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EFFECT OF POTASSIUM FERTILIZATION ON WATER ECONOMY AND MAIZE PRODUCTIVITY IN NEWLY RECLAIMED SALINE SOIL OF EGYPT

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ABSTRACT

A field experiment was carried out on saline soil (loamy sand soil) at Gelbana Village, El-Tina Plain, North – Western Sinai Peninsula , Egypt during two successive growing summer seasons of 2011 and 2012 to study the influence of potassium fertilization on the productivity of maize (*Zea mays L.* , cv. Trible hybrid 310) and yield component . The maize was grown on newly reclaimed saline soil of Egypt under different levels of irrigation water. The used irrigation water resource was El-Salam Canal . Potassium fertilization was applied as soil application at rates of 0 , 24 , 36 and 48 kg K_2O / fed. and as foliar application at rates of 0 , 1 , 2 and 4 % K_2O, equal to 0, 4 , 8 and 16 kg K_2O/ fed., respectively which dissolved in 400 liter water of irrigation and sprayed . The used K fertilizer was K_2SO_4 (48 % K_2O) . Each rate of added K as soil application and foliar application was added on two equal doses after 30 and 65 days from sowing . Surface irrigation system was used , where the soil was irrigated at three levels of water requirement (WR) of maize plant under saline soil conditions. These levels were 50 , 75 and 100 % of WR , which equal 4250 m^3 / fed. The experiment was carried out in split design with three replicates .

The obtained data show that , K fertilization with either of soil or foliar application resulted in a significant increase of the measured growth parameters .i.e. stover and yield (ton / fed.) , grains weight (g / plant) , ears weight (g / plant) , weight of 100 grains (g) and biological yield (ton / fed.) . According to the mean values of RC (%) , the grains yield was more than stover yield with foliar application , where the stover yield was more than grains yield with soil application. The increases in these parameters were increased with increasing K rate . At the same irrigation level , the yields of stover and grains produced from each one m^3 of the added water was increased with the increase rate of added K as soil or foliar application. Under different treatments of K fertilization, the grain content (%) of N , P , K and protein were increased significantly and its become more significant with the increase of added irrigation water. Maize grains contents (mg / kg) of Fe , Mn and Zn were increased significantly with the increase of added K fertilization for both soil and foliar applications . Except K, the contents of the determined macro and micronutrients resulted from the treatments of soil application, were higher than those associated the treatments of foliar application . Under saline soil conditions, the best treatment was soil application of K fertilization at rate of 48 kg K_2O / fed. with irrigation at 100 % WR .

The important conclusion which may be extract from the obtained data is potassium fertilization increased irrigation water use economy . The best value of water economy were with 48 kg K_2O / fed. as soil application and 4 % K_2O as foliar application at 50 % WR .

Keywords: Potassium fertilization , Methods and rates application, Saline soil, Water economy, Maize productivity and quality .

INTRODUCTION

Soil salinization is one of the major causes of declining agricultural productivity in many arid and semiarid regions of the world . Excessive salt concentrations in soil , in most cases , cannot be reduced with time by routine irrigation and crop management practices (Qadir *et al.,* 2001*)* . Also, the increasingly uses of low quality water and conventional agriculture practice continue on worsening the problem (Darwish *et al.,* 2005) .

Soil moisture is one of the most important factors which influence the yield and quality of crop as it affects the chemical, biological and physical conditions of soil . In the scarcity of the fresh water resources that , limited in a portion amounting 55 milliard m^3 water annually from Nile water . In addition, all drainage water between Aswan and Cairo are returned back to the Nile River, there by reused in the Delta where several main drains discharge to the Rosetta and Domitta branches (Amer *et al.,* 1996) .Thus, El-Salam Canal is one of the national promising projects involves the reuse of drainage water, after reducing its salinity levels by mixing the Nile water with Bahr Hadoos drains (1.095 milliard m^3 drainage water) and El – Serw drain (1.245 milliard m^3 drainage water) , which are considered the main source for the drainage water, while the fresh Nile water is about 2.11 milliard m^3 water (DRI , 1993) .

Potassium is one of the essential nutrients required for plant growth and reproduction. In general, potassium nutrition improves water use efficiency by its involvement in stomata regulation as well as by affecting growth and dry matter production . Also , both water use efficiency and water economy values show clearly that the high rate of K application had positive effect on the beneficial use of the water for different crops (Shehata *et al.,* 1990). Anderson *et al*.(1992) found water use efficiency was increased (12 %) of barley with high potassium application on coarse textured sandy soil. One of the mechanisms for improving plant tolerance to drought is to apply K which seems to have a beneficial effect in overcoming soil moisture stress. Potassium fertilization mitigates the adverse effects of moisture stress in plants by increasing translocation and maintaining water balance within plants (Greenwood and Karpinets , 1997) . Foliar fertilization of crops can complement and guarantee the availability of nutrients to crops for obtaining higher yields (Arif *et al.,*2006). Spraying wheat plants with K before subjecting the plants to drought treatment diminished the negative effects of drought on growth and in turn increases yield per plant (El-Ashry and El-Kholy , 2005) since, plants are able to utilize foliar-applied K and translocation it to almost all plant parts . El-Gamal (2008) mentioned that K nutrition improved water use efficiency. Kolahchi and Jalali (2007) stated that soluble K was increased with increasing number of irrigation and increasing potassium application rate .

Corn *(Zea mays L.)* known as maize is the world's third most important cereal crops after wheat and rice. Corn is grown primarily for grain and secondarily for fodder in raw material for industrial process . The grain is used for both human and animal consumption . The vegetation is part of the plant contgreen and either dried or med into silage for animal food. Maize is one of the most important foods in Egypt , where it is planted for use than 1.979 million fed. (2005) . The average grains yield slightly over 3.52 ton / fed. (Fayed , 2009) .

The objective of this study was to the evaluate application methods and rates of potassium fertilization efficiency under different water requirement levels in newly reclaimed saline soil in relation to maize growth and yield components .

MATERIALS AND METHODS

A field experiment was carried out on saline soil (loamy sand soil) at Gelbana Village , El- Tina Plain , North – Western Sinai Peninsula , Egypt during two successive growing summer seasons of 2011 and 2012 to study the influence of potassium fertilization (rate and application methods) on maize and water use economy under irrigation by El-Salam Canal water. Representative surface soil samples (0 - 30 cm) were taken from the soil used before performance of the experiment. Soil samples were air - dried, ground, good mixed, sieved through a 2 mm sieve and analyzed for some physical and chemical properties according to the methods described by Black (1965) and Cottenie *et al*. (1982) . The obtained data were recorded in Table (1).

Table (1) :Physical and chemical properties and the content of available macro – and micronutrients of the studied soil.

<table>
<tr><th rowspan="3">Physical properties</th><th colspan="4">Particles size distribution (%)</th><th rowspan="2">Textural grade</th><th rowspan="2">Bulk density (Mg / m³)</th><th rowspan="2">Total porosity (%)</th><th rowspan="2">Field capacity (%)</th></tr>
<tr><th>Coarse sand</th><th>Fine sand</th><th>Silt</th><th>Clay</th></tr>
<tr><td>13.27</td><td>57.56</td><td>9.23</td><td>19.94</td><td>Loamy sand</td><td>1.60</td><td>36.50</td><td>20.50</td></tr>
</table>

<table>
<tr><th rowspan="3">Chemical properties</th><th rowspan="2">pH 1:2.5 soil : water susp.</th><th rowspan="2">EC (soil paste) dS m⁻¹</th><th colspan="4">Soluble cations (meq / l)</th><th colspan="3">Soluble anions (meq / l)</th><th rowspan="2">OM (%)</th><th rowspan="2">CEC (cmol / kg)</th><th rowspan="2">CaCO3 (%)</th></tr>
<tr><th>Na⁺</th><th>K⁺</th><th>Ca²⁺</th><th>Mg²⁺</th><th>Cl⁻</th><th>HCO3⁻</th><th>SO4²⁻*</th></tr>
<tr><td>8.02</td><td>9.45</td><td>68.32</td><td>0.85</td><td>8.89</td><td>16.44</td><td>60.35</td><td>7.82</td><td>26.33</td><td>0.48</td><td>22.80</td><td>5.98</td></tr>
</table>

<table>
<tr><th rowspan="3">Available nutrients</th><th colspan="3">Macronutrients (mg / kg)</th><th colspan="4">Micronutrients (mg / kg)</th></tr>
<tr><th>N</th><th>P</th><th>K</th><th>Fe</th><th>Mn</th><th>Zn</th><th>Cu</th></tr>
<tr><td>44.00</td><td>4.71</td><td>187.01</td><td>3.96</td><td>2.63</td><td>0.82</td><td>0.55</td></tr>
</table>

*** SO_4^{2-} were calculated as the difference between the content of soluble cation (Na^+ , K^+ , Ca^{2+} and Mg^{2+}) and soluble anions (Cl^- and HCO_3^-) .**

Water samples were taken every month i.e. May , June, July and August during cultivation period of maize plants of two growing seasons, to detect the changes in water quality during the experimental work. The water samples were analyzed for some chemical properties according to the methods which were described by Cottenie *et al.* (1982) and Klute (1986) . The obtained data were recorded in Table (2).

The experimental plots in this study were 72 unit, including 3 levels of irrigation water, i.e. 50 , 75 and 100 % of water requirement (WR) of maize which equal to 2125 , 3187 and 4250 m^3 water, respectively × 2 application methods of K fertilizer (soil and foliar application) × 4 application rates of K fertilizer × 3 replicates. The area of each plot was 10.5 m^2 (3 m width × 3.5 m length, i.e. 1/400 fed.). So, the design of this experiment was spilt plot with three replicates . All agricultural practices beginning from sowing to harvesting were carried out as recommended by Egyptian Ministry of Agriculture . Before sowing , all plots were fertilized with ordinary super phosphate (15.5 % P_2O_5) at a rate of 45 kg / fed.

Maize grains (*Zea mays L.* , cv. Trible hybrid 310) were sown at 20 and 25 of May in the first (2011) and second season (2012) , respectively in 30 cm spaced hills at a rate of two grains / hill on rows with 70 cm width . Surface irrigation system was used where the applied amounts of irrigation water were calculated the based on the recommendations of Egyptian Ministry of Agriculture, the water requirement (WR) through grown season of maize plants under low water quality and saline soil conditions is 4250 m^3 / fed . The plants were thinned after 20 days from sowing at one plant per hill. Also, the plots were fertilized with urea (46 % N) at a rate of 120 kg N / fed. (recommended dose) , which divided into three equal doses, where these doses were added after 21 , 42 and 63 days from sowing . The used K fertilizer in this study was potassium sulphate (48 % K_2O) . Finally, the tested rates in soil application method were 0 , 24 ,36 and 48 kg K_2O/ fed. These rates equal 0, 100, 150 and 200 % of K recommended dose (24 kg K_2O / fed.) . Each rate of added K as soil application was added on two equal doses after 30 and 65 days of sowing. On the other hand, the application rates of K in the foliar method were 0 , 1 , 2 and 4 % K_2O , equal to 0, 4, 8 and 16 kg K_2O , respectively. The foliar solution was prepared at both rates and applied at the level of 400 liter / fed. using hand sprayer twice at the same time of soil application .

At 18 and 22 September of 2011 and 2012 respectively, the plants of each plot were harvested separately above the soil surface . The harvested plants were cure - dried and the ears were separated from stover. Also , the grains were separated from ears. After that some of agronomic traits were recorded, i.e., weight of stover yield (ton / fed.) ,weight of ear (g / plant) , weight of grain (g / plant) , weight of grains yield (ton / fed.) and weight of 100 grains (g) , where , ton = 1000 kg and ardab = 140 kg .

Table (2) : Irrigation water analysis during two seasons .
a – pH and salinity .

Determination		During the first season				During the second season			
		1^{st}	2^{nd}	3^{rd}	4^{th}	1^{st}	2^{nd}	3^{rd}	4^{th}
pH		8.11	8.31	8.35	8.43	8.40	8.42	8.55	8.50
EC (dS m^{-1})		2.50	2.31	2.10	2.20	2.30	2.28	2.42	2.36
Soluble cations and anions (meq / l)	Ca^{+2}	1.70	1.65	1.15	1.10	2.60	2.58	2.70	1.70
	Mg^{+2}	3.15	2.35	2.45	3.55	4.90	4.70	4.10	4.40
	Na^{+}	18.00	19.00	17.00	17.00	15.00	16.00	17.00	18.00
	K^{+}	0.24	0.32	0.36	0.32	0.53	0.48	0.58	0.46
	$CO_3^{=}$	nil	nil	nil	nil	nil	nil	nil	nil
	HCO_3^{-}	5.90	5.70	3.40	4.50	4.20	5.10	6.40	4.60
	Cl^{-}	12.30	12.5	12.10	11.20	10.60	11.70	12.00	12.80
	$SO_4^{=}$	5.89	5.12	5.56	6.47	6.20	6.00	5.90	6.20
SAR		11.56	13.44	12.67	11.15	7.75	8.39	9.22	10.31

1^{st} , 2^{nd} , 3^{rd} and 4^{th} = May , June , July and August , respectively .

b – Macronutrients and trace elements .

Sample	Macro nutrients (mg / l)				Trace elements (mg / l)				
	NO_3-N	NH_4-N	P	K	Fe	Mn	Zn	Pb	B
During first season									
1^{st}	5.90	19.3	5.61	9.36	0.26	0.47	0.74	0.68	0.029
2^{nd}	6.60	21.5	4.23	12.48	0.43	0.53	1.35	0.89	0.030
3^{rd}	6.10	19.1	4.84	14.04	0.41	0.66	1.52	1.01	0.036
4^{th}	6.10	20.4	4.81	12.48	0.37	0.62	1.49	1.23	0.028
During second season									
1^{st}	8.20	23.10	4.80	20.67	0.29	0.42	0.82	0.14	0.036
2^{nd}	7.40	20.80	4.90	18.72	0.37	0.45	0.75	0.16	0.041
3^{rd}	5.90	19.40	5.30	18.62	0.42	0.56	0.88	0.18	0.043
4^{th}	5.60	20.10	4.70	17.94	0.39	0.51	0.86	0.13	0.033

1^{st} , 2^{nd} , 3^{rd} and 4^{th} = May , June , July and August , respectively .

For chemical determination, dried grains were fine powdered and wet digested according to the method described by Chapman and Pratt (1961) . Nitrogen , P and K content in the digests were determined according to the methods described by Cottenie *et al.(* 1982) and Page *et al.* (1982) . Crude protein percent was estimated in such organ by multiplying N % by 5.75 as described by A.O.A.C. (1990) . The atomic absorption spectrophotometer was used to determine Zn, Mn and Fe concentrations in prior organ according to the methods recommended by A . O. A. C. (1990) .

Water economy was calculated by dividing the crop yield by the amount of added water (Talha *et al.,* 1980) . As judged by kg of plant organs produced per m^3 water consumed .

Results of all the studied parameters were statistically analyzed using the combined analysis of the two growing seasons according to Gomez and Gomez (1984) . The significant differences among means were tested using the least significant differences (L. S. D.) at 5 % level of significance .

RESULTS AND DISCUSSION

Growth Parameters :

Effect of K fertilization .

The presented data in Tables (3 and 4) show the effect of the studied treatments of K fertilization and irrigation water on maize growth parameters and its relative change (RC) . The data show, K fertilization as soil or foliar application resulted in a significant increase of the measured growth parameters .i.e. stover yield (ton / fed.) , grain weight (g / plant) , ears weight (g / plant) , weight of 100 grains (g), grains yield (ton / fed.) and biological yield (ton / fed.). The increases in these parameters were due to the increase of added K . The rate of these increases which reflect the rate response of maize plant to K fertilization and measured as relative change (RC,%) was positive and varied from parameters to another. According to the mean values of RC (%) , the studied growth parameters takes the following order : grain yield > stover yield > weight of 100 grain > grains weight > ears weight for foliar application , and its stover yield > grains yield > weight of 100 grain > grains weight > ears weight for soil application . This arrangement was found at different application rates of K fertilization. Also, this arrangement show high effect of K fertilization on the grains yield of maize. In addition this order was not affected by irrigation rate. In this respect, Abou El-Defan *et al.* (1999) ; El - Bana and Gomaa (2000) and Basak (2006) obtained similar results .

Regarding to the effect of application methods of K fertilizer on some growth parameters of maize plant, data recorded in Tables (3 and 4) show that, the found increases in the studied growth parameters and its RC (%) resulted from soil application were higher than those associated with the treatments of foliar application . This trend was attributed to the greater units of added K in soil application compared with that used in foliar application . With both soil and foliar applications at the same irrigation rate, the rate of the found increases in the studied growth parameters was decreased with the increase of added K fertilizer. These results are in agreement with those obtained by El - Bana and Gomaa (2000) and Hu *et al* . (2008) obtained similar results .

The calculated values of agronomic efficiency (AE) for each added unit of K fertilizer (kg K_2O) for both soil and foliar applications which recorded in Tables (3 and 4) show that , with different application rates of K under different irrigation levels , AE values of added K as foliar were higher than those found in the soil application . This trend show high efficiency and greater response of maize plant to each weight unit of added K in foliar application compared with that resulted from soil application. These findings were resulted from the direct uptake of added K in foliar application by plant leaves and also from rapid adsorption and fixation reactions for added K as soil application (Basak , 2006) . The values of AE were decreased with the increase of added K in both foliar and soil applications and with all growth parameters under study. These findings are in harmony with those obtained by Abou El-Defan *et al.* (1999) and El-Gamal (2008) .

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Concerning to the data of biological yield (ton / fed.) which recorded in Tables (3 and 4) as affected by the studied treatments of K fertilization may be observed that, under different irrigation regime, the values of biological yield were increased with the increase rate of added K fertilization in foliar and soil application . Biological yield associated with K soil fertilization was higher than those resulted from K foliar fertilization. These findings show high positive and increase effect of soil application on grains and stover yield (ton / fed.) compared with that found with foliar application. The high values of biological yield were found at rate of 48 kg K_2O at soil application. In this respect Abou El-Defan *et al.* (1999) and Karki *et al.* (2005) obtained on similar results .

Effect of irrigation regime .

Data in Tables (3 ,4 and 5) show that, the increase of added irrigation water increases significantly some growth parameters under study and non significant increases on the others , where the lowest values were associated the treatments of 50 % of WR. These findings may be supported by the calculated values of RC (%) which were negative and varied from parameter to another . These values also show that , with both foliar and soil application methods of K fertilization at different application rates, the high negative values of RC were found with weight of 100 grain and the low negative values were recorded with stover yield. These findings were observed at 50 and 75 % WR . The same data also show that , the values of RC of growth parameters as affected by rates of added irrigation water in K soil application were more negative compared with those found with the treatments of foliar application. These findings concluded that , the drought resulted in the decrease of K absorption which applied as soil application compared with that occurred with foliar application. These results are in agreement with those obtained by Anderson *et al.* (1992) and El-Dardiry *et al.* (2010) .

Table (5) : Relative change (%) of some growth parameters of maize plant* as affected by reduction of irrigation level (RCIL) under the studied treatments of K – fertilization .

Potassium treatments		Irrigation level (% of WR)	Stover yield (ton/fed.)	Ears weight (g/plant)	Grains weight (g/plant)	Weight of 100 grain (g)	Grains yield (ton / fed.)
Application method	Application rate						
Control	0	50	-8.725	-2.426	-3.378	-16.000	-10.474
		75	-6.516	-1.617	-1.351	-8.000	-3.087
Foliar application of K_2O (%)	1	50	-1.698	-3.266	-5.357	-25.714	-8.942
		75	-0.796	-1.759	-2.381	-14.286	-2.327
	2	50	-2.036	-3.713	-4.706	-28.947	-3.591
		75	-0.170	-2.228	-2.353	-15.789	-1.526
	4	50	-0.689	-3.828	-5.202	-30.952	-6.822
		75	-0.284	-1.914	-2.890	-16.667	-1.554
Soil application (kg K_2O / fed.)	24	50	-6.573	-4.600	-5.202	-20.513	-2.068
		75	-4.353	-1.695	-2.312	-10.256	-1.169
	36	50	-1.305	-5.176	-5.682	-25.000	-1.871
		75	-0.507	-2.118	-2.841	-13.636	-0.595
	48	50	-1.436	-6.818	-6.145	-25.532	-2.510
		75	-0.790	-2.500	-2.793	-10.638	-1.004

*** Mean values of two growth seasons .**

Data in Table (6) show , the irrigation water economy for maize plants grown under saline conditions varied widely according to the added water rates as a percent of water requirement of maize plant under Egyptian conditions and also to application rates methods of K fertilization . These data show that, at the same level of irrigation , the yield produced from both stover and grains (for each one m^3 of the added water) was increased with the increase rate of added K as soil or foliar application . The increases in the produced stover were higher than those recorded with grains . These findings means that , irrigation water economy was increased with K fertilization especially with soil application . So , under narrow and small shortage of irrigation water supply may be over coming by K fertilization . The results show that, the best values of water economy was with 48 kg K_2O / fed. for soil application and 4 % K_2O for foliar application at 50 % WR . In this respect, Shehata *et al.* (1990) and Fusheng (2006) obtained similar results .

Combined effect of K fertilization and irrigation regime .

Based on the recorded data in Tables (3 to 6) and the premenition discussion for the individual effect of either of K fertilization or irrigation regime it may be observed and concluded that, there is a good positive relationship between these two factors . All growth parameters under study were increased with the increase of both K fertilization and irrigation water rates individually and in combination, where AE of the tested K fertilization rates were increased with the increase of added irrigation water especially with soil K fertilization. Also water economy of irrigation water increased with the increase of added K fertilization where these increases were higher than with soil application .

Table (6) : Water economy as affected by rates and methods application of K fertilization .

Yield component*	Irrigation level (% of WR)	Methods and rates application of K fertilization						
		Control 0.0 K	Foliar application of K_2O (%)			Soil application (kg KO_2 / fed.)		
			1	2	4	24	36	48
Stover	50	0.7581	1.7440	2.1732	2.3059	2.0602	2.5628	2.5835
	75	0.5177	1.1735	1.4766	1.5438	1.4063	1.7226	1.7339
	100	0.4153	0.8871	1.1092	1.1609	1.1026	1.2984	1.3106
Grain	50	0.3821	0.9393	1.0108	1.0155	1.0249	1.0861	1.0965
	75	0.2758	0.6718	0.6884	0.7154	0.6897	0.7336	0.7424
	100	0.2134	0.5158	0.5242	0.5449	0.5233	0.5534	0.5624

*** Mean values of two growth seasons .**

Maize Grains Content of N, P, K and Protein :
Effect of K fertilization.

The presented data in Tables (7 and 8) show that, the maize grains content (%) of N, P, K and crude protein and their relative changes (RC,%) as affected by both K application methods and their application rates . These data reveals that, with both foliar and soil applications, the content of these macronutrients was increased significantly with the increase of added K fertilization rates . This trend was found in the two growth seasons with all irrigation regime treatments . These results were in confirmation with those found by Ibrahim (2005) and El-Dardiry *et al.* (2010) . With different irrigation treatments, grains maize contents of N , P, K and protein in the plants treated by K as soil application were higher than those treated by K as foliar application. This trend was resulted from the greater units of K_2O added per fed. in the soil application compared with that added as foliar application. Thus, the calculated values of RC (%) for the content of N , P , K and crude protein under soil application treatments were higher than those recorded with those found for the treatments of foliar application. Also, the values of RC for these determinations were increased with the increase of added K in both soil and foliar applications . The increases of grains maize contents of N , P , K and protein as a result of K fertilization were varied from one to another, where the high RC values were recorded with P followed by K . In this respect, El-Bana and Gomaa (2000) and El- Gamal (2008) obtained similar results .

Table (7) : Effect of K – fertilization on maize grains content (%) of N , P , K and protein and their relative changes* (RC , %) under different irrigation level with foliar application of K .

Added of K_2O (%)	Irrigation level (% of WR)	N		P		K		Protein	
		%	RC (%)	%	RC (%)	%	RC (%)	%	RC (%)
0	50	0.875		0.195		1..050		5.031	
	75	0.930		0.215		1.100		5.348	
	100	0.990		0.230		1.180		5.693	
	Mean	**0.932**		**0.213**		**1.110**		**5.357**	
1	50	1.040	18.86	0.225	15.38	1.340	27.62	5.980	18.86
	75	1.075	15.59	0.265	23.26	1.395	26.82	6.153	15.05
	100	1.105	11.62	0.305	32.61	1.430	21.19	6.354	11.61
	Mean	**1.073**	**15.36**	**0.265**	**23.75**	**1.388**	**25.21**	**6.162**	**15.17**
2	50	1.100	25.71	0.245	25.64	1.365	30.00	6.325	25.72
	75	1.125	20.97	0.290	34.88	1.425	29.55	6.469	20.96
	100	1.165	17.68	0.335	45.65	1.480	25.42	6.699	17.67
	Mean	**1.130**	**21.45**	**0.290**	**35.39**	**1.423**	**28.32**	**6.498**	**21.45**
4	50	1.110	26.86	0.265	35.90	1.380	31.43	6.383	26.87
	75	1.155	24.19	0.355	65.12	1.430	30.00	6.641	24.18
	100	1.195	20.71	0.395	71.74	1.495	26.69	6.871	20.69
	Mean	**1.153**	**23.92**	**0.338**	**57.59**	**1.435**	**29.37**	**6.632**	**23.91**
LSD at 0.05 level									
(A)		0.0019		0.0018		0.0024		0.0019	
(B)		0.0032		0.0021		0.0031		0.0043	
(A x B)		0.0039		0.0037		0.0049		0.0039	

*** Mean values of two growth seasons .**
A = Irrigation level , B = Added of K and A x B = Interaction .

Table (8) : Effect of K – fertilization on maize grains content (%) of N , P , K and protein and their relative changes* (RC , %) under different irrigation level with soil application of K .

Added of K (kg K_2O / fed.)	Irrigation level (% of WR)	N		P		K		Protein	
		%	RC (%)	%	RC (%)	%	RC (%)	%	RC (%)
0	50	0.875		0.195		1.050		5.031	
	75	0.930		0.215		1.100		5.348	
	100	0.990		0.230		1.180		5.693	
	Mean	**0.932**		**0.213**		**1.110**		**5.357**	
24	50	1.190	36.00	0.280	43.59	1.390	32.38	6.843	36.02
	75	1.255	34.95	0.315	46.51	1.455	32.27	7.220	35.00
	100	1.305	31.82	0.350	52.17	1.495	26.69	7.504	31.81
	Mean	**1.250**	**34.26**	**0.315**	**47.42**	**1.447**	**30.45**	**7.189**	**34.28**
36	50	1.240	41.71	0.320	64.10	1.415	34.76	7.130	41.72
	75	1.305	40.32	0.370	72.09	1.480	34.55	7.504	40.31
	100	1.365	37.88	0.410	78.26	1.540	30.51	7.849	37.87
	Mean	**1.303**	**39.97**	**0.367**	**71.48**	**1.478**	**33.27**	**7.494**	**39.97**
48	50	1.260	44.00	0.350	79.49	1.450	38.10	7.245	44.01
	75	1.335	43.55	0.435	102.33	1.510	37.27	7.676	43.53
	100	1.400	41.41	0.480	108.70	1.605	36.02	8.050	41.40
	Mean	**1.332**	**42.99**	**0.422**	**96.84**	**1.537**	**37.13**	**7.657**	**42.98**
LSD at 0.05 level									
(A)		0.0017		0.0025		0.0026		0.0020	
(B)		0.0045		0.0024		0.0032		0.0042	
(A x B)		0.0034		0.0050		0.0053		0.0040	

*** Mean values of two growth seasons .**
A = Irrigation level , B = Added K and A x B = Interaction .

Effect of irrigation regime .

The data recorded in Tables (7 and 8) show that, under different application rates of K fertilization as soil or foliar applications, the grains contents (%) of N , P , K and protein were increased significantly with the increase of irrigation water amounts. This trend was cleared by the calculated values of RC (%) for the contents of these parameters where the highest values were recorded with the plants irrigated by 100 % WR followed by these irrigated at 75 % WR . These results are in agreement with those obtained by El-Gamal (2008) and El - Dardiry *et al.* (2010) .

Data in Table (9) show the values of RC (%) of grains content of N , P , K and protein at same application rate of added K as soil and foliar applications as affected by added amounts (% WR) of irrigation water . These values were negative and became more negative with soil application compared with those found with foliar treatments . The negative level of these values varied from K treatment to another . Such these negative effect of irrigation water depression was mentioned by Saini and Westagate (2000); Fusheng (2006) and El-Gamal (2008) .

The combined effect of K fertilization and irrigation regime .

According to the presented data in Tables (7 to 9) and the premeditative discussion for the individual effects of both K fertilization and irrigation regime , it may be concluded that , increasing application rates of K fertilization and added irrigation water were resulted in a high increases of grain contents of N , P , K and protein . These increases were more higher in K soil application with different levels of irrigation regime .

Table (9) : Relative change* (%) of maize grains content of macro – and micronutrients and protein as affected by reduction of irrigation level under the studied treatments of K fertilization .

Potassium treatments		Irrigation level (% of WR)	Macronutrients (RC , ma.)			Protein (RC, p.)	Micronutrients (RC , mi.)		
Application method	Application rate		N	P	K		Fe	Mn	Zn
Control	0	50	-11.62	-15.22	-11.02	-11.63	-22.12	-12.24	-4.01
		75	-6.06	-6.52	-6.78	-6.06	-10.90	-5.40	-1.89
Foliar application of K_2O (%)	1	50	-5.88	-26.23	-6.29	-5.89	-20.93	-2.74	-0.98
		75	-2.72	-13.12	-2.45	-3.16	-10.47	-1.32	-0.75
	2	50	-5.58	-26.87	-7.77	-5.58	-18.53	-2.97	-0.90
		75	-3.43	-13.43	-3.72	-3.43	-9.60	-1.02	-0.28
	4	50	-7.11	-32.91	-7.69	-7.10	-15.46	-2.96	-1.00
		75	-3.35	-10.13	-4.35	-3.35	-9.28	-0.83	-0.24
Soil application (kg K_2O / fed.)	24	50	-8.81	-20.00	-7.02	-8.81	-17.58	-9.49	-2.93
		75	-3.83	-10.00	-2.68	-3.79	-9.89	-4.93	-1.17
	36	50	-9.16	-21.95	-8.12	-9.16	-20.00	-9.93	-2.87
		75	-4.40	-9.76	-3.90	-4.40	-9.60	-3.45	-1.52
	48	50	-10.00	-27.08	-9.66	-10.00	-20.00	-11.13	-1.31
		75	-4.64	-9.38	-5.92	-4.65	-9.52	-4.73	-0.09

*** Mean values of two growth seasons .**

Maize Grains Content of Some Micronutrients :
Effect of K fertilization .

The presented data in Tables (10 and 11) show that, the maize grain contents (mg / kg) of Fe, Mn and Zn were increased significantly with the increase of added K fertilization for both soil and foliar applications . With different treatments of irrigation, the content of these micronutrients resulted from the treatments of soil application were higher than those associated the treatments of foliar application . So , all values of RC (%) calculated for the grain contents of Fe , Mn and Zn were positive . Also, these values of RC (%) for the soil application were higher than those associated the treatments of foliar one at different treatments of irrigation (Tables, 10 and 11) . In both application methods of K fertilization the high content was recorded with Fe followed by Zn . On the other hand, the highest values of RC for soil application were found with Mn followed by Fe , where were found with Fe followed by Mn for the treatments of foliar application . These findings were found with different application rates of K fertilization under all treatments of irrigation . These results are in agreement with those obtained by Abou El - Defan *et al.* (1999) and Karki *et al*. (2005) .

Table (10) : Effect of K – fertilization on maize grains content (mg / kg) of some micronutrients and their relative changes* (RC , %) under different irrigation level with foliar application of K .

Added of K_2O (%)	Irrigation level (% of WR)	Fe (mg /kg)	Fe RC (%)	Mn (mg /kg)	Mn RC (%)	Zn (mg /kg)	Zn RC (%)
0	50	29.50		9.11		27.50	
	75	33.75		9.82		28.11	
	100	37.88		10.38		28.65	
	Mean	**33.71**		**9.77**		**28.09**	
1	50	34.00	15.25	10.29	12.95	29.24	6.33
	75	38.50	14.07	10.44	6.31	29.31	4.27
	100	43.00	13.52	10.58	1.93	29.53	3.07
	Mean	**38.50**	**14.28**	**10.44**	**7.06**	**29.36**	**4.56**
2	50	36.50	23.73	10.45	14.71	28.61	4.04
	75	40.50	20.00	10.66	8.55	28.79	2.42
	100	44.80	18.27	10.77	3.76	28.87	0.77
	Mean	**40.60**	**20.67**	**10.63**	**9.01**	**28.76**	**2.41**
4	50	41.00	38.98	10.48	15.04	28.65	4.18
	75	44.00	30.37	10.71	9.06	28.87	2.70
	100	48.50	28.04	10.80	4.05	28.94	1.01
	Mean	**44.50**	**32.46**	**10.66**	**9.38**	**28.82**	**2.63**
LSD at 0.05 level							
Irrigation level (A)		0.579		0.122		0.070	
Added of K (B)		0.924		0.075		0.108	
Interaction (A x B)		N.S.		0.243		0.140	

*** Mean values of two growth seasons .**

Table (11) : Effect of K – fertilization on maize grains content (mg / kg) of some micronutrients and their relative changes* (RC , %) under different irrigation level with soil application of K .

Added of K (kg K_2O/ fed.)	Irrigation level (% of WR)	Fe (mg /kg)	Fe RC (%)	Mn (mg /kg)	Mn RC (%)	Zn (mg /kg)	Zn RC (%)
0	50	29.50		9.11		27.50	
	75	33.75		9.82		28.11	
	100	37.88		10.38		28.65	
	Mean	**33.71**		**9.77**		**28.09**	
24	50	37.50	27.12	12.49	37.10	32.49	18.15
	75	41.00	21.48	13.12	33.60	33.08	17.68
	100	45.50	20.12	13.80	32.95	33.47	16.82
	Mean	**41.33**	**22.91**	**13.14**	**34.55**	**33.01**	**17.55**
36	50	40.00	35.59	13.06	43.36	32.55	18.36
	75	45.20	33.93	14.00	42.57	33.00	17.40
	100	50.00	32.00	14.50	39.69	33.51	16.96
	Mean	**45.07**	**33.84**	**13.85**	**41.87**	**33.02**	**17.65**
48	50	42.00	42.37	13.33	46.32	33.14	20.51
	75	47.50	40.74	14.29	45.52	33.55	19.35
	100	52.50	38.60	15.00	44.51	33.58	17.21
	Mean	**47.33**	**40.57**	**14.21**	**45.45**	**33.42**	**19.02**
LSD at 0.05 level							
Irrigation level (A)		0.579		0.122		0.070	
Added of K (B)		0.9240		0.078		0.108	
Interaction (A x B)		N.S.		0.243		0.140	

***Mean values of two growth seasons.**

Effect of irrigation regime .

The presented data in Tables (10 and 11) show that, the maize grain contents (mg / kg) of Fe , Mn and Zn were increased with the increase of added irrigation water. These increases were found at all application rates of K fertilization either of soil or foliar application. This enhanced effect of the increase of added water may be cleared by the calculated values of RC (%) for grain contents of Fe , Mn and Zn as recorded in Table (9) . The values of RC at 75 % WR were higher than those at 50 % WR . This trend was found with the three micronutrients under different treatments of K fertilization. These results may be attributed to the high release rate of these micronutrients followed by increase of their absorbed rates by plants with the increase of soil moisture content specially under saline conditions. The effect of irrigation level on the content of Fe , Mn and Zn was varied from nutrient to another, where these nutrients may be arranged according to their content of maize grains as follows : Fe > Zn > Mn . Also, with the three micronutrients and at the same level of irrigation , the calculated values of RC (%) for these nutrients were not replaced defined trend which varied from treatment to another. These results are in agreement with those obtained by Fusheng (2006) and El-Dardiry *et al.* (2010) .

The combined effect of K fertilization and irrigation regime .

According to the presented data in Tables (9 , 10 and 11) and the previous discussion for the individual effects of both K fertilization and irrigation regime , it may be concluded that , increasing application rates of K fertilization and irrigation level (% of WR) were associated with clear increases of grains content (mg / kg) of Fe , Mn and Zn . These increases were higher for the treatments of K soil application at different levels of irrigation regime than foliar one .

Conclusion.

The obtained data reveal the following conclusions , under newly reclaimed saline soil , K fertilization improved plant growth and its content of nutrients, the K fertilization as soil application was more confirmed than foliar one . Agronomic efficiency of K fertilization value was the best with irrigation at 100 % water requirement .

REFERENCES

Abou El-Defan , T. A. ; El- Kholi , H.M.A. ; Rifaat , M.G.M. and Abd Allah, A.E. (1999) . Effect of soil and foliar application of potassium on yield and mineral content of wheat grains grown in sandy soils. Egypt. J. Agric. Res., 77 (2) 513 – 522 .

Amer , M. ; Abdel Wahab, M. and Shrief, M. M. (1996) . An integrated study for sea water in treason in the Nile Delta aquifer. Water Resources Strategic Research Activity (WRSR) . Ministry of Public Works and Water Resources, Cairo, Egypt .

Anderson, M. N.; Jensen, C. R. and Losch, R. (1992) . The interaction effects of potassium and drought in field grown barley (I) Yield , water use efficiency and growth . Soil and Plant Sci. , 42 (1) 34 – 44 .

A.O.A.C. (1990) ." Association of Official Methods of Analysis Chemists, Official Methods of Analysis ." 5 th Ed. Washington , D. C. , USA .

Arif , M. ; Khan, M. A. ; Akbar , H. and Ali , S. (2006) . Prospects of wheat as a dual purpose crop and its impact on weeds. Pak. J. Weed Sci. Res. , 12 (1 - 2) 13 – 17 .

Basak , R. K. (2006) . " Fertilizers" Kalyani Publishers, Ludhiana-New Delhi, Nodia (U. P.) ,Hyderabad, Chennai , Calcutta, Cuttack .

Black , C. A. (1965) . " Methods of Soil Analysis ." Part 1 Amer. Sco. of Agron. Ince. Madison , Wisconsin , USA .

Chapman , H. O. and Pratt , P. E. (1961) ." Methods of Analysis for Soil , Plant and Water ". California Univ., Div. Agric. Sci., Davis, California , USA .

Cottenie , A. ; Verloo, M. ; Kiekens , L. ; Velghe , G. and Camerlyek , R. (1982) . " Chemical Analysis of Plants and Soils " . Laboratory of Analytical and Agro chemistry, State Univ. Ghent, Belgium .

Darwish , T. ; Atallah , T. ; Moujabber , M. and El – Khatib , N. (2005) . Salinity evolution and crop response to secondary in two agro - climatic zones Lebanon , Agric. Water Manage . 78 : 152 – 164.

DRI (1993) . Drainage Research Institute , Drainage water in the Nile Delta, discharge , salinities and chemical composition , Reuse monitoring program , Report 35 , Cairo, Egypt .

El-Ashry–Soad M. and El - Kholy , M. A. (2005) . Response of wheat cultivars to chemical desiccants under water stress conditions. J. Appl. Sci. Res., 1 (2) 253 – 262.

El-Bana , A.Y.A. and Gomaa, M. A. (2000) . Effect of N and K fertilization on maize grown in different population under newly reclaimed sandy soil . Zagazig J. Agric. Res., 27 (5) 1179 – 1195 .

El-Dardiry, E. I. ; Abd El-Hady , M. and El-Ashry , S. M. (2010) . Effect of water regime and potassium application on water relations and nutrients uptake of wheat plant. Int. J. Academic. Res. , 2 (2) 75 – 82 .

El-Gamal , B. A.H. (2008) . Response of wheat plants grown on low cation exchange capacity soils to fertilization with potassium . M. Sc. Thesis, Fac. of Agric. , Minufiya Univ., Egypt .

Fayed , S.A.Z. (2009) . Effect of irrigation with sewage and drainage water on properties of some new reclaimed soils and plant growth . M. Sc. Thesis, Fac. of Agric., Minufiya Univ., Egypt .

Fusheng , L. (2006) . Potassium and Water Interaction . International Workshop on Soil Potassium and K Fertilizer Management, Agric. Col. , Guangxi Univ., 14 November .

Gomez , K. A. and Gomez , A. A. (1984) ." Statistical Procedures for Agricultural ", Research , 2 nd (Ed.) John Wily and Sons, New York .

Greenwood , D. J. and Karpinets , T. V. (1997) . Dynamic model for the effect of K fertilizer on crop growth , K uptake and soil K in arable cropping . 1- Description of the model . Soil Use and Manag. , 13 : 178 – 183 .

Hu , Y. ; Zoltan , B. and Schmidhalter , U. (2008) . Effect of foliar application on the growth and mineral nutrient content of maize seedling under drought and salinity. Soil Sci. and Plant Nutri. 45 (1) 133-141 .

Ibrahim , S. M. (2005) . Responses of vegetative growth and chemical composition of Jojoba seedlings to some agricultural treatments . Ph.D. Thesis , Fac. of Agric., Minia Univ., Egypt .

Karki , T. B. ; Ashok , K. and Gautama , R. C. (2005) . Influence of integrated nutrient management on growth , yield , content and uptake of nutrients and soil fertility status in maize (*Zea mays*) . Ind. J. of Agric. Sci. , 75 (10) 682 – 685 .

Klute , A. (1986) . " Methods of Soil Analysis". American Society of Agron., Inc. Soil Sci. Soc. of Amer., Inc. Madison Wisconsin , USA , 2 nd Edition.

Kolahchi , Z. and Jalali , M. (2007) . Effect of quality of the leaching of potassium from sandy soil . J. Arid Environ. , 68 (4) 624 - 639. (C. F. , El -Gamal , 2008) .

Page , A. L. ; Miller , R. H. and Keeney , D. R. (1982) ." Methods of Soil Analysis" . Part (2) , Amer. Soc. of Agron., Madison , Wisconsin , USA.

Qadir , M. ; Ghafoor , A. and Murtaza , M. (2001) . Amelioration strategies for saline soils . Land Degradation and Development . 11 (6) 501 – 521.

Saini , H. S. and Westagate , M. E. (2000) . Reproductive development in grain crops during drought . Adv. Agron. , 68 : 59 – 95 .

Shehata , H. M. ; El-Dosouky , M. H. and El-Kadi , M. A. (1990) . Influence of K- fertilization for crops on water use efficiency in calcareous soil . Desert Inst. Bull. , A.R.E. , 40 (2) 177 – 190 .

Talha , M. ; Aziz , M. A. and El-Toni , E. M. (1980) . The combined effect of irrigation intervals and cycocel treatments on *Pelargonium Graveolens L.* II. Evapotranspiration and water economy. Egypt. J. Soil Sci., 20 (2) 121 .

تأثير التسميد البوتاسي علي إقتصاديات الماء و إنتاجية الذرة في الأراضي الملحية حديثة الإستصلاح في مصر

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أجريت تجربة حقلية علي أرض ملحية (طميية – رملية) بقرية جلبانة – سهل الطينة – شمال غرب شبه جزيرة سيناء – مصر , خلال موسمي نمو صيف متتاليين لعامي ٢٠١١ - ٢٠١٢ م , و ذلك لدراسة تأثير التسميد البوتاسي علي إنتاجية محصول الذر ة صنف هجين ثلاثي ٣١٠ و تركيبه الكيميائي و نموه تحت مستويات مختلفة من ماء الري . حيث كان مصدر الري ترعة السلام . و تم إضافة السماد البوتاسي بطريقتين (أرضية – رش) و كان معدل الإضافة الأرضية هو : صفر , ٢٤ , ٣٦ و ٤٨ كيلو جرام بو2أ / فدان بينما كان معدل الإضافة عن طريق الرش هو : صفر , ١ , ٢ و ٤ ٪ بو2أ وهذه النسب تساوي صفر , ٤ , ٨ و ١٦ كيلو جرام بو2أ / فدان علي التوالي حيث تم إذابتها في ٤٠٠ لتر من ماء الري . و كان السماد البوتاسي المستخدم كبريتات البوتاسيوم ٤٨ ٪ بو2أ و تم إضافته علي جرعتين متساويتين (بعد ٣٠ , ٦٥ يوم من الزراعة) سواء كانت أرضية

أو رش . و كان الري سطحيا بثلاث مستويات هي ٥٠ , ٧٥ و ١٠٠ ٪ من الإحتياجات المائية لهذا المحصول تحت هذه الظروف و هي ٤٢٥٠ م٣ مياه / فدان . و صممت التجربة بنظام قطع منشقة في ثلاث مكررات . و أوضحت النتائج مايلي : -

إضافة التسميد البوتاسي سواء كان إضافة أرضية أو رشا يؤدي إلي زيادة معنوية في مدلولات النمو التي تحت الدراسة مثل محصول القش و الحبوب (طن / فدان) , وزن الحبوب (جم / نبات) , وزن الكيزان (جم / نبات) , وزن المائة حبة (جم) و أيضا المحصول الحيوي (طن / فدان) و ذلك تحت نفس مستوي ماء الري . و طبقا لمتوسط قيم التغير النسبي فإن مدلولات النمو أوضحت أن محصول الحبوب > محصول القش و ذلك في إضافة البوتاسيوم عن طريق الرش , بينما في الإضافة الأرضية فإن محصول القش > محصول الحبوب .

تحت جميع معاملات التسميد البوتاسي فإن محتوي الحبوب من النيتروجين , الفوسفور و البوتاسيوم (٪) و البروتين يزيد زيادة معنوية بزيادة ماء الري المضاف . كما أن محتوي الحبوب من الحديد , المنجنيز و الزنك يزيد زيادة معنوية بزيادة إضافة التسميد البوتاسي سواء في الإضافة عن طريق الرش أو الأرض . و عموما فإن محتوي المغذيات الكبري و الصغري المقدرة في الحبوب كان أعلي في الإضافة الأرضية عنه في الإضافة عن طريق الرش فيما عدا عنصر البوتاسيوم . كما أشارت النتائج أنه تحت ظروف الأراضي الملحية فإن أحسن معاملة كانت مع الإضافة الأرضية لسماد البوتاسيوم بمعدل ٤٨ كيلو جرام بو2أ / فدان مع إضافة ماء ري بمعدل ١٠٠ ٪ من الإحتياجات المائية .

و أخيرا أشارت النتائج أن التسميد البوتاسي يزيد من الإستخدام الإقتصادي لمياه الري و كان ذلك أكثر وضوحا مع الإضافة الأرضية لسماد البوتاسيوم بمعدل ٤٨ كيلو جرام بو2أ / فدان و الإضافة عن طريق الرش بمعدل ٤ ٪ بو2أ و ذلك عند ٥٠ ٪ من الإحتياجات المائية في كليهما .

قام بتحكيم البحث

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Table(4) : Effect of K-fertilization and its agronomic efficiency (AE) under different irrigation level on some growth parameters of maize plant*and its relative change (RC ,%) with soil application of K .

Added of K (kg K_2O / fed.)	Irrigation level (% of WR)	Stover yield			Ears weight			Grains weight			Weight of 100 grains			Grains yield			Biological yield (ton / fed.)
		(ton / fed .)	RC (%)	AE (ton / kg K_2O)	(g / plant)	RC (%)	AE (g / kg K_2O)	(g / plant)	RC (%)	AE (g / kg K_2O)	(g)	RC (%)	AE (g / kg K_2O)	(ton / fed.)	RC (%)	AE (ton / kg K_2O)	
0	**50**	1.611			362			143.0			21.00			0.812			2.423
	75	1.650			465			146.0			23.00			0.879			2.529
	100	1.765			371			148.0			25.00			0.907			2.672
	Mean	**1.675**			**366**			**145.7**			**23.00**			**0.866**			**2.541**
24	**50**	4.378	171.757	0.1153	394.0	8.840	1.3333	164.0	14.685	0.8750	31.00	47.619	0.4167	2.178	168.227	0.0569	6.556
	75	4.482	171.636	0.1180	406.0	11.233	1.7083	169.0	15.753	0.9583	35.00	52.174	0.5000	2.198	150.057	0.0550	6.680
	100	4.686	165.496	0.1217	413.0	11.321	1.7500	173.0	16.892	1.0417	39.00	56.000	0.5833	2.224	145.204	0.0549	6.910
	Mean	**4.515**	**169.630**	**0.1183**	**404.3**	**10.465**	**1.5972**	**168.7**	**15.777**	**0.9583**	**35.00**	**51.931**	**0.5000**	**2.200**	**154.496**	**0.0556**	**6.715**
36	**50**	5.446	238.051	0.1065	403.0	11.326	1.1389	166.0	16.084	0.6389	33.00	57.143	0.3333	2.308	184.236	0.0416	7.754
	75	5.490	232.727	0.1067	416.0	13.973	1.4167	171.0	17.123	0.6944	38.00	65.217	0.4167	2.338	165.984	0.0405	7.828
	100	5.518	212.635	0.1043	425.0	14.555	1.5000	176.0	18.919	0.7778	44.00	76.000	0.5278	2.352	159.316	0.0401	7.870
	Mean	**5.485**	**227.804**	**0.1058**	**414.7**	**13.285**	**1.3519**	**171.0**	**17.375**	**0.7037**	**38.33**	**66.120**	**0.4259**	**2.333**	**169.845**	**0.0407**	**7.818**
48	**50**	5.490	240.782	0.0808	410.0	13.260	1.0000	168.0	17.483	0.5208	35.00	66.667	0.2917	2.330	186.946	0.0316	7.820
	75	5.526	234.909	0.0808	429.0	17.534	1.3333	174.0	19.178	0.5833	42.00	82.609	0.3958	2.366	169.170	0.0310	7.892
	100	5.570	215.581	0.0793	440.0	18.598	1.4375	179.0	20.946	0.6458	47.00	88.000	0.4583	2.390	163.506	0.0309	7.960
	Mean	**5.529**	**230.424**	**0.0803**	**426.3**	**16.464**	**1.2569**	**173.7**	**19.202**	**0.5833**	**41.33**	**79.092**	**0.3819**	**2.362**	**173.207**	**0.0312**	**7.891**
LSDat 0.05 level																	
(A)		**0.0025**			**2.060**			**1.700**			**0.934**			**0.0015**			**0.0021**
(B)		**0.0028**			**3.075**			**1.960**			**1.893**			**0.0028**			**0.0012**
(A × B)		**0.0051**			**4.120**			**N.S**			**1.869**			**0.0030**			**0.0043**

*** Mean values of two growth seasons .**

A = Irrigation level , B = Added of K and A x B = Interaction .

Table(3) : Effect of K-fertilization and its agronomic efficiency (AE)under different irrigation level on some growth parameters of maize plant* and its relative change (RC,%) with foliar application of K .

Added of K_2O (%)	Irrigation level (% of WR)	Stover yield			Ears weight			Grains weight			Weight of 100 grain			Grains yield			Biological yield (ton / fed.)
		(ton / fed.)	RC (%)	AE (ton / kg K_2O)	(g / plant)	RC (%)	AE (g / kg K_2O)	(g / plant)	RC (%)	AE (g / kg K_2O)	(g)	RC (%)	AE (g / kg K_2O)	(ton / fed.)	RC (%)	AE (ton / kg K_2O)	
0	**50**	1.611			362			143.0			21.00			0.812			2.423
	75	1.650			465			146.0			23.00			0.879			2.529
	100	1.765			371			148.0			25.00			0.907			2.672
	Mean	**1.675**			**366**			**145.7**			**23.00**			**0.866**			**2.541**
1	**50**	3.706	130.04	0.5238	385	6.354	5.750	159.0	11.189	4.000	26.00	23.810	1.250	1.996	145.81	0.2960	5.702
	75	3.740	126.67	0.5225	391	7.123	6.500	164.0	12.329	4.500	30.00	30.435	1.750	2.141	143.57	0.3155	5.881
	100	3.770	113.60	0.5013	398	7.278	6.750	168.0	13.514	5.000	35.00	40.000	2.500	2.192	141.68	0.3213	5.961
	Mean	**3.739**	**123.44**	**0.5159**	**391**	**6.918**	**6.333**	**163.7**	**12.344**	**4.500**	**30.33**	**31.415**	**1.833**	**2.110**	**143.69**	**0.3109**	**5.848**
2	**50**	4.618	186.65	0.3759	389	7.459	3.375	162.0	13.287	2.375	27.00	28.571	0.750	2.148	164.53	0.1670	6.766
	75	4.706	185.21	0.3820	395	8.219	3.750	166.0	13.699	2.500	32.00	39.130	1.125	2.194	149.60	0.1644	6.900
	100	4.714	167.08	0.3686	404	8.895	4.125	170.0	14.865	2.750	38.00	52.000	1.625	2.228	145.64	0.1651	6.942
	Mean	**4.679**	**179.65**	**0.3755**	**396**	**8.191**	**3.750**	**166.0**	**13.950**	**2.542**	**32.33**	**39.900**	**1.167**	**2.190**	**153.26**	**0.1655**	**6.869**
4	**50**	4.900	204.16	0.2056	402	11.050	2.500	164.0	14.685	1.313	29.00	38.095	0.500	2.158	165.76	0.0841	7.058
	75	4.920	198.18	0.2044	410	12.329	2.813	168.0	15.068	1.375	35.00	52.174	0.750	2.280	159.39	0.0876	7.200
	100	4.934	179.55	0.1981	418	12.668	2.938	173.0	16.892	1.563	42.00	68.000	1.036	2.316	155.35	0.0881	7.250
	Mean	**4.918**	**193.96**	**0.2027**	**410**	**12.016**	**2.750**	**168.3**	**15.548**	**1.417**	**35.33**	**52.756**	**0.771**	**2.251**	**160.17**	**0.0866**	**7.169**
LSD at 0.05 level																	
(A)		**0.0036**			**2.523**			**2.614**			**1.619**			**0.070**			**0.0012**
(B)		**0.0077**			**4.046**			**1.399**			**3.395**			**0.096**			**0.0021**
(A × B)		**0.0073**			**N.S**			**N.S**			**3.238**			**N.S**			**0.0025**

***Mean values of two growth seasons .**
A = Irrigation level , B = Added of K and A x B = Interaction .

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