of nutrients in crop [21]. The positive effect of applying potassium was reported by Ali and Mowafy [4], who indicated that adding potassium fertilizer significantly increased number of pods/plant, weight of pods and seeds/plant, pods and seeds yields. Moreover, Mohamed and Gobarah [5] showed that increasing soil K levels significantly increased number of pods/plant, weight of pods and seeds/plant, pods and seed yields. These results indicated that foliar nutrition of groundnut plants with potassium may increase the efficiency of potassium utilization in enhancing physiological fact that potassium involved in plant metabolism as well as large number of enzymes that are activated by potassium as foliar spray or as soil application encouraged for increasing the plant capacity building metabolites [22]. These findings are in harmony with those obtained by Menjell [12] and Gowthami and Rama [13], who reported that higher yield might be due to the significant effect of nutrient potassium sprays enhancing number of pods per plant and improved pod filling and phytomass production due to increased photosynthetic activity and effective translocation of assimilates to reproductive parts resulting

Table 1: Effect of soil and foliar application of potassium on yield and yield components of groundnut during summer seasons 2013 and 2014 (average of two seasons)

Potassium(K)	Pods weight (g/plant)	Number of pods/plant	Seed yield (g/plant)	Number of seeds/plant	100- seed weight (g)	Shelling %	Oil %	Oil yield (g/plant)
Control	15.12c	9.17d	9.11c	15.50d	44.84c	61.28b	44.22b	4.02d
K_{soil}	25.0.7b	20.83c	15.89b	25.33c	48.68bc	58.18b	48.89a	6.58c
K_{foliar}	23.70b	27.00b	16.27b	39.50b	56.58b	76.93a	49.03a	8.85b
K_{soil}+K_{foliar}	32.44a	34.17a	22.27a	45.83a	55.32a	72.74a	49.92a	11.13a
LSD 0.05	3.07	3.45	1.86	3.68	8.66	8.96	1.67	1.22

Table 2: Yield and Yield components of two groundnut cultivars in response to soil and foliar application of potassium fertilizer during summer seasons 2013 and 2014 (average of two seasons)

Varieties	Potassium (K)	Pods weight (g/plant)	Number of pods/plant	Seed yield (g/plant)	Number of seeds/plant	100- seed weight (g)	Shelling %	Oil %	Oil yield (g/plant)
Giza-6	Control	13.14f	8.00	8.88d	13.68e	35.70	67.98b	46.24b	4.10
	K_{soil}	29.11b	20.67	13.90c	29.11d	39.55	47.60c	49.00a	6.14
	K_{foliar}	24.19cd	28.67	18.14b	24.19b	57.00	76.70b	48.80a	8.91
	K_{soil}+K_{foliar}	38.61a	35.33	20.22b	38.61a	60.52	52.99c	50.13a	10.13
Mean	--	26.26a	23.17	15.28	35.58a	48.19b	61.32b	48.54	7.32
Line- 623	Control	17.11d	10.33	9.34d	17.33e	53.97	54.59c	42.19c	3.94
	K_{soil}	21.02b	21.00	17.88b	25.33d	57.79	68.76b	48.79a	7.03
	K_{foliar}	23.21c	25.33	14.40c	32.33c	56.15	77.16b	49.25a	8.81
	K_{soil}+K_{foliar}	26.26a	33.00	24.32a	35.00c	70.12	92.49a	49.71a	12.12
Mean	--	21.90b	22.42	16.48	27.50b	59.51a	73.25a	47.49	7.98
LSD 0.05		4.35	NS	2.63	5.20	NS	12.67	2.35	NS

in higher yield. Similar results were obtained by Aboelill *et al.* [23], who reported that foliar K spray increased the yield and its attributes in groundnut grown in newly reclaimed sandy soil.

Data in Table 1 also indicated that the 100-seed weight and shelling percentage were increased by applying K_{foliar} compared to untreated plants or other two potassium treatments, however the differences between K_{foliar} and K_{soil}+K_{foliar} and K_{soil} and control treatment were not significant. The highest 100-seed weight (56.86g) and shelling percentage (76.93%) were obtained with the treatment received K_{foliar}. Regarding to oil content and oil yield the results in Table 1 indicated that application of potassium fertilizer as soil or foliar as well as when combination with them were not significantly affected for oil percentage, while applying these treatment either soil or foliar singly as well as in combination with them resulted in a significant increase in oil content compared to control plants, such increases in oil content reached to 4.67, 4.81 and 5.70%, respectively. El-Emam *et al*. [8] on sesame cleared that 1000-seed weight was increased by adding potassium fertilizer as soil application. Bassiem and Anton [9] on sesame and Gabr [10] on groundnut found that applying potassium as soil application increased seed oil content. Umar and Bansal [24] indicated that the best results of groundnut plants were achieved with foliar application of 1% KCl. The positive effect of potassium on seed oil content (%) might be due to important role of K in enhancing enzymes activity and metabolism of lipids [22].

Oil yield was also different significantly with the present treatments. The highest oil yield (11.13g) was obtained by the treatment received K_{soil}+K_{foliar} followed by K_{soil} (8.85g) and K_{foliar} (6.58g), while the lowest (4.02g) with untreated plants. The increase of oil yield in groundnut plants received potassium fertilizer (soil + foliar) as one treatment estimated by 176.87% in comparison with the untreated plants. The increment in oil yield/ha using K application could be due to the increase in seed yield/plant and seed oil content (%). These results are in accordance with those emphasized by Salwau and Hassanein [7] with foliar application of potassium. Also, Hafiz and El-Bramawy [18] indicated that oil yield/ha of sesame was significantly increased by increasing potassium sulphate concentration as foliar nutrition from zero to 2%. Ibrahim and Eleiwa [25] reported significantly high oil (%) values in groundnut seeds when K was applied at a rate of 50 Kg/acre. They stated that this might be due to the enhanced absorption of nutrients from the soil solution resulting from their abundance when higher fertilization rates were applied and hence promoted better assimilation leading to higher oil percentage and oil yield.

Data presented in Table 2 indicated that the yield and yield components of two groundnut cultivars were significantly affected by soil or foliar application of potassium fertilizer and also with combination of them as one treatment, except number of pods per plant; 100-seed weight and oil yield were not significantly affected. In general, Giza-6 cultivar was superior in pods weight and number of seeds per plant than other cultivar Line- 623, while 100-seed weight and shelling % were significantly increased with Line-623 compared to the other cultivar Giza-6. Data in Table 2 also indicated that in both cultivars, application of K_{soil}+K_{foliar} as one treatment resulted in a significant increase in pods weight, seed yield per plant, number of seeds per plant, shelling % and seed oil content in comparison to untreated plants (control). The same trend was observed with number of pods per plant, 100-seed weight and oil yield per plant, but these increases were not reaching to the level of significant. However, in Giza-6 applied of K_{soil} singly increased pods weight, number of seeds per plant and oil % compared to other treatment received K_{foliar} singly. On the other hand, applied the K_{foliar} singly with Line-623 increased the pods weight per plant, number of pods and seeds per plant, shelling %, oil content and oil yield in comparison to the treatment received K_{soil} singly (Table 2). In general, the highest values of pods weight (38.61g), number of seeds per plant (36.61) and oil percentage (50.13%) were obtained by Giza-6 x K_{soil}+K_{foliar}, while the highest values of seed yield per plant (24.32g), shelling percentage (92.49%) and oil yield per plant (12.12g) were obtained with Line-623 x K_{soil}+K_{foliar}.

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 [26]. The positive effect of applying potassium was reported by many researchers Ali and Mowafy [4] indicated that adding potassium fertilizer significantly increased each of pods/plant, weight of pods and seeds/plant, 100-seed weight, pod and seed and oil yields. Moreover, Mohamed and Gobarah [5] showed that increasing soil K levels significantly increased number of branches and pods/plant, weight of pods and seeds/plant, 100-seed weight as well as pod, seed and oil yields. 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 [22]. Moreover, K enhances translocation from leaves to 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 [27, 28]. 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. The present results are in agreement with those obtained by Aboelill *et al.* [23] and El–Habbasha *et al.* [29], on groundnut, who reported that foliar spray with potassium (800 cm^3/acre) or soil application (90kg/ha) increased the number of pods and seeds per plant, pods weight, 100-seed weight and oil content.

Effect of Soil and Foliar Application of Potassium on Calcium and Some Micronutrients Contents in the Seeds of Two Groundnut Cultivars: Data in Table 3 indicated that application of soil potassium fertilizer singly increased the calcium content in the seeds of Giza- 6 cultivar compared to control plants or K_{foliar} and K_{soil}+K_{foliar}, while it was increased by applying K_{soil}+K_{foliar} with Line-623 in comparison to untreated plants or K_{soil} and K_{foliar}. On the other hand, the Fe, Zn and Mn contents were increased in Giza-6 cultivar by applying K_{soil}+K_{foliar} in comparison to untreated plants or K_{soil} and K_{foliar}, while in Line-623 under the same treatment Fe and Zn contents were increased in comparison to untreated plants or K_{soil} and K_{foliar}. The Mn content was only increased with applying potassium as foliar spray in the same cultivar.

Table 3: Effect of soil and foliar application of potassium fertilizer on calcium and some micronutrients contents in the seeds of two groundnut cultivars during summer season 2013

Varieties	Potassium (K)	Ca (ppm)	Fe	Zn	Mn
			(mg/g DW)		
Giza-6	Control	14.36	1.13	0.21	0.11
	K_{soil}	24.10	1.47	0.29	0.13
	K_{foliar}	21.30	1.48	0.55	0.14
	K_{soil}+K_{foliar}	23.16	2.14	0.56	0.17
Mean	--	20.73	1.56	0.40	0.14
Line- 623	Control	14.05	0.87	0.35	0.20
	K_{soil}	18.65	0.96	0.50	0.21
	K_{foliar}	20.14	1.02	0.88	0.22
	K_{soil}+K_{foliar}	21.33	1.14	1.10	0.18
Mean	--	18.54	1.00	0.71	0.27

However, the highest value of calcium (24.10 mg/g DW) was obtained with Giza-6 x K_{soil}, while the highest values of Fe (2.14 mg/g DW), Zn (1.10 mg/g DW) and Mn (0.22 mg/g DW) were obtained by Giza-6 x K_{soil}+K_{foliar}, Line-623 x K_{soil}+K_{foliar} and Line-23 x K_{foliar}, respectively. Foliar feeding is often the most effective and economical way to correct plant nutrients deficiencies, which improve nutrients utilization by plants and increasing nutrients uptake [25]. El-Habbasha *et al.* [29] on groundnut, reported that the nitrogen and phosphorus seed content were increased by applying 90kg K_2O/ha. This means that the potassium fertilizer may enhance plant utilization of nutrients and water which was reflected in increasing uptake of some macro and micronutrients by plants.

CONCLUSION

It can be concluded that application of potassium fertilizer either soil or foliar applied increased the yield and yield components of two groundnut cultivars. The higher yield might be due to the significant effect of nutrient potassium sprays in combination with soil potassium application resulted in an increased in number of pods per plant, pods weight, seed yield per plant, oil and oil yield. The maximum benefit due to application of K fertilizer is not obtained in absence of adequate quantities of available macronutrients in the soil. It has been well established that most of the plant nutrients are absorbed through the leaves and absorption would be remarkably rapid and nearly complete. Moreover, foliar feeding practice would be more useful in early maturing crops grown in newly reclaimed sandy soil characterized with low soil fertility.

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