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Effect of Irrigation Regimes and Foliar Spraying of Potassium on Yield, Yield Components and Water Use Efficiency of Wheat (*Triticum aestivum* L.) in Sandy Soils

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Abstract: Two field experiments were conducted at Al-Hussein society for reclaiming and cultivating land - 64Km Cairo Alexandria desert road, Giza Governorate, Egypt. during 2007/2008 and 2008/2009 growing seasons, to study the effect of irrigation regimes (1350, 1600 and 1850 m^3/fed.) and different treatments spraying with potassium (1, 2, 3% and control, 48 kg K_2O/ fed. as soil application) on yield, yield components and water use efficiency of wheat (Giza 168 cultivar). Results indicated that the differences between irrigation regimes for leaf area index, plant height, number of tillers/plant, number of spikelets per spike, spike length, 100-grain weight, harvest index in first season only, water use efficiency and grain yield per fed. were significant in the two seasons. Irrigation wheat plants with 1850m^3/fed. gave the highest values for all studied traits except harvest index and water use efficiency. On the other hand, irrigation with 1350 m^3/fed gave the highest values for water use efficiency only, in the two seasons. The differences between 1600m^3/fed and 1850 m^3/fed were insignificant for all studied traits except water use efficiency. Number of tillers, spike length, in the first season only, leaf area index, plant height, number of spikelets / spike, 100-grain weight, grain yield/fed., harvest index and water use efficiency were significantly increased with increasing potassium concentration from 1 to 2 or 3% in the two growing seasons. The interaction between irrigation regimes and spraying with potassium were significant for all studied traits except leaf area index and harvest index in the second season, plant height, number of tillers / plant, number of spikelet's / spike, spike length in the first and second seasons. Irrigation wheat plants with 1600m^3/fed and foliar application of 2 or 3% potassium gave the highest values of most studied attributes. The differences between foliar spraying of 1% potassium and the control treatment were significant, while, the differences between the control treatment and 2 or 3% potassium spray were insignificant of most studied attributes. Also, results show that, irrigation wheat plants until 1600 m^3/fed in critical stages of wheat and sprayed with 2% potassium increased the grain yield /fed and yield components and water use efficiency under new reclaimed soil conditions.

Key words: Wheat · Irrigation regimes · Potassium fertilizer · Sandy soil · Water salinity · New reclaimed soils · Sprinkler irrigation

INTRODUCTION

Wheat (*Triticum aestivum,* L.) is one of the main cereal crops, cultivated to meet great demands of the population for human feeding. It is the most important staple for bread flour in Egypt. Rapid increase in wheat consumption outpaced domestic production due to population growth. The area of wheat in Egypt was estimated at about 2841795[(1)] feddan in the 2008/2009 season, which produced about 8.000 million tons. Over all agriculture production from wheat has tended to increases increscent years, but even this is not enough to keep up with population growth.The adequate supply of irrigation water and potassium application as foliar spraying are two main factors affecting directly the growth and productivity of wheat plant.Water supply is limiting factor for crop production, for sustainable agriculture, it is desirable to obtain higher grain yield using the least amount of irrigation water. Grain yield was affected by both the magnitude of water deficit and stage of growth subjected to deficit. Schneider and Howell, [1] indicated that increasing irrigation water amounts from zero to 100% of soil water significantly increased grain yield. Awad *et al.* [2] found that increasing irrigation

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water amounts from 60 to 100% significantly increased the yield and its components. Mahlooji and Akbari [3] showed that using water salinity in sprinkler irrigation with concentration 7000 ppm decreased the grain yield by 50% compared with 3200 ppm. El-Hadi and Khadr [4] found that wheat responded to water stress conditions for surface or sprinkler irrigation (with using normal (100%) or half normal (50%) from recommended) in newly reclaimed (sandy or calcareous soils) with applied 120kg K_2O/ha. Grain yield significantly increased by 14% approximately. Haikel and Melegy [5] concluded that the maximum grain yield and lowest water use efficiency of wheat Giza 164 variety was obtained irrigated with recommended requirement +25% under sprinkler irrigation system and sandy soil conditions. Singh *et al.* [6] found that the yield and yield components of wheat plants were decreased with decreased the irrigation water amount as well as the quality.

Potassium play vital role and stimulates biological process in the plant cell as enzymes activity, respiration, photosynthesis, chlorophyll, creation, carbohydrate formation, water amounts balance in leaves and regulate stomata opining as well as direct effect on the disease resistance. Many researches reported about the important role of potassium as foliar spraying in increasing all studied attributes of wheat. El-Defan *et al.* [7] indicated that potassium, as soil application at a rate 16 kg K_2O/fed + foliar application of 1% K_2O, 24kg K_2O / fed + foliar 1.5% k_2O were superior for grain yield, straw yield and 100-grain weight, followed by foliar K treatments only, compared with control (24 kg k_2O/fed.). Abdi *et al.* [8] reported that foliar spraying of potassium with 1 or 5% (KCl) before flowering increased grain yield and number of grain per head, while, spraying after flowering increased significantly protein content and 1000-kernel weight. Arabi *et al.* [9] found that foliar application potassium at a rate 5 g/liter + 60g K_2O /ha soil application in three critical stages increased grain yield compared with control. Aissa and Mhiri [10] reported that foliar application of 3% potassium sulfate during critical water deficit improved the grain yield by 6.5-9.1%, while, application 2% potassium sulfate during elongation and early heading stages increased grain yield and weight of 1000 grains by 15.4 and 9.04%, respectively, compared with control. Hussein [11] indicated that foliar spraying with potassium and Nervatine and a supplemental irrigation during heading stage of wheat (Sakha 93 variety) significantly increased the number of tillers / plant, spike length, number of grains/spike, grain weight / spike, number spikes/ m^2, 1000-grain weight and grain yield. Khan *et al.* [12] studied the response of wheat to foliar application K under rainfed conditions. The results indicated that potassium application with concentration 0.5% as KCl significantly increased the biological yield of wheat.

The sandy soil contains small amounts of potassium and organic matter. Therefore, it could be compensate this case by adding potassium as foliar spray raising water use efficiency for wheat in sandy soils. Therefore, the main objective of the investigation was to study the influence of foliar spraying of potassium on yield, yield components and water use efficiency at sandy soils.

MATERIALS AND METHODS

Two field experiments were carried out at Al- Hussein society for reclaiming and cultivating Land- 64 Km Cairo Alexandria desert road Giza Governorate, Egypt, during 2007/2008 and 2008/2009 seasons, to study the effect of irrigation regimes and foliar spraying with potassium on yield, yield components and water use efficiency of wheat (*Triticum aestivum,* L.) Giza 168 cultivar.

Mechanical and chemical analysis of the soil of the experimental sit according to standard method of Page [13] and Arnold [14] are presented in Table 1.

Table 1: Mechanical and chemical analysis of experimental site in 2007 / 2008 and 2008/2009 seasons

Mechanical Analysis	2007/2008	2008/2009
Sand %	91.68	91.40
Silt %	2.00	2.00
Clay %	6.32	6.60
Texture Class	Sand	Sand
Chemical Analysis		
pH	8.50	8.30
EC (mmohs/cm.)	0.73	0.74
$CaCO_3$ %	6.96	5.60
Ca^{++} meq /l	2.24	1.60
Mg^{++} meq/l	2.76	2.40
Na^{+} meq /l	2.43	2.47
K^{+} meq/l	0.59	0.88
$CO_3 + HCO_3$ meq /l	0.40	0.60
Cl^{-} meq /l	7.50	2.10
SO_4^{--} meq /l	0.12	4.65
Available (N) ppm	28.00	31.00
Available (P) ppm	9.21	9.45
Available (K) ppm	45.34	42.31
Fe^{++} ppm	2.00	2.20
Cu^{++} ppm	0.10	0.18
Zn^{++} ppm	1.10	0.32
Mn^{++} ppm	2.70	1.80

Table 2: Chemical properties of the irrigation water at the experimental site in 2007/2008 and 2008/2009 seasons

Water properties	2007/2008	2008/2009
pH	7.2	7.3
E.C mmohs / cm.	2.26	3.00
Ca^{++} meq / l	4.00	3.68
Mg^{++} meq / l	10.00	10.52
Na^{+} meq / l	9.21	9.91
K^{+} meq / l	0.21	0.39
CO_3^{-} meq / l	-	-
HCO_3^{-} meq / l	2.40	2.26
Cl^{-} meq / l	13.50	16.10
SO_4^{--} meq / l	7.52	6.14
Sodium Adsorption Ratio (S.A.R) as %	3.48	3.72
Residual sodium carbonate (R.S.C) %	-11.6	-11.94
Sodium soluble proportion (S.A.P) %	39.33	40.48

Studied Factors

A-irrigation Regimes:

- Irrigation with 1350m^3/fed. (Without irrigation planting). (I_1)
- Irrigation with 1600m^3/fed. (I_2)
- Irrigation with 1850m^3/fed. (I_3) (Water salinity from 1500-1920 ppm).

Sprinkler irrigation system is used in application water amounts every three days from planting until Heading stage and every two days from heading stage till maturity stage. Stopping irrigation was after 140 days from sowing in the two seasons and harvesting time was after 155 and 150 days from sowing in the first and second seasons, respectively.

B- Potassium Fertilizer Concentrations:

- Foliar spraying with 1%.
- Foliar spraying with 2%.
- Foliar spraying with 3%, were applied during critical growth stages of wheat (tillering stage, stem elongation stage, early heading and heading stages, i.e. at 30, 50, 70 and 90 days after sowing, respectively.
- Control, the recommended rate in new reclaimed sand soils, 48kg K_2O/fed in the form of potassium sulphate (48% K_2O) was added in equal four portions.

The experimental design was split plot with three replications, irrigation amounts were devoted to the main plots, while potassium concentrations were assigned to the sub- plots. Grains of wheat cultivar Giza 168 were sown at the rate of 60 kg/fed. on November 25th and 22th in the first and second seasons, respectively. The experimental unit area in both seasons was 21 m^2 (10x2.1m), 10 rows in each plot and 20 cm apart. Nitrogen fertilizer at the rate of 90kg N/fed. In the form of ammonium nitrate 33.5% N was applied in four equal doses for each at 15, 45, 60 and 75 days from sowing, respectively. Phosphorus fertilizer at the rate of 31.00 kg P_2O_5/fed in the form of calcium superphosphate (15.5% P_2O_5) was applied at sowing. Other cultural practices were performed as recommended for wheat production.

Studied Attributes: At harvest ten individual plants were chosen at random from each plot in both seasons and the following data were recorded.

- Leaf area index was calculated by the following formulae leaf area per plant (cm^2) = (Length x maximum width x 0.79) according to Voldeng and Simpson [15].

$$\text{Leaf Area Index (LAI)} = \frac{\text{Leaf area per plant (cm}^2\text{)}}{\text{Ground area per plant (cm}^2\text{)}}$$

- Plant height, in cm.
- Number of tillers / plant
- Number of spikelets / spike
- Spike length, in cm.
- 100- grains weight, in g
- Grain yield / fed., in ardab (One ardab= 150 kg)
- Harvest index %
- Water use efficiency (WUE) was calculated using the equation of Vites [16] for grain yield, as follow:

$$\text{Water use efficiency (WUE)} = \frac{\text{Grains yield, in kg/fed}}{\text{Irrigation water amounts, in m}^3\text{/fed.}}$$

The obtained data of plant parameters were Statistically analyzed according to the methods suggested by Gomez and Gomez [17]. Means obtained were differentiated by using the LSD values at 0.05 level of significance.

RESULTS AND DISCUSSION

Effect of irrigation regimes on growth, yield, yield components and water use efficiency of wheat in 2007/2008 and 2008/2009 seasons are presented in Table 3 and 4a and b. Leaf area index and plant height were significantly affected by different water regimes. The differences between treatments were significant in both seasons. The differences between 1600 m^3 /fed. and

Table 3: Effect of spraying with potassium and irrigation water amounts on leaf area index, plant height and number of tillers / plant in sandy soils of wheat at 95 days from sowing during 2007/2008 and 2008/2009 seasons

	2007/2008					2008/2009				
	Potassium					Potassium				
Irrigation amounts m^3/fed*	Control	1%	2%	3%	Mean	Control	1%	2%	3%	Mean
				Leaf area index						
I_1	5.75	4.71	5.75	5.75	5.49	3.88	3.43	3.87	3.87	3.76
I_2	5.81	5.77	5.81	5.81	5.80	4.73	4.32	4.73	4.73	4.63
I_3	5.81	5.77	5.82	5.81	5.80	4.72	4.32	4.73	4.74	4.63
Mean	5.79	5.42	5.79	5.79	5.70	4.44	4.02	4.44	4.45	4.34
LSD 5%	I= 0.01 K= 0.01 I x K = 0.01					I= 0.02 K= 0.11 I x K = NS				
				Plant height (cm)						
I_1	94.33	90.66	93.66	93.66	93.08	92.66	89.67	92.33	92.66	91.83
I_2	96.00	93.66	95.66	95.33	95.16	94.00	92.33	94.00	94.33	93.66
I_3	95.66	94.00	95.66	95.66	95.25	93.66	92.66	94.00	94.66	93.75
Mean	95.33	92.77	95.00	94.88	94.50	93.44	91.55	93.44	93.88	93.08
LSD 5%	I= 0.83 K= 0.48 I x K = NS					I= 0.61 K= 0.59 I x K = NS				
				Number of tillers/plant						
I_1	5.33	4.33	5.00	5.00	4.91	3.67	3.33	3.66	3.66	3.58
I_2	6.33	5.00	6.00	6.00	5.83	4.00	3.67	4.00	4.00	3.91
I_3	6.00	5.00	6.33	6.33	5.91	4.33	3.66	4.33	4.33	4.17
Mean	5.88	4.77	5.77	5.77	5.55	4.00	3.55	4.00	4.00	3.88
LSD 5%	I= 0.29 K= 0.36 I x K = NS			I= 0.19 K= NS I x K = NS						

I_1 = 1350 m^3 / fed I_2 = 1600 m^3 / fed I_3 = 1850 m^3 / fed, one feddan = 4200 m^2

Table 4a: Effect of spraying with potassium and irrigation water amounts on number of spikelets/spike, spike length and 100-grain weight in sandy soils of wheat during 2007/2008 and 2008/2009 seasons

	2007/2008					2008/2009				
	Potassium					Potassium				
Irrigation amounts m^3/fed.	Control	1%	2%	3%	Mean	Control	1%	2%	3%	Mean
				Number of spikelets/spike						
I_1	17.66	17.00	17.66	17.66	17.50	19.00	17.66	18.33	19.00	18.50
I_2	20.33	18.33	20.33	20.33	19.83	20.33	18.33	20.33	21.00	20.00
I_3	20.33	19.00	20.33	20.33	20.00	21.00	19.00	21.00	21.00	20.50
Mean	19.44	18.11	19.44	19.44	19.11	20.11	18.33	19.88	20.33	19.66
LSD 5%	I= 0.09 K= 1.04 I x K = NS					I= 1.13 K= 0.71 I x K = NS				
				Spike length (cm)						
I_1	12.00	11.00	12.00	12.00	11.75	12.00	11.33	11.66	12.00	11.75
I_2	13.33	11.66	13.33	13.33	12.91	12.33	11.67	12.00	12.33	12.08
I_3	13.66	11.67	13.66	13.33	13.08	12.33	12.00	12.34	12.34	12.25
Mean	13.00	11.44	13.00	12.88	12.58	12.22	11.66	12.00	12.22	12.03
LSD 5%	I= 0.33 K= 0.52 I x K = NS					I= 0.29 K= NS I x K = NS				
				100-grain weight (g)						
I_1	4.017	3.803	4.013	4.017	3.963	3.973	3.740	3.967	3.977	3.914
I_2	4.140	4.010	4.143	4.140	4.108	4.123	4.027	4.120	4.127	4.099
I_3	4.143	4.013	4.147	4.147	4.101	4.123	4.030	4.120	4.127	4.100
Mean	4.100	3.942	4.101	4.101	4.061	4.073	3.932	4.069	4.077	4.037
LSD 5%	I= 0.01 K= 0.01 I x K = 0.01					I= 0.02 K= 0.01 I x K = 0.02				

Table 4b: Effect of spraying with potassium and irrigation water amounts on grain yield (ardab/fed.) and harvest index in sandy soils of wheat during 2007/2008 and 2008/2009 seasons

	2007/2008					2008/2009				
	Potassium					Potassium				
Irrigation amounts m^3/fed.	Control	1%	2%	3%	Mean	Control	1%	2%	3%	Mean
	Grain yield (ardab/fed)*									
I_1	4.017	3.803	4.013	4.017	3.963	3.973	3.740	3.967	3.977	3.914
I_2	4.140	4.010	4.143	4.140	4.108	4.123	4.027	4.120	4.127	4.099
I_3	4.143	4.013	4.147	4.147	4.101	4.123	4.030	4.120	4.127	4.100
Mean	4.100	3.942	4.101	4.101	4.061	4.073	3.932	4.069	4.077	4.037
LSD 5%	I= 0.01 K= 0.01 I x K = 0.02					I= 0.05 K= 0.04 I x K = 0.06				
	Harvest index %									
I_1	35.41	34.61	35.36	35.53	38.49	45.49	44.02	45.53	45.49	45.13
I_2	40.72	38.51	40.44	40.86	38.56	45.65	43.86	45.69	45.61	45.20
I_3	40.85	38.53	40.91	40.62	38.53	45.71	44.04	45.55	45.68	45.25
Mean	38.99	37.21	38.90	39.00	38.53	45.62	43.97	45.59	45.60	45.19
LSD 5%	I= 0.23 K= 0.24 I x K = 0.41					I= NS K= 0.37 I x K = NS				

* One ardab = 150 kg wheat grains

1850 m^3 /fed. were insignificant. The highest values for leaf area index (5.80 and 4.63) and plant height (95.25 and 93.75). The positive effect for irrigation on leaf area index and plant height may be attributed to the effect of irrigation on the encouragement of cell elongation, cell division and consequently increase merestemic growth. These results corroborated finding of Haikel and Melegy [5].

Data presented in Table 3 and 4a indicated that numbers of tillers, number of spikelets /spike, spike length and 100-grain weight were significantly affected by different water regimes. The differences between treatments were significant in the two seasons. The highest values for number of tillers (5.91 and 4.17), number of spikelets / spike (20.00 and 20.50), spike length (13.08 and 12.25) and 100-grain weight (4.108 and 4.100) were obtained with application 1850m^3 irrigation water in the two seasons, respectively, except 100 - grain weight in the first season were obtained from the I_2(1600 m^3 /fed). Data presented in Tables 3 and 4a also indicated that the differences between I_2 and I_3 were insignificant. The positive effect of irrigation on studied traits may be due to the increase plant height and leaf area index, consequently increased net assimilation rate and dry matter accumulation. In addition , increasing irrigation water amount (1850 m^3 /fed) or decreasing irrigation water amount (1350 m^3 /fed) may by attributed to unbalanced soil water-air relations that led to reducing the photosynthesis activity and unbalanced relations between plant hormones and biological processes in the whole plant organs. These adverse conditions in the treated soils are undoubtedly of great importance throughout the vegetative growth and dry matter accumulation in the wheat plants. On the other hand, the beneficial effect of 1600 m^3 /fed. could be explained by enhancing plant growth and protecting soil fertility in the long run, that can be achieved through maintaining good soil water - air relation for mechanism of nutrients uptake by plant root. Thus, these favorable soil conditions are more related to a suitable medium in which seeds can be available. Also, potassium play vital role in water amounts balance in leaves and regulate stomata opining, carbohydrate formation and enzymes activity. These results are completely in agreement with those obtained by Schneider and Howell [1], Awad *et al.* [2], El-Hadi and Khadr [4] and Singh et *al.*, [6].

Application of 1600 or 1850 m^3 /fed irrigation water increased significantly grain yield /fed in the both seasons, while, the harvest index was significantly increased in the first season only (Tables 3 and 4b). The differences between I_2 and I_3 were insignificant. The increase grain yield /fed may be attributed to the increase in number of tillers / plant, number of spikelets / spike, spike length and 100 - grain weight. These results are in agreement with those obtained by Awad *et al.* [2], El-Hadi and Khadr [4] and Singh *et al.*, [6].

Regarding foliar spraying of potassium, results in Tables 3 and 4a, b indicated that a significant effects of potassium application on all studied traits in both seasons, except number of tillers and spike length in the

second season. Application of 2% potassium increased significantly leaf area index in the first season, while, application of 3% potassium increased leaf area index and plant height in the second season. On the other hand, the treatment received no potassium fertilizer (control) increased plant height in the first season. The differences between potassium concentrations 2 or 3% were insignificant. Such increases in the above mention traits may be due to the role of potassium element in stimulates biological processes in the plant cell as enzymes activity, respiration, photosynthesis, chlorophyll, creation of carbohydrate. Similar results were obtained by Hussein [11].

Data presented in Table 3 and 4a also indicated that number of tillers, number of spikelets / spike, spike length and 100 – grain weight were increased significantly with 2 or 3% potassium, as well as the control treatment in the both seasons, except number of tillers and spike length in the second season. Application 2% potassium gave the highest values for number of spikelets / spike, spike length and 100-grain weight in the first season, while, application 3% potassium gave the highest number of spikelets / spike and 100 - grain weight in the second season. On the other hand, the control treatment gave the highest number of tillers in the first season. The differences between potassium concentration 2 and 3% swere insignificant. From these results, it could be concluded that potassium application to wheat plants increased photosynthetic productivity of the plants and increasing the rate of dry matter translocation to the grains leading in a significant increase in the total grains weight and filling of grains, also, it could be attributed to the role or potassium in carbohydrate formation, water balance in leaves and regulate stomata opining as well as a direct effect stress resistance and increased water use efficiency. These, vital role of potassium reflected on yield and yield components. These results are completely in agreement with those obtained by El-Defan *et al.* [7], Abdi *et al.* [8] and Khan *et al.* [12], they indicated that foliar spraying of potassium increased yield and yield components with differences percentages.

Potassium increased significantly grain yield /fed and harvest index. Application 3% potassium gave the highest grain yield in the both seasons, as well as, harvest index in the first season , while, the control treatment gave the highest value in the second season (Table 4 b). Also, the differences between 2 and 3% potassium were not significant. The significant effect of potassium on grain yield and harvest index may be attributed to increased leaf area index, number of tillers, number of spikelets / spike, 100 - grain weight that led to increased the grain yield / fed. These results are in agreement with Arabi *et al.* [9], Aissa and Mhiri [10] and Hussein [11].

Concerning, the interaction effect between irrigation regimes and foliar spraying potassium was significant for most attributes studied in the two seasons, except leaf area index and harvest index in the second season only, plant height, number of tillers, number of spikelets/ spike and spike length in the two seasons. Results in Tables 3 and 4a ,b revealed that increasing irrigation water amount from 1350 to 1600 or 1850m^3/fed.in combination with of different concentration of potassium foliar spraying led to a significantly increase of most attributes studied. On the other hand, at the same irrigation regimes the differences between potassium concentration (control or 1% or 2 and 3%) were significant on most attributes studied in the two seasons. The highest value of leaf area index and harvest index in the first season (5.82 and 40.91) was produced by using I_3 (1850m^3/fed.) with 2% potassium, while the highest values for 100-grains weight (4.147 and 4.127g) was obtained with I_3 (1850m^3/fed.) and spraying 3% potassium in the first season with I_2 (1600m^3/fed.) and 2% potassium in the second season, while for grain yield / fed. (14.78 and 14.07, ardab) was obtained with I_2 and 3% or 2% potassium, in the two seasons, respectively, as compared with the other interactions. These findings are in agreement with those obtained by Arabi *et al.* [9], who indicated that using potassium with concentration 5g/l+60kg / ha soil application in three critical stages increased grain yield compared with control treatments. Aissa and Mhiri [10] found that foliar spray of potassium sulfate with concentration 3% during critical water deficit improved the grain yield by 6.5-9.1%, while, application of potassium sulfate with concentrate 2% during the elongation and early heading stages increased grain yield and weight of 1000 grains by 15.4 and 9.04%, respectively, compared with control treatment. El- Hadi and Khadr [4] indicated that wheat responded to water stress conditions under surface or sprinkler irrigation systems in sandy soils with applied 120kg K_2O. Hussein [11] indicated that foliar spraying with potassium + Nervatine with a supplemental irrigation at heading stage of wheat significantly increased yield and its components.

Water Use Efficiency (WUE): The water use efficiency presented in Table 5 is expressed as kg grain / m^3 water consumed by the wheat plants. This criterion has been used to evaluate the crop production under different

Table 5: Effect of spraying with potassium and irrigation water amounts on water use efficiency (kg/m^3) in sandy soils of wheat during 2007/2008 and 2008/2009 seasons

	2007/2008					2008/2009				
	Potassium					Potassium				
Irrigation amounts m^3/fed.	Control	1%	2%	3%	Mean	Control	1%	2%	3%	Mean
I_1	1.45	1.35	1.45	1.45	1.42	1.33	1.22	1.33	1.33	1.30
I_2	1.37	1.32	1.37	1.37	1.35	1.31	1.29	1.31	1.31	1.30
I_3	1.19	1.15	1.19	1.19	1.18	1.14	1.12	1.14	1.14	1.13
Mean	1.33	1.27	1.38	1.38	1.32	1.26	1.21	1.26	1.26	1.24
LSD 5%	I= 0.002 K= 0.002 I x K = 0.003					I= 0.003 K= 0.002 I x K = 0.003				

applied treatments per unit of consumed water by the crop plants. Results illustrated in Table 5 showed that irrigation wheat plants at I_1 (1350m^3/fed.) achieved a significant increase for the water use efficiency value and it was decreased with increasing irrigation water amounts up to 1850m^3/fed., ranged from 1.42 and 1.18 and 1.30 to1.13 kg/m^3 water. in the first and second seasons, respectively. These findings are in harmony with the scientific approaches that supposed the plant roots could be extract more soil water from a greater depth under conditions stress as compared to those irrigated at a relatively wet. That means the stored water in soil at water stress can be used with more efficiency. These results are in agreement with those reported by El- Hadi and Khadr [4] indicated that wheat responded to water stress conditions at in newly reclaimed with applied 120 kg K_2O / ha. Haikel and Melegy [5] concluded that the maximum grain yield and lowest water use efficiency of wheat was recorded at irrigated with recommended requirement under sandy soils conditions and sprinkler irrigation system.

Table 5 also indicated that water use efficiency tended to increase with increasing potassium concentration, where, wheat plants sprayed with 2 or 3% recorded the highest value of water use efficiency as compared with 1% or the control treatment in the two seasons. These results are in agreement with those reported by El-Hadi and Khadr [4], Arabi *et al.* [9], Aissa and Mhiri [10] and Hussein [11].

Results also showed that, irrigation wheat plants at 1350 m^3/fed. in critical stages of wheat with spraying 2% potassium gave the highest value of water use efficiency as compared with other interactions in the two seasons. This is undoubtedly of great importance due to the superiority was not only taken as a criterion for increasing the outputs of vegetative growth and crop yield for wheat plants. It could be recommended that irrigation wheat plants at 1600 m^3 /fed. in critical stages of wheat with sprayed with 2% potassium increased grain yield /fed and its components and water use efficiency under new reclaimed soil conditions.

REFERENCES

1. Schneider, A.D. and T.A. Howell, 1997. Methods, amounts and timing of sprinkler irrigation for winter wheat. Transactions of the ASAE., 40(1): 137-142.
2. Awad, A.M., H. El- Zaher, M.A. Moustafa, M.A. Sayed and A.M. Osman, 2000. Wheat production on sandy soils using different fertilization methods and irrigation regimes. Alex. J. Agric. Res., 45(1): 35-61.
3. Mahlooji, M. and M. Akbari, 2001. Effect of water salinity in sprinkler irrigation on yield of different wheat cultivars. Seed and Plant, 17(2): 16-17.
4. El-Hadi, A.H.A and M.S. Khadr, 2003. Efficiency of potassium fertilization under saline and drought conditions in Egyptian soils. Potassium and water management in West Asia and North Africa Proceedings of the Regional. Workshop of the International Potash Institute Amman- Jordan, from 5-6 November- 2003, pp: 85-96.
5. Haikel, M.A. and A.M. El- Melegy, 2005. Effect of irrigation requirements, seeding rates and bio-mineral fertilizer on wheat productivity in newly reclaimed soil under sprinkler irrigation system. J. Productivity and Development, 10(1):113-134.
6. Singh, R.B., C.P.S. Chauhna and P.S. Minhas, 2009. Water production functions of wheat irrigation with saline and alkali waters using double line source sprinkler system. Agric. Water Management, 96(5): 736-744.
7. El-Defan, T.A.A., H.M.A. El-Kholi, M.G.M. Rifaat and A.E.A. Allah, 1999. Effect of soil and foliar application of potassium on yield and mineral content of wheat grains grown in sandy soils. Egyptian J. Agric. Res., 77(2): 513-522.

8. Abdi, M., G. Nour- Mohamedi and A. Golchin, 2002. The influence of foliar nutrition of urea and potassium chloride on grain yield, grain protein content, yield components and leaf relative water content of Sardari wheat under rainfed conditions. J. Agric. Sci. Islamic Azad Univ., 8(1): 29-38.
9. Arabi, M.I.E., N. Mirali and M. Jawhar, 2002. Effect of foliar and soil potassium fertilization on wheat yield and severity of *Septoria tritici* blotch. Aust. Plant Pathology, 31(4): 359-362.
10. Aissa, A.D. and A. Mhiri, 2002. Phosphorus and potassium fertilization of durum wheat in high yielding cultivation in Tunisia. Cahiers Agric., 11(6): 391-397.
11. Hussein, S.M.A., 2005. Effect of supplemental irrigations, seeding rates and foliar application of potassium, macro and microelements on wheat productivity under rainfed conditions. Bull. of Faculty of Agric. Cairo Univ., 56(3): 431-453.
12. Khan, M.Z., S. Muhammad, M.A. Naeem, E. Akhtar and M. Khalid, 2006. Response of some wheat (*Triticum aestivum,* L.) verities to foliar application of N and K under rainfed conditions. Pakistan. J. Bot., 38(4): 1027-1034.
13. Page, A.L., 1982. Chemical and Microbiological properties. American Society of Agron. Inc. Soil Sci. Society of America, Inc. Madison Wisconsin, USA.
14. Arnold, K., 1986. Methods of Soil Analysis: Physical and Mineralogical Methods. Second edition. American Society of Agron. Inc. Soil Sci. Society of America. Inc. Madison Wisconsin.
15. Voldeng, H.D. and G.M. Simpson, 1967. Leaf area as an indicator of potential grain yield in wheat. Con. J. Plant Sci., 47: 359-365.
16. Vites, F. Jr., 1965. Increasing water use efficiency by soil management in plant environment and efficiency water use. J. American Society of Agron., 26: 537-546.
17. Gomez, K.A. and A.A. Gomez, 1984. Statistical Procedures for Agricultural Research. John Wiley and Sons, Inc., New York, USA.