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RESPONSE OF BARLEY PLANTS TO N AND K FERTILIZATION UNDER CONDITION OF SALT AFFECTED SOILS.

BY

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ABSTRACT

The aim of the present study was to assess the response of barley plants (Hordum vulgare cv. Giza 123) to N and K fertilization under condition of saline non-sodic, non-saline sodic and saline sodic soils.

Three soils were collected from El-Qalyoubia, Kafr El-Shikh, and El-Sharkia Governorates, representing saline non sodic, non-saline sodic, and saline sodic soils, respectively. Two pot experiments were conducted; one for assessing N fertilization and the other for K fertilization. The design of each experiment was a randomized complete block – factorial involving two factors (N or K rate and soil) in three replicates. N and K rates were 0, 22.5, 45 and 90 kg N/fed. for N; and, 12, 24, and 48 kg K_2O/fed. for K. Pots of 6 kg capacity were used and packed with the soils. Barley plant was used as indicator plant. At maturity, plants were harvested and separated into grains and straw and analyzed for N, P, K, Na, Ca, Mg and Cl. The obtained results could be summarized as follows:

Application of N increased plant growth, with progressive magnitude as the rate increased; the increase was more pronounced in the saline non-sodic soil than in the non-saline sodic and the saline sodic soils.

Straw yield increased with increasing N application. The main effect of N application showed increases in straw yield amounting to 12, 25 and 31 % at 22.5, 45 and 90 kg N/fed, respectively. The rate of response differed according to soil condition.

Grain yield significantly increased with increasing N application. The main effect of N application showed increases by 23, 25 and 54 % at 22.5, 45 and 90 kg N/fed., respectively. The rate of response differed according to soil condition.

N-uptake in straw and grains increased by increasing N-application, The increase progressed with increasing N rate. Also, P, K, Na, Ca, Mg and Cl uptake in straw and grains increased upon application of N.

Application of K increased plant growth and the increase was more pronounced in the saline non-sodic soil than in the others. The main effect of K rate showed increases of 11, 31 and 33 % for straw yield and 37, 58 and 59 % for grain yield at 12, 24 and 48 kg K_2O/fed., respectively. Application of K resulted in a progressive and significant increase in K- uptake in both straw and grains. This pattern of response occurred in all soils indicating no significant interaction caused by the soils. Also, N, P, Na, Ca, Mg and Cl-uptake was increased upon application of K.

INTRODUCTION

In regions of arid and semiarid climate excess soluble salts often occur in the upper soil layer of cultivated soils. High salt levels in the crop root zone cause severe yield depressions and low crop quality as a function of the salinity tolerance of cultivated crops and cultivars. As a result of increased salinity, plant growth and potential yield are reduced. This effect is not only due to the ionic concentration but also is dependent on the ionic ratios and ion species as well. The presence of excess amounts of soluble salts in a nutrient medium adversely affects the growth and development of most plant species due to water deficit, ion toxic effect or by altering the plant mineral nutrition. Increased salinity also reduces water availability and nutrient uptake by plants. High salt concentration in soil solution generates a high osmotic pressure and a correspondingly, a low water potential and some nutritive imbalance.

The growth and physiological reactions of higher plants are affected by salinity in many ways. One effect is that, in salinized rithzosphere, the uptake of mineral nutrients is inhibited, including uptake of nitrogen which plays a very important role in plant growth. The inhibition of uptake was caused mainly by the osmotic effects of salts.

Peuke and Jeschke, (1999) found that addition of salts to the uptake solution led to inhibition of nitrate uptake by barley seedlings; they concluded that the inhibition of N uptake was caused mainly by osmotic effects of salts.

Attia (2002) found that N % in wheat grains and straw was significantly decreased with increasing nitrogen fertilizer level under irrigation with saline water whereas nitrogen content (mg/pot) was increased.

Ali *et al.* (2001) reported that barley plants produced a significantly higher dry matter yield, under saline conditions, when grown with mixed N nutrition than with NH_4 or NO_3 alone and the interaction between salinity and N nutrition was found to be significant with all variables.

Dry matter production is affected by both soil salinity and sodicity; addition of nutrients in form of fertilizer may increase plant tolerance to such condition and increase its yield. Attia (2002) reported that wheat grain and straw yields increased with increasing nitrogen fertilization level up to 90 mg /kg soil under high salinity level of irrigation water; this indicates that plants have increased resistance to the hazardous effect of salinity and sodicity when fertilized with N fertilizer. He concluded that addition of N fertilizer maximized plant resistance to the hazardous effect of salinity and sodicity, and that the response of yield to applied N varied widely according to variety as well as soil characteristics.

Fertilization assumes an important role since sodic soils are poor in fertility. High rates of N than utilized on non-sodic soils resulted in an increased crop yields (Nitant *et al.*, 1972). Response to N-fertilization depends on soil conditions, plant species, source and time of nitrogen fertilizer application, and plant nutrient supply in general. Abdalla (2004) reported that application of N and K fertilizers to barley plants grown under salinity and sodicity conditions induced higher plant growth, yield and nutrients uptake as compared with zero fertilizer applications.

Potassium is important in regulating transpiration in plant and dry matter production per unit water supply in salinized soils. This may be due to potassium shortage under such conditions. Sodic soils are dominated by Na which adversely affects K concentration of the plants (Joshi *et al.*, 1979). Potassium fertilization maintains high productivity and good quality of different crops (Zohry *et al.*, 2002). It is involved in several important metabolic activities associated with photosynthesis, respiration, chlorophyll development and water content of leaves (Roy *et al.*, 1981). Abd El-Hadi *et al.* (2002) and Zohry *et al.* (2002) and El-Arqan *et al.* (2002) reported that grain and straw yields of wheat and barley were significantly increased by the addition of potassium fertilizer. Rehan *et al.* (2004) Rehan *et al.* (2004) reported that potassium fertilization alleviated the adverse effect of saline irrigation water on all the studied parameters of wheat plants since the reduction in grain and straw yields were reduced from 13 and 12 % to 9 and 6 %, when K was added at 24 kg K_2O/fed and to 7 and 4 % at 48 kg K_2O/fed, respectively.

The aim of the present work is to assess the response of barley plants to N and K fertilization under conditions of soil salinity and sodicity

MATERIALS AND METHODS

Three soils were collected from El-Qalyoubia Kafr El-Shikh, and El-Sharkia Governorates representing saline non sodic, non-saline sodic, and saline sodic soils, respectively. Chemical and Physical properties of the soils, which were determined according to the standard methods outlined by Klute (1986) and Page *et al.* (1982), are shown in Table 1.

Two pot experiments were conducted to assess the response to the added mineral fertilizer under condition of soil salinity and sodicity. Barley grains (Hordum vulgare cv. Giza 123) were grown. Experiments were carried out for fertilization with N or K. Two experiments were done, one for each of N, and K fertilizers. The design of each experiment was a randomized complete block – factorial involving two factors in three replicates as follows:

Factor A: The concerned macronutrient: four treatments as follows:
R_0 = Non-fertilized; R_1 = Fertilized at rate 1
R_2 = Fertilized at rate 2; R_3 = Fertilized at rate 3
Rates were 0, 22.5, 45, and 90 kg N/fed.; and 0, 12, 24 and 48 kg K_2O/fed.

Factor B: Soil: three soils: a saline non-sodic, a non-saline sodic and a saline sodic

Thus, the total number of treatments for each experiment was 4 x 3 x 3 = 36.

Table (1) Some chemical and physical properties of the used soils.

Soil properties	Saline non-sodic Soil	Non-saline Sodic Soil	Saline sodic soil
pH Sat. Extr.	6.95	8.47	7.56
EC $dS.m^{-1}$ Sat. Extr.	10.51	2.85	15.11
Organic matter %	2.11	1.87	1.59
$CaCO_3$ %	1.95	2.85	4.65
CEC $cmol_c$/kg soil	54.95	45.96	37.98
ESP	11.82	40.4	58.4
Soluble cations $mmol_c$ /L (in saturation extract)			
Ca^{2+}	33.62	8.00	39.23
Mg^{2+}	27.41	6.00	24.11
Na^+	39.69	6.50	80.98
K^+	5.3	8.50	8.15
Soluble anions $mmol_c$ /L (in saturation extract)			
HCO_3	3.80	21.00	7.00
* CO_3^{2-}	0.00	0.00	0.00
Cl^{-1}	34.40	7.00	101.00
SO_4^{2-}	67.82	1.00	44.47
Particle size distribution			
Coarse sand %	12.20	1.80	3.70
Fine sand %	18.80	4.80	23.10
Silt %	37.80	38.40	34.20
Clay %	31.30	55.00	39.00
Textural class	Clay loam	Clay	Clay loam
Water holding capacity	31.70	45.20	34.45
WP	16.25	23.00	17.75
Available nutrients (mg kg^{-1} soil)			
N	67.67	35.82	2.44
P	4.85	3.56	3.70
K	392.80	294.51	247.45

The N- experiment:

This experiment was carried out to study the effect of salinity and or sodicity on the response to fertilization with N. Rates of N were as follows: 0, 22.5, 45,0 and 90,0 kg N/fed. soil (as NH_4NO_3, 33.5 % N). All pots received 15 mg P/kg soil (as Ca-super phosphate, 15.5 % P_2O_5); and 24 mg K_2O/kg soil (as K_2SO_4, 48 % K_2O).

The K- experiment

This experiment was carried out to study the effect of salinity and or sodicity on the response to fertilization with K. Rates of K were 0, 12, 24, and 48 kg K_2O/fed. soil (as K_2SO_4, 48 % K). All pots received 15 mg P/kg soil (as Ca-super phosphate, 15.5 % P_2O_5); and 45 mg N/kg soil (as NH_4NO_3 33.5 % N).

The experimental work:

Polyvenyle chloride pots of six kilograms capacity were used, packed with 6 kg soil/pot. Twenty barley grains (v. Giza 123) were sown. Basal doses of fertilizers for each experiment were applied for all pots. The concerned nutrient for each experiment was given to pots which were allocated for it, and at the rate designated for it. After complete germination plants were thinned to 5 plants/pot. Irrigation was done to maintain the soil moisture content at about the water holding capacity during the period of experiment.

200 ml of Hogland's solution (excluding the nutrient of the concerned experiment) per pot were added twice during the growth period. At maturity, plants were harvested and separated into grains and straw, oven dried at 70 C° for 24 hours and the dry weight of was recorded.

Plant analysis:

Barley straw and grains were ground and 0.5 gram samples were digested using a mixture of sulphuric and perchloric acids (3:1 v/v). Digests were diluted
to a 100 ml volume and analyzed for N, P, K, Na, Ca, Mg and Cl.

Statistical analysis:-

The obtained data were subjected to the statistical analysis according to Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

The N-experiment

Effect of application of nitrogen fertilizer on growth, yield and nutrients uptake by barley plants grown under conditions of saline, sodic and saline sodic soils.

A- Barley growth

Plates 1 and 2 illustrate the effect of applied N-fertilizer on growth of barley plants growing on saline non-sodic, non-saline sodic and saline sodic soils. Plate 1 shows that increasing N application rate from 0 to 90 kg N/Fed. caused a general increase in the growth of barley plants growing on all of the three soils. The highest growth was noticed in the saline non-sodic soil followed by the non-saline sodic one, while the lowest growth was noticed with the saline sodic soil. Comparison between different rates of applied N Plate (2) shows that application of N at a concerned rates caused greater growth of plants grown on the saline non-sodic soil than plants grown on the non-saline sodic or the saline sodic soils. The increase in barley plant growth due to N application may reflects an enhancement effect in increasing photosynthetic activities, which would resulted in increasing photosynthetic gains and consequently plant growth. The effect of N rates on the growth of barley grown on the three soils under consideration could be arranged in the descending order:

Saline non-sodic soil > non-saline sodic soil > saline sodic soil

B- Barley yield:

Results in Table 2 show that application of N- fertilizer particularly at increasing rates resulted in a progressive and significant increase in the straw yield. The increase in dry matter yield of straw induced an increase in N-uptake (Table 3). These results are similar to those obtained by Attia (2002) with wheat and Abdalla (2004) with barley. The increase in straw yield may be due to the effect of N-fertilizer on increasing the number of tillers/plant as well as plant height as compared with zero N-fertilizer application. The main effect of N rate showed increases of 11.69, 25.34 and 30.55 % at application 22.5, 45 and 90 kg N/Fed., respectively.

There was an interaction between N rate and soil type. The response to N application differed among the three soils. In the saline non- sodic soil there was a significant difference in straw yield between R_0, R_1 and R_2 and no significant difference between R_2 and R_3. In the non-saline sodic soil there were significant differences between R_0, R_2 and R_3 and no significant difference between R_2 and R_3. In the saline sodic soil there were no significant differences between the different rates of application; the only rate which gave a significant increase in straw yield as compared with R_0 is R_3 (90 kg N/Fed). Thus, increasing N application rate increased plant tolerance to salinity and sodicity and thus increased its yield; under saline sodic conditions it may be necessary to apply high rate of N to the growing plants to increase its tolerance to salinity and sodicity. The highest increase in straw yield was obtained in the saline non-sodic soil whereas the lowest was obtained in the saline sodic one.

Data presented in Table 2 show that barley grain yield increased with N application and the increase was progressive with increased N rate; the increase was highly significant. The current results are similar to results reported by Mostafa (1990), Abou Khadrah *et al* (1999), Elsikhry (1999), Attia (2002) and Abdalla (2004). The increase in grain yield could be attributed to that the applied N-fertilizer increased plant tillering and hence the number of spikes/plant which in turn reflected on increasing grain yield. The main effect of N application showed increases in grain yield by 2.6, 28 and 54 % at N application rates of 22.5, 45 and 90 kg N/Fed., respectively. The highest increase in grain yield thus occurred at the highest rate (R_3, 90kg N/Fed.) of N.

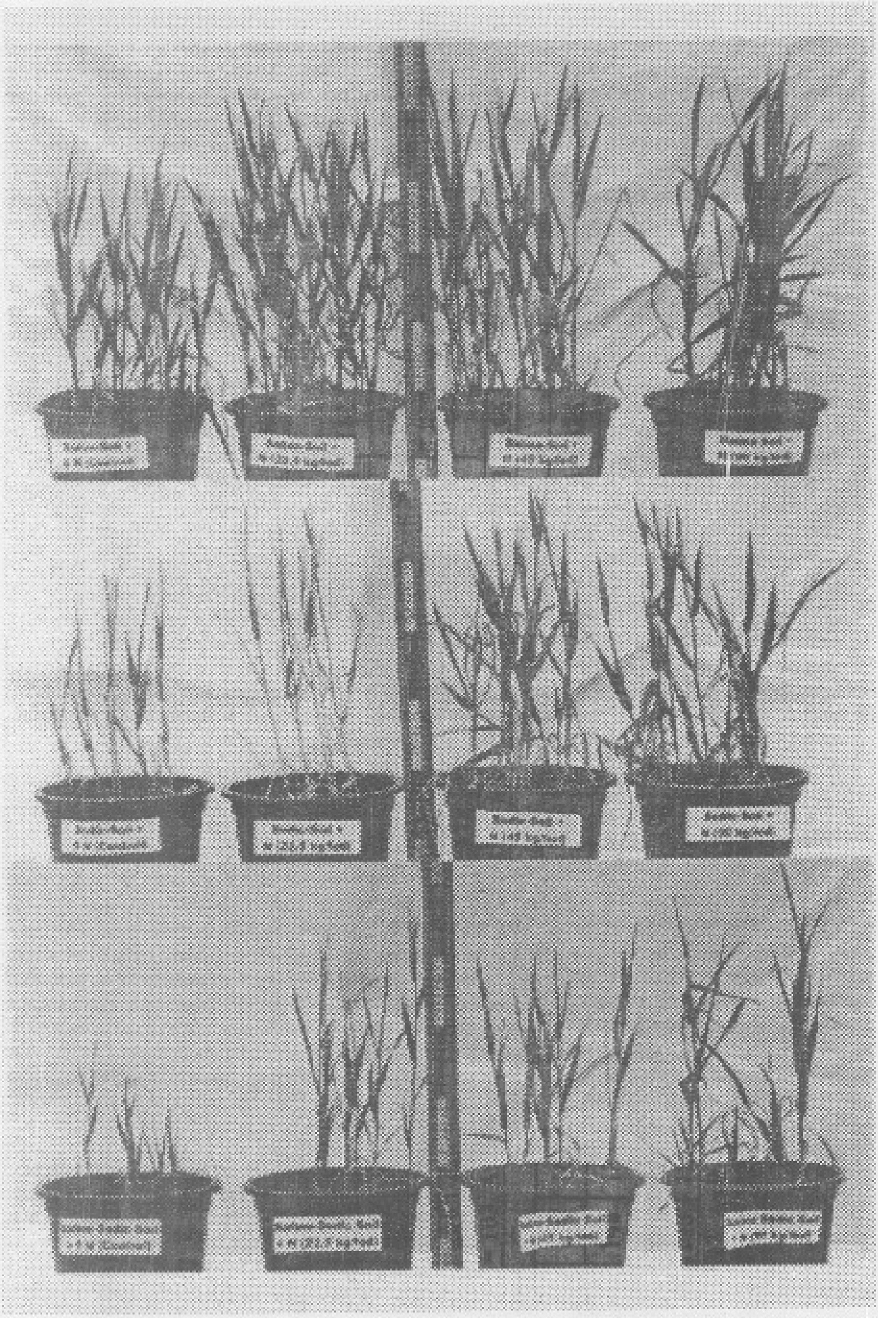

Plate (1): Effect of application of N - fertilizer at increasing rate on growth of barley plants grown under condition of saline non-sodic, non-saline sodic ansaline sodic soi.

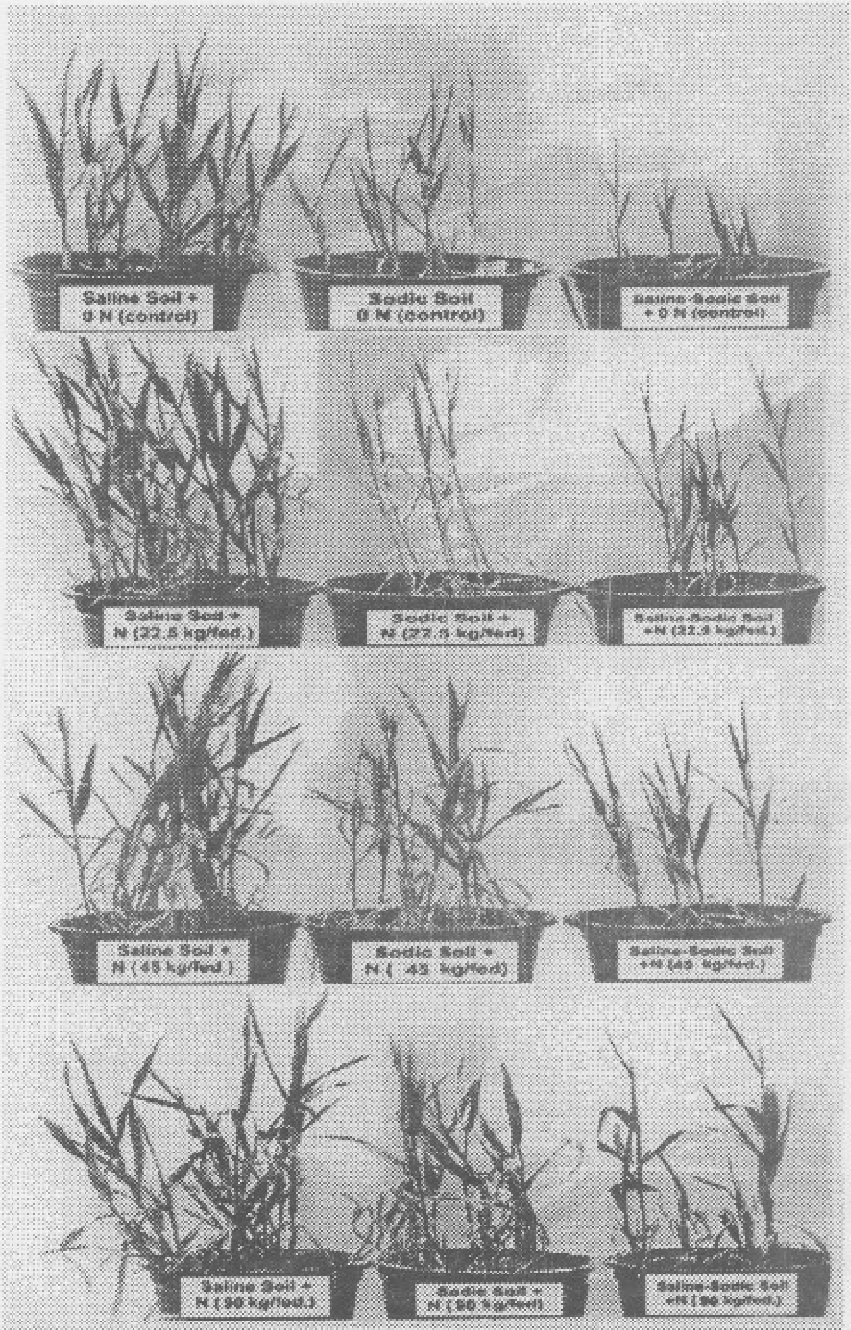

Plate (2): A comparison between the effect of different N-fertilizer rates on growth of barley plants grown under conditions of saline non-sodic, non-saline sodic and saline sodic soils.

The interaction effect between the soil type and the applied N rate shows that under conditions of the saline non-sodic and non-saline sodic soils there was no significant difference between R_1 and R_2 but a highly significant difference occurred between R_2 and R_3. On the other hand, in the saline sodic soil there was no significant difference between R_1 and R_2 or between R_2 and R_3 while a significant difference occurred between R_1 and R_3. This result shows the necessity of plants to apply high rates of N under saline sodic conditions in order to alleviate the hazardous effect of salinity and sodicity. Therefore, the increased nitrogen application encouraged the tolerance of barley plants to salinity effect and sodicity hazards especially at the highest rate of application (90 kg N kg/Fed.).

The lowest grain yield of barley was obtained in the saline sodic soil and the highest one was in the saline non - sodic soil. Grain yield obtained by the saline non-sodic and non-saline sodic soils was 3.12 and 1.31 times, respectively as compared with that obtained under conditions of the saline sodic soil. This reflects a combined effect of salinity and sodicity on plants growing under such conditions, which would exert a retarding effect on tillering, numbers of spikes and plant height and consequently decreased its yield. The aforementioned results indicate that the application of N fertilizer to barley plants enhances its tolerance to salinity and sodicity.

Table (2): Effect of N-fertilization rate on straw and grain yields (g/pot) of barley grown under conditions of saline non-sodic, non- saline sodic and saline sodic soils.

Soil (B)	N – fertilizer rate (A)									
	R_0	R_1	R_2	R_3	Mean	R_0	R_1	R_2	R_3	Mean
	Straw yield (g/pot)					Grain yield (g/pot)				
Saline non-sodic	14.89	17.43	18.84	19.48	**17.66**	9.70	12.24	12.69	15.07	**12.42**
Non-saline sodic	9.55	9.92	11.84	12.67	**11.00**	4.63	4.70	4.91	6.67	**5.23**
Saline sodic soil	6.08	6.77	7.62	7.65	**7.03**	2.88	3.82	4.45	4.79	**3.98**
Mean	**10.18**	**11.37**	**12.76**	**13.29**		**5.74**	**6.92**	**7.35**	**8.84**	
LSD at 5%	**A =0.79, B = 0.68, AxB = 1.00**					**A = 0.54, B = 0.47, AxB = 0.94**				

R_0= Non fertilizer (0 mg N/kg soil) R_1= 22.5 mg N/kg soil
R_2= 45 mg N/kg soil R_3= 90 mg N/kg soil

C - Nitrogen and other nutrients uptake by barley plants:

Results in Table 3 show an increase in N–uptake by applying N which was progressive with increasing N rate. The main effect of N application showed increases of 24.86, 44.20 and 56.91 % at 22.5, 45, and 90 kg N/Fed., respectively. The current results are similar to results reported by Mostafa (1990) Attia (2002), and Abdalla (2004) who reported that the higher is the level of N fertilization the higher is the N uptake and content in both straw and grains of barley plant. This pattern of response occurred in both the saline non-sodic and the non-saline sodic soils. On the other hand, in the saline sodic soil there was a significant difference between R_2 (45 kg N/Fed.) and R_1 (22.5 kg N/Fed.) with R_2 surpassed R_1, whereas, no significant difference occurred between R_2 (22.5 kg N/fed.) and R_3 (90 kg N/Fed.). The highest uptake was obtained in the saline non-sodic soil whereas the lowest was obtained in the saline sodic one. The decrease in N uptake by barley straw under conditions of the saline sodic soil was associated with a very low dry matter yield obtained in this soil (Table 2).

Regarding P uptake, N application showed increased P-uptake by straw. The highest P-uptake was obtained in the non-saline sodic soil in particular with the high rates of nitrogen. High P–uptake in the non-saline sodic soils may be partly due to the high pH of the soil which lead to high solubility of P.

In case of K, data of Table 3 show a synergistic effect of N on K-uptake as it increased with increasing N rate. This may be due to application of N the form of NO_3-N which may have enhanced K-uptake. Salinity showed a less depressive effect on K–uptake when it was the only harmful factor affecting plant growth. However, sodicity reveals high depressive effect on K-uptake. The highest negative effect on K-uptake was indicated when both of salinity and sodicity were combined together. These results are similar to those shown by Abdala (2004).

Concerning Na-uptake by straw, data of Table 3 reveal a an increase due to N application. The highest values of Na uptake were found in the saline sodic soil followed by the saline non-sodic soil, while the lowest values were obtained in the non-saline sodic soil. Regarding Ca-uptake, a trend similar to that obtained with N-uptake was noticed. Mg-uptake was not significantly affected by neither nitrogen rate nor salinity and sodicity. Uptake of Cl was increased by N application, and it was highest in the saline non-sodic soil followed by the saline sodic soil and lowest in the non-saline sodic soil.

Concerning the effect of applied N at increasing rate on N-uptake by barley grains data in Table 4 show that there was a progressive increase in N – uptake with increasing N application rate. The current results are similar to the results reported by Mostafa (1990), Abou Khadrah *et al.* (1999), Hagag *et al.* (1999), Attia (2002) and Abdalla (2004). This reflects the role of N fertilizer in increasing photosynthetic area which resulted in increased photosynthetic gains (Sarhan and Abdel – Salam, 1999). The main effect of showed increases of 20.27, 38.29, and 34.68 % at 22.5, 45 and 90 kg N/Fed. application, respectively compared with R_0 of N application. The increase in N-uptake by barley grains at R_2 of N application was higher than that at R_3. The increase in N uptake by increasing N application rate reflects an accumulation of proteins under saline conditions which would not be readily available for plant growth (Lal and Singh, 1974). This pattern of response occurred in both the saline non-sodic and the saline sodic soils whereas in the non – saline sodic soil the increase in N-uptake in grains was higher at R_3 than at R_2. The interaction effect caused by the soils showed that the highest increase in N- uptake occurred with R_2 in the saline non-sodic, and the saline sodic soil too; in the non- saline sodic soil, the highest value occurred with R_3.

Table (3): Effect of N-fertilization rate (R) on nutrients uptake (mg/pot) by straw of barley plants grown under conditions of saline non-sodic, non-saline sodic and saline Sodic soils

Soil (B)	N -fertilizer rate (A)																			
	R_0	R_1	R_2	R_3	Mean	R_0	R_1	R_2	R_3	Mean	R_0	R_1	R_2	R_3	Mean	R_0	R_1	R_2	R_3	Mean
	N					P					K					Na				
Saline non-sodic	281	351	382	405	355	86	88	104	106	**96**	667	689	713	775	**711**	191	219	226	236	**218**
Non-saline sodic	175	194	226	273	217	82	86	147	154	**117**	324	355	434	470	**396**	70	99	161	129	**95**
Saline sodic	89	133	155	167	136	16	45	82	86	**57**	104	128	187	268	**172**	80	101	316	332	**228**
Mean	**181**	**226**	**254**	**282**		**61**	**73**	**111**	**115**		**365**	**391**	**445**	**504**		**130**	**156**	**217**	**218**	
LSD at 5%	A = 5, B = 4, AxB = 8					A = n.s, B = 42, AxB = n.s					A = n.s, B = 116, AxB = n.s					A = 44, B = 48, AxB = 77				
	Ca					Mg					Cl									
Saline non-sodic	291	258	277	304	**282**	29	43	50	51	**43**	554	772	858	958	**786**					
Non-saline sodic	137	151	206	237	**182**	26	36	45	70	**44**	429	498	683	722	**583**					
Saline sodic	85	120	126	149	**120**	22	30	31	76	**23**	241	272	286	302	**276**					
Mean	**171**	**176**	**203**	**230**		**26**	**36**	**42**	**66**		**408**	**514**	**609**	**661**						
LSD at 5 %	A = n.s, B = 34, AxB = 94					A = n.s, B = 17, AxB = n.s					A = 71, B = 82, AxB = 143									

R_0 = Non fertilizer (0 mg N/kg soil) R_1 = 22.5 mg N/kg soil R_2 = 45 mg N/kg soil R_3 = 90 mg N/kg soil

Table (4): Effect of N-fertilization rate (R) on nutrients uptake (mg/pot) by grains of barley plants grown under conditions of saline non-sodic, non-saline sodic and saline Sodic soils

Soil (B)	N -fertilizer rate (A)																			
	R_0	R_1	R_2	R_3	Mean	R_0	R_1	R_2	R_3	Mean	R_0	R_1	R_2	R_3	Mean	R_0	R_1	R_2	R_3	Mean
	N					P					K					Na				
Saline non-sodic	413	486	495	582	**494**	261	266	407	400	**334**	98	143	122	113	**119**	18	36	37	40	**33**
Non-saline sodic	137	159	170	254	**180**	70	88	149	171	**120**	42	44	78	63	57	13	13	27	28	**20**
Saline sodic	117	147	156	168	**147**	68	104	203	137	**128**	33	44	141	66	71	27	34	50	46	39
Mean	**222**	**267**	**307**	**299**		133	153	253	236		58	77	114	81		19	28	38	38	
LSD at 5%	A = 2, B = 2, AxB = 4					A = 58, B = 50 AxB = n.s					A = 36, B = 31, AxB = n.s					A = n.s, B = 9, AxB = n.s				

Soil (B)	Ca					Mg					Cl				
Saline non-sodic	110	148	161	185	**151**	31	41	42	74	**47**	411	519	603	721	**563**
Non-saline sodic	53	67	73	84	**69**	19	22	41	34	**29**	179	189	200	218	**197**
Saline sodic	30	47	59	92	**57**	14	17	18	38	**22**	118	133	160	392	**201**
Mean	**64**	**87**	**98**	**120**		**21**	**27**	**34**	**49**		**236**	**280**	**321**	**444**	
LSD at 5%	A = n.s, B = 28, AxB = n.s					A = 17, B = 15, AxB = n.s					A = 97, B = 112, AxB = n.s				

R_0 = Non fertilizer (0 mg N/kg soil) R_1 = 22.5 mg N/kg soil R_2 = 45 mg N/kg soil R_3 = 90 mg N/kg soil

The highest uptake was obtained by the saline non-sodic soil whereas the lowest was obtained by the saline sodic one. Under conditions of R_1 and R_2 the two soils of non-saline sodic and saline sodic soils were not significantly different in N-uptake indicating that such rates were suitable for producing N-uptake in these two soils. The decrease in N uptake by barley grains under conditions of the saline sodic soil could be attributed to the low grain yield obtained under such condition. The retarding effect of salinity and sodicity on N-uptake by barley grains, is shown.

Concerning P, K, Na, Ca, Mg and Cl uptake, results in Table 4 show that application of N-fertilizer significantly increased P, K, Ca, Mg and Cl uptake in grains whereas no significant effect occurred to Na-uptake. The highest P, K, Ca, Mg and Cl-uptake occurred in the saline non-sodic soil whereas the lowest uptake of these nutrients occurred in the saline sodic soil except for Cl where the lowest uptake occurred in the sodic soil. The highest Na-uptake occurred in the saline sodic soil whereas the lowest uptake occurred in the non-saline sodic one. The increase in the uptake of the above-mentioned nutrients is a consequence of the increase in dry matter yield. These results are in agreement with those obtained by El –Arquan *et al* (2002) and Abdalla (2004)

In conclusion the retarding effect of soil salinity, sodicity and salinity and sodicity on plant response to added N - fertilizer could be arranged as follows Saline sodic soil > non – saline sodic soil > saline non-sodic soil

The K- experiment

Effect of application of potassium fertilizer on growth, yield and nutrients uptake by barley plants growing under conditions of saline, sodic and saline sodic soils.

A – Barley growth

Plate 3 and 4 illustrate the effect of applied K-fertilizer at increasing rate on growth of barley plants grown on the saline non-sodic, non-saline sodic and saline sodic soils. Application of K caused a an increase in plant growth in all of the three soils (Plate 3); the increase was more pronounced in the non-saline sodic soil than in the saline non-sodic and saline sodic ones. The beneficial effect of K may be due to its role in metabolic activities associated with photosynthesis, respiration, chlorophyll development and water content of leaves (Roy *et al.*, 1981). Plate 4 shows a comparison between the effect of different rates of applied K to the three soils under consideration. Application of K at increasing rates was associated with a higher growth of barley plants particularly on non-saline sodic soil than in the saline non-sodic and saline sodic ones especially when applied at a medium rate (24 kg K_2O/Fed.). The highest increase in plant growth occurred in plants grown on the non- saline sodic soil under R_2 of K-fertilizer and lowest one occurred in these grown on the saline non-sodic soil under R_1 application.

B – Barley yield

Results in Table 5 show that application of K particularly at increasing rates resulted in a progressive and significant increase in straw yield. The increase in straw yield was in line with the increase in the number of tillers and shoot height (Plate 3). The main effect of K showed increases in straw yield of 11.26, 30.77 and 32.93 % at application of 12, 24 and 48 kg K_2O, respectively.

R_2 surpassed R_1 significantly, whereas each of R_2 and R_3 were rather similar. This result is in agreement with that obtained by Abdalla (2004) and El-Arquan (2002). There was an interaction effect caused by the soil since the increased yield which was associated with increased K rate occurred in the saline non-sodic soil and the non-saline sodic one, where each increase in K application was accompanied with an associated increase in straw yield with the highest increase under R_3 and R_2 in the saline non-sodic and non-saline sodic soils respectively. In the saline non-sodic soil significant differences, in straw yield, occurred among R_1, R_2 and R_3 of K-fertilizer, whereas in the non-saline sodic soil significant differences occurred among the four rates of K. Under conditions of the saline sodic soil the significant increase occurred only at R_3. This result indicates that application of K at a high rate has simulative effect on barley tolerance to salinity combined with sodicity. These result are in agreement with those obtained by Abdalla (2004) and Rehan *et al.* (2004).

The highest straw yield was obtained in the saline non-sodic soil whereas the lowest was obtained in the saline sodic one.

Regarding grain yield, results in Table 5 show that barley grain yield significantly increased with application of K. The main effect of K showed increases by 37.1, 57.7 and 59.0 % at application of 12, 24 and 48 kg K_2O/Fed, respectively; no significant differences occurred between R_2 and R_3. There was a significant interaction effect between the soil and K application: in the saline non-sodic soil as well as the non-saline sodic one, the increase in K rate was accompanied by a significant increase in grain yield; in the saline sodic soil, however R_1 and R_2 only which gave a significant increase; no significant difference occurred between R_2 and R_3. Therefore the increase in K up to the highest level increased the tolerance of barley to sodicity and salinity hazards when applied in the non-saline sodic soil or the saline non-sodic, whereas under saline sodic conditions K application increased barley tolerance to salinity combined with sodicity at the low and the moderate rates. Also, results of Table 5 show that under conditions of the saline sodic soil when straw yield increased grain yield decreased and visa versa; the lowest and the highest straw yield was obtained under R_2 and R_3, respectively whereas the lowest and the highest grain yield was obtained under R_3 and R_2 of K, respectively. The highest grain yield of barley was obtained under conditions of the saline non-sodic soil and the lowest one was obtained under conditions of the saline sodic soil. The low yield of both straw and grains of barley, obtained under condition of the saline sodic soil, as compared with two other soils reflects the combined effect of salinity and sodicity on plants growth as shown by the decrease in tillering, number of spikes and plant height (Plate 3). Application of K fertilizer to barley plants increases its tolerance to adverse conditions.

C – Potassium and other nutrients uptake by barley plants:

Results in Table 6 indicate that application of K particularly at increasing rate resulted in a progressive increase in K-uptake; the increase was significant up to R_2. This pattern of response occurred in all of the three soils. The main effect of K showed increases of 27, 54, and 62 % at application of 12, 24 and 48 kg K_2O/Fed., respectively. The highest K uptake was obtained in the saline non-sodic soil whereas the lowest was obtained in the saline sodic one.

Plate (3): Effect of application of K - fertilizer at increasing rate on growth of barley plants grown under condition of saline non-sodic, non-saline sodic ansaline sodic soi.

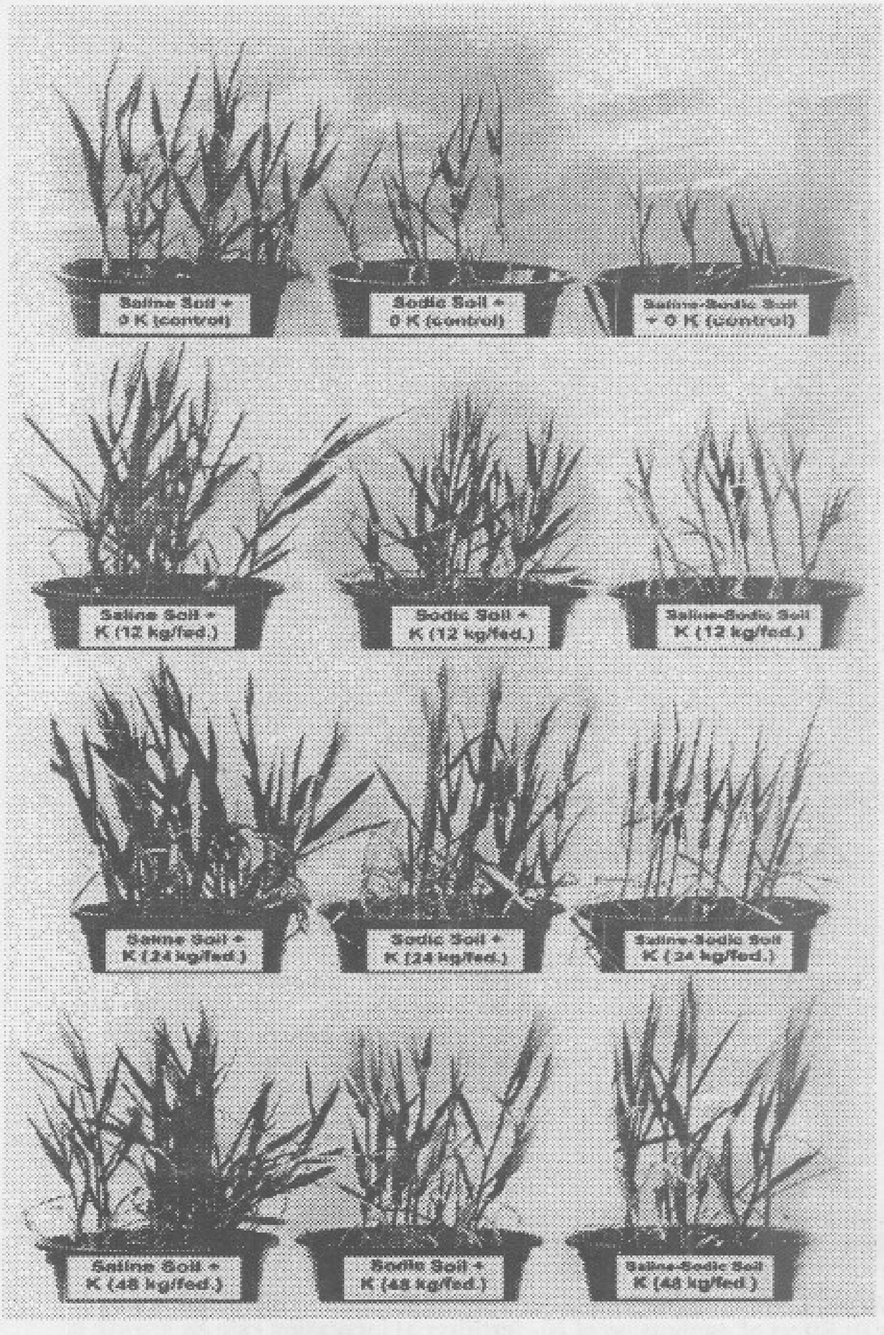

Plate (4): A comparison between the effect of different rates of K-fertilizer on growth of barley plants grown under conditions of saline non-sodic, non-saline sodic and saline sodic soils.

Table (5): Effect of K-fertilization rate on straw and grain yields (g/pot) of barley plants grown under conditions of saline, sodic and saline Sodic soils.

Soil (B)	Fertilizer - K rate (A)									
	R_0	R_1	R_2	R_3	Mean	R_0	R_1	R_2	R_3	Mean
	Straw yield (g/pot)					Grain yield (g/pot)				
Saline non-sodic	16.25	16.66	18.57	21.01	**18.12**	10.99	12.55	14.13	15.17	**13.35**
Non-saline sodic	9.23	11.77	16.22	13.77	**12.75**	4.17	8.22	9.16	9.53	**7.77**
Saline sodic	6.49	7.14	7.02	7.71	**7.09**	3.04	4.18	5.42	3.70	**4.08**
Mean	**10.66**	**11.86**	**13.94**	**14.17**		**6.07**	**8.32**	**9.57**	**9.65**	
LSD at 5%	**A = 0.57, B = 49, A x B = 99**					**A = 0.7 1, B = 0.62, A x B = 1.23**				

R_0= Non fertilizer (0 mg K/kg soil) **R_1**= 12 mg K/ kg soil
R_2= 24 mg K/ kg soil **R_3**= 48 mg K/ kg soil

Concerning N, P, Ca, Mg, Na and Cl uptake in straw, results of Table 5 show that application of K- fertilizer increased their uptake except P-uptake under condition of the saline non- sodic soil and Na-uptake under conditions of the non-saline sodic one where their uptake increase with increasing K application rate up to R_1 then it tended to decrease with increasing the rate of K application up to R_2 and R_3. The decrease in P uptake under conditions of the saline non-sodic soil may be due to the competition between Cl and phosphate ions in the root zoon; the decrease in Na-uptake may be due to the antagonistic effect between K and Na ions. The increase in nutrients uptake by straw upon increasing K-application rate may be due to the increase in straw yield and the increased needed for ion absorption for osmotic adjustment under high salinity. The highest nutrients uptake was obtained by the saline soil whereas the lowest nutrient was obtained by the saline sodic one.

As for nutrients uptake by grains, Results in Table 7 show that there was an increase in K-uptake due to K application; the increase was progressive with increasing K application rate and significant. The main effect of K showed increases of 40.7, 51.3, and 67.7 % at application of 12, 24 and 48 kg K_2O, respectively. The highest K-uptake was obtained in the saline non-sodic soil whereas the lowest was obtained in the saline sodic one.

Concerning N, P, Na, Ca, Mg and Cl- uptake by grains, results in Table 7 show a trend rather similar to that obtained with these nutrients uptake by straw. The highest nutrients uptake occurred by the saline non-sodic soil whereas the lowest nutrient uptake occurred by the saline sodic one. These low nutrients uptake by barley straw and grains under conditions of the saline sodic soil could be attributed to the low dry matter yield obtained under such conditions.

Table (6): Effect of K-fertilization rate (R) on nutrients uptake (mg/pot) by straw of barley plants grown under conditions of saline non-sodic, non-saline sodic and saline Sodic soils

Soil (B)	K -fertilizer rate (A)																			
	R_0	R_1	R_2	R_3	Mean	R_0	R_1	R_2	R_3	Mean	R_0	R_1	R_2	R_3	Mean	R_0	R_1	R_2	R_3	Mean
	N					P					K					Na				
Saline non-sodic	136	160	167	256	**180**	128	140	70	53	**98**	812	815	1038	1065	**932**	178	196	260	257	**223**
Non-saline sodic	70	97	153	103	**106**	67	72	295	256	**173**	402	661	765	773	**650**	80	130	128	93	**108**
Saline sodic	63	87	116	223	**123**	45	58	89	135	**82**	95	183	211	284	**193**	245	276	295	300	**279**
Mean	**90**	**115**	**145**	**194**		**80**	**90**	**151**	**148**		**436**	**553**	**671**	**707**		**168**	**201**	**228**	**217**	
LSD at 5%	A = 42, B = 36, AxB = 71					A = 50, B = 43, AxB = 87					A = 83, B = 72, AxB = n.s					A = 42, B = 36, AxB = n.s				
	Ca					Mg					Cl									
Saline non-sodic	316	317	384	397	**354**	71	73	83	90	79	736	758	881	927	**786**					
Non-saline sodic	201	244	296	279	**255**	41	42	63	73	55	432	460	570	616	**583**					
Saline sodic	126	148	165	181	**155**	30	34	35	54	38	209	327	344	362	**276**					
Mean	**214**	**236**	**282**	**286**		47	50	60	72		459	515	598	635						
LSD at 5%	A = 40, B = 35, AxB = n.s					A = 20, B = n.s AxB = n.s					A = n.s, B = 78, AxB = 156									

R_0 = Non fertilizer (0 mg K/kg soil) R_1 = 12 mg K/ kg soil R_2 = 24 mg K/ kg soil R_3 = 48 mg K/ kg soil

Table (7): Effect of K-fertilization rate (R) on nutrients uptake (mg/pot) by grains of barley plants grown under conditions of saline non-sodic, non-saline sodic and saline Sodic soils

Soil (B)	K -fertilizer rate (A)																			
	R_0	R_1	R_2	R_3	Mean	R_0	R_1	R_2	R_3	Mean	R_0	R_1	R_2	R_3	Mean	R_0	R_1	R_2	R_3	Mean
	N					P					K					Na				
Saline non-sodic	426	530	563	630	**538**	162	204	253	288	**227**	96	113	114	131	**113**	37	39	44	48	**42**
Non-saline sodic	173	373	653	653	**463**	93	189	147	141	**142**	39	82	87	89	74	17	30	29	26	**26**
Saline sodic	133	170	246	396	237	40	67	74	88	67	33	42	53	62	48	28	27	37	49	35
Mean	244	358	487	560		98	153	158	172		56	79	85	94		27	32	37	41	
LSD at 5%	A = 119, B = 103, AxB = 207					A = 46, B = 39, AxB = n.s					A = 0.55 B = 0.48 AxB =0.96					A = 10, B = 8, AxB = n.s				
	Ca					Mg					Cl									
Saline non-sodic	138	139	150	162	**148**	13	25	30	46	**29**	564	745	859	681	**825**					
Non-saline sodic	56	90	148	135	**107**	19	35	36	36	**31**	210	307	495	501	**520**					
Saline sodic	37	43	53	80	53	17	18	19	19	18	165	283	385	277	311					
Mean	77	94	113	126		17	29	26	33		312	445	580	487						
LSD at 5%	A = 25, B = 22, AxB = n.s					A = n.s, B = n.s AxB = n.s					A = 116 B = 100 AxB – n.s									

R_0= Non fertilizer (0 mg K/kg soil) R_1 = 12 mg K/ kg soil R_2= 24 mg K/ kg soil R_3= 48 mg K/ kg soil

CONCLUSION

Generally, it could be concluded that barley plants responded positively to nitrogen fertilizer application especially at the higher rate (90 kg N kg/Fed.), where the increase in straw and grain yields was 30, 33 and 26 % for straw yield, and 55, 44 and 66 % for grain yield in the saline, sodic and saline sodic soils respectively. This reflects the necessity of plant to have high rate of N under saline sodic conditions in order to alleviate the hazardous effect of salinity and sodicity combined together. Nitrogen application encouraged the tolerance of barley plants to salinity effect and sodicity hazards through the accumulation of nutrients in plant cells which needed for osmotic adjustment and hence increase the uptake of water as well as nutrients which would reflect on increasing plant growth and its yield. There was a significant difference between $R_2$and R_3 in the case of grain yield only.

As for K- fertilization, there was a positive to K particularly at increasing rates; and the highest rate (48 kg K_2O/fed.) gave 29, 49 and 19 % increase for straw yield and 38, 129 and 22 % increase for grain yield in the saline non-sodic, non-saline sodic and saline sodic soils, respectively. Potassium fertilization has a simulative effect on barley tolerance to salinity combined with sodicity. Application of K-fertilizer alleviated the adverse effects of salinity and sodicity and so increased straw and grain yields. There was no significant differences between R_2 and R_3.

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إستجابة نبات الشعير للتسميد النيتروجيني والبوتاسى تحت ظروف الأراضى المتأثرة بالأملاح

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تعتبر الملوحة الزائدة فى بيئة نمو النبات ذات تأثير مثبط لنمو النبات من خلال تأثيرها على جوانب عدة من التمثيل الغذائى للنبات. وإضافة الأسمدة قد تعتبر وسيلة للحصول على نمو مرضى تحت الظروف الملحية. لذلك كان الهدف من البحث الحالى هو دراسة إستجابة نبات الشعير للتسمد النيتروجينى والبوتاسى تحت الظروف الملحية والصودية والملحية الصودية . ولتحقيق الهدف من البحث تم إحضار ثلاثة أراضى من كل من محافظة القليوبية، كفر الشيخ والشرقية ممثلة للأراضى الملحية الغير صودية ، الأراضى الصودية الغير ملحية والأراضى الملحية الصودية على الترتيب. وقد تم إجراء تجربتان تسميد بكل من عنصرى النيتروجين والبوتاسيوم (كل عنصر على حده) استخدم فيهما نبات الشعير صنف جيزة ١٢٣ كدليل وكان التصميم المستخدم لكل تجربة هو تصميم تجربة عاملية فى قطاعات كاملة العشوائية تشتمل على عاملين وثلاث مكررات. إستخدمت أصص سعة ٦ كيلو جرام حيث عبئت بالتربة وأضيف لها العنصر تحت الدراسة ؛ حيث أضيف النيتروجين بمعدل ٢٢,٥ و ٤٥ و ٩٠ كجم ن/فدان (سماد نترات الأمونيوم) ؛ والبوتاسيوم بمعدل ١٢ و ٢٤و ٤٨ كجم بو٢أ (سماد كبريتات البوتاسيوم). تم زراعة ٢٠ حبة شعير بكل أصيص ثم خفت إلى ٥ نباتات بعد تمام الإنبات وتركت حتى النضج، حيث حصدت النباتات وفصل القش عن الحب وقدر الوزن الجاف لكل منهما ثم قدر محتواهما من العناصر الغذائية، والنتائج المتحصل عليها يمكن تلخيصها فيما يلى:

الإستجابة للتسميد النيتروجنى :

أدت إضافة النتروجين إلى حدوث زيادة عامة فى نمو نباتات الشعير فى كل الأراضى تحت الدراسة حيث إزداد النمو مع زيادة معدل النيتروجين المضاف؛ وكانت الزيادة فى النمو فى الأرض الملحية الغير صودية عند أى معدل من معدلات الإضافة أكبر منها فى الأرضين الأخريين.

أدت إضافة النيتروجين إلى حدوث زيادة معنوية فى محصول القش وكانت الزيادة مطردة مع معدل الإضافة ويرجع ذلك إلى زيادة التفريع وإرتفاع النبات وكانت مقدار الزيادة ١٢ ، ٢٥ و ٣١ % عند المعدل الأول والثانى والثالث على الترتيب مقارنة بمعاملة الكنترول وإن إختلف معدل الإستجابة بحسب ظروف الأرض.

إزداد محصول الحبوب زيادة معنوية مع زيادة معدل النتروجين المضاف ويرجع ذلك إلى زيادة التفريع ومن ثم زيادة عدد السنابل. أظهر التأثير العام للنيتروجين زيادات فى محصول الحبوب مقدارها ٢٣ ، ٢٥ و ٥٤ % عند المعدل الأول والثانى والثالث على الترتيب مقارنة بالكنترول وإن إختلف معدل الإستجابة بحسب ظروف الأرض.

أدت إضافة النيتروجين إلى حدوث زيادة مطردة ومعنوية فى إمتصاص النيتروجين والعناصر المغذية الأخرى بواسطة القش والحبوب.

الإستجابة للتسميد البوتاسي:

أدت إضافة البوتاسيوم إلى حدوث زيادة في النمو ومحصول القش عند المعدلات الثلاثة وكانت الزيادة مطردة مع زيادة معدل البوتاسيوم المضاف ومعنوية فقط عند المعدل الأول والثاني. وقد أظهر التأثير العام لأضافة البوتاسيوم زيادات في محصول القش مقدارها ١١ و ٣١ و ٣٣ % عند المعدل الأول والثاني والثالث على الترتيب مقارنة بالكنترول ، وقد إختلف ذلك على حسب ظروف الأرض. تدل النتائج المتحصل عليها على أن إضافة البوتاسيوم عند المعدل العالي لها تأثير مشجع على تحمل الشعير للملوحة مع الصودية.

إزداد محصول الحبوب زيادة معنوية مع زيادة معدل البوتاسيوم المضاف. وقد أظهر التأثير العام لإضافة البوتاسيوم زيادات في محصول الحبوب مقدارها ٣٧ و ٥٨ و ٥٩ % عند المعدل الأول والثاني والثالث على الترتيب مقارنة بالكنترول ، وإن إختلف ذلك بحسب ظروف الأرض.

أدت زيادة إضافة البوتاسيوم إلى حدوث زيادة مطردة في إمتصاص البوتاسيوم وكذلك العناصر المغذية الأخرى بواسطة القش والحبوب وكانت الزيادة معنوية حتى المعدل الثاني. وقد حدث هذا النمط من الإستجابة في الثلاثة أراضي تحت الدراسة حيث لم يكن هناك تفاعل معنوي في هذا الخصوص.

الخلاصة:

إستجابت نباتات الشعير إيجابيا للتسميد النيتروجيني بمعدلات متزايدة خاصة عن المعدل العالي من الإضافة (٩٠ كجم/ فدان) ، حيث أدت إضافة هذا المعدل إلى زيادة محصول القش بنسبة ٣٠ و ٣٣ و ٢٦ % ؛ وزيادة محصول الحبوب بنسبة ٥٥ و ٤٤ و ٦٦ % في الارض المليحة والأرض الصودية والملحية الصودية على الترتيب؛ كان هناك فرق معنوي بين المعدل الثاني والثالث في حالة محصول الحبوب ؛ وعلى ذلك يحتياج النبات لمعدل عالي من النيتروجين خاصة تحت الظروف الملحية والصودية لمعارضة أو لمواجهة الظروف الضارة لهما. إضافة النتروجين تشجع تحمل الشعير للتأثيرات العكسية للملوحة وأضرار الصودية من خلال زيادة تجميع المغذيات في الخلايا النباتية واللازمة للضبط الأسموزي للخلايا ومن ثم زيادة إمتصاص الماء والمغذيات والتي قد تنعكس على زيادة نمو النبات ومحصوله.

تشير النتائج إلى أن إضافة البوتاسيوم إلى نبات الشعير تزيد من تحمله للظروف المعاكسة للملوحة والصودية حيث أدت إضافته بمعدل ٤٨ كجم بو٢أ/فدان إلى زيادة محصول القش بنسبة ٢٩ و ٤٩ و ١٩ % وزيادة محصول الحبوب بمعدل ٣٨ و ١٢٩ و ٢٢ % في الأرض الملحية والصودية والملحية الصودية على الترتيب. أظهر البوتاسيوم تأثير محفذ لتحمل الشعير لأضرار الملوحة مرتبطة بالصودية . إضافة البوتاسيوم لطفت الأثار المعاكسة للملوحة والصودية على النبات وبذلك إزداد محصول القش والحبوب ، ليس هناك فرق معنوي بين المعدل الثاني والثالث.

الإضافات المتزايدة من النيتروجين والبوتاسيوم تشجع على تحمل الشعير للتأثيرات العكسية للملوحة والصودية خاصة عند المعدل العالي من الإضافة.