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Effect of Potassium Humate and Potassium Silicate on Growth and Productivity of Wheat Plants Grown under Saline Conditions.

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ABSTRACT

A lysimeter experiment was carried out at Sakha Agricultural Research Station, Kafr El-Sheikh governorate, during the growth season of 2013-2014 to investigate the effect of potassium humate, potassium silicate and/or their interaction on improving growth parameters and yield components of wheat plants grown under salinity stress. Irrigation of wheat plants with diluted sea water i.e. EC 6, 9 and 12 dS/m reduced growth parameters and yield components, these reductions were gradually increased with increasing the concentrations of diluted sea water. Addition of potassium humate at (4 & 8 kg/fed.) to soil and foliar application of potassium silicate at (500 & 1000 ppm) alone or together increased growth parameters and yield components of wheat plants grown under salinity stress, the duality treatments of potassium humate and potassium silicate were the most effective treatments especially at low concentration in amelioration the depressive effect of salinity on growth and yield of wheat plants.

Keywords: Wheat - Salinity - Potassium Humate - Potassium Silicate - Growth – Productivity.

INTRODUCTION

Salinity is a common abiotic stress factor seriously affected crop production in different regions, particularly in arid and semiarid regions (Flowers, 2004). It is estimated that over 800 million hectares of land in the world are affected by salinity (Munns, 2005). In most cases, the negative effect of the salinity have been attributed to increase in Na^+ and Cl^- ions in different plants hence these ions produce the critical conditions for plant survival by intercepting different plant mechanisms.

Soil salinity affects plant growth and productivity in a variety of ways, reducing water uptake, causing toxic accumulation of sodium and chloride ions and reducing nutrients availability (Jaleel *et al*., 2007). Also, salinity induces water deficit even in well-watered soil by decreasing the osmotic potential of soil solutes (Mansour and Abd El-Hady, 2014).

Wheat and barley are considered the two main grain crops, especially in the arid and semi-arid zones, that depend on rains in cultivation. Breed wheat is the main food of people in many countries and about 70 percent calories and 80 percent protein of human is supplied from its consumption. Therefore, considering increasing country and world population and current shortage of food worldwide, evaluation of methods and strategies which lead to increasing production and optimal use of produced wheat is one of the important and significant issues (Munns *et al*., 2006).

Application of humic substances (HS), the major component of soil organic matter could improve plant growth of wheat plants under the conditions of salinity (Kulikova *et al*., 2005). The beneficial effects of HS on plant growth may be related to their indirect effects in increasing the fertilizer efficiency or direct effects in improvement of the plant biomass. Their effects have been mainly attributed to the complexing properties of HS, which increase the availability of micronutrients, such as Fe and Zn from sparingly soluble hydroxides (Stevenson, 1994). Moreover, their effects appear to be mainly exerted on cell membrane functions, promoting nutrient uptake (Azizi *et al*., 2007), or plant growth and development, by acting as hormone-like substances (Nardi *et al*., 1996).

Silicon (Si) is the second most abundant element of both the surface of the earth's crust and in the soil (Gong *et al*., 2006). It is never found in soil as free form and is always combined with other elements, usually forming oxides or silicates (Richmond and Sussman, 2003). Silicon has been found to minimize the various biotic and abiotic stresses in several crops and it has a beneficial effects on plant growth and improve yield production (Soratto *et al*., 2012), a significant increase in fresh and dry weights of tomato plants were detected by using Si under saline conditions (Haghighi and Mohammad, 2013). Si accumulation decreases transpiration and increasing water uptake, being an important mechanism for plants grown under drought conditions (Melo *et al*., 2003).

The present work was planned to investigate the efficiency of potassium humate and/or potassium silicate to alleviate the adverse effect of diluted sea water salinity on the growth and yield components of wheat plants.

MATERIALS AND METHODS

A lysimeter experiment was carried out at Sakha Agricultural Research Station, Kafr El-Sheikh governorate, during growth season of 2013-2014 to investigate the effect of diluted sea water irrigation, potassium humate, potassium silicate and/or their interaction treatments on growth parameters and yield components of wheat plants. The seeds of wheat plants (*Triticum aestivum*, cv. sakha 93) obtained from the Department of Cereal Research, Agricultural Research Station, Sakha, Kafr-El Sheikh were planted on 15th November in 2013 at equal distance and depth from the soil surface.

Planting was done in lysimeter plots (1 m2) filled with clay soil. The soil was fertilized with NPK at rates of 75 kg N as urea, 100 kg P2O5 and 50 kg K2O/ feddan, which added in the form of calcium superphosphate (15.5% P2O5) and potassium sulphate (48% K2O), respectively. Superphosphate and potassium sulphate were added in one dose before planting, whereas, nitrogen was added at two equal doses, the first one before the post planting irrigation and the second dose at the tillering stage (before the second irrigation). The physical and chemical properties of the soil used are presented in Table (1) and Mediterranean Sea water analysis is shown in Table (2), as determined in Agricultural Research Station, Sakha.

The plots were laid out in split plot design with 3 salt treatments, EC 6, 9 and 12 dS/m of Mediterranean Sea water near Baltim district and tap water was used for dilution along with control (Tap water 0.5 dS/m). Each level of salinity was divided into 4 groups, the 1st group representing the control; in the 2nd group, K-humate was applied to the soil at rates of 4 or 8 kg/ feddan and incorporated into the soil before salinity. On the other hand, in the 3rd group, the plants were sprayed with 500 or 1000 ppm of K-silicate. In the 4th group, plants subjected to the effect of potassium humate followed by potassium silicate as duality treatment at the different growth stages.

Table 1. Physical and chemical properties of the soil used.

Particle size distribution				Chemical properties									
Sand%	Silt%	Clay%	Texture	PH*	EC**, dS/m	Cations, meq/L				Anions, meq/L			
						Mg^{++}	Ca^{++}	K^{+}	Na^{+}	CO_3^{-2}	HCO_3^{-}	Cl^{-}	SO_4^{-2}
16.56	31.26	52.18	Clay	8.23	3.76	4.9	7.5	0.8	26.7	- -	3.5	19.7	16.7

Suspension of * 1: 2.5   ** soil paste extract

Table 2. Chemical analysis of the sea water used.

Analysis of Sea water	pH	EC, dS/m	Cations and anions, meq/L							
			Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{-2}	HCO_3^{-}	Cl^{-}	SO_4^{--}
	7.43	54.50	75.50	147.36	315.14	10.0	--	39.75	398.0	110.25

EC = electrical conductivity.

The first foliar spray was carried out after 30 days from the sowing; the second one was carried out after 50 days from the sowing and the third one after 75 days from the sowing.

An the studied season, all treatments were replicated 3 times to measure growth parameters after 45, 65 and 90 days from sowing for each treatment. Growth parameters including, plant height, fresh and dry weights of shoot and leaf area were determined. The plants were harvested (after 150 days from planting) to determine the yield components, including: spike length, 100-grain weight, number of grains/spike and weight of grains/spike.

Soil samples were air-dried and ground to pass through a 2 mm sieve. The different determinations of soil chemical and physical properties were carried out as follows: particle size distribution of the sample was determined according to the international method (Piper, 1950). Soil acidity (pH) values were measured in the soil water suspensions (1:2.5). Cations, anions and total soluble salts were estimated in the 1:5 saturated soil water extract. Plant samples were dried at 70 ºC and then weighted. Apart of the dried samples were wet digested according to chapman and Pratt (1961). Sodium and potassium was estimated by using the flame photometer. Calcium and magnesium were determined by using the versene method according to Jackson (1967). Chloride was determined by titration with silver nitrate and sulphate was determined by subtracting anions from total cations. The fresh and dry weights of shoot were calculated as g/ plant and the plant height recorded in centimeters. The leaf area (cm^2/ leaf) was determined using the following equation proposed by Quarrie and Jones (1979); Leaf area= Length × Breadth × 0.75.

Statistical analysis

The obtained results were statistically analyzed using the least significant differences (LSD) at 0.05% level of probability (Cochran and Cox, 1960).

RESULTS AND DISCUSSION

I. Growth Parameters:

Data presented in Table (3) declare the effect of different levels of diluted sea water salinity (EC 6, 9 and 12 dS/m) on some growth parameters of wheat plants at 45, 65 and 90 days after sowing. Irrigation with different concentrations of diluted sea water significantly decreased shoot height of wheat plants. This reduction was more pronounced with increasing the concentrations of diluted sea water. These results are true during all growth stages of wheat growth. This reduction of plant growth under salinity stress is consistent with the fact that salinity induces accumulation of certain ions and deficiency of the others and lowers the external water potential in the cell. Moreover, the decrease in plant growth may be due to the disturbance in metabolic activities affected by the decrease of water absorption and disturbance in water balance (Fahad *et al*., 2015). Additionally, Abd El-Monem (2010) noticed that growth may be due to the disturbance in phytohormone levels through the salinity effects on either the biosynthesis or the destruction of the plant hormones. They stated a large decrease in indol acetic acid and cytokinins contents led to a rapid abscicic acid accumulation.

Table 3. Effect of different concentrations of irrigation water salinity on some growth parameters of wheat plants at different growth stages.

Parameters	Plant height (cm)			Fresh weight (g/plant)			Dry weight (g/plant)			Leaf area (cm^2)		
Treatments	45 days	65 days	90 days	45 Days	65 Days	90 Days	45 days	65 days	90 days	45 days	65 days	90 days
Control	35.04	62.22	77.10	6.18	8.48	10.11	1.36	1.63	2.06	26.28	33.93	35.44
S_1	33.00	59.35	73.75	5.34	7.12	8.34	1.19	1.39	1.64	22.54	28.10	30.02
S_2	30.09	54.81	70.67	4.02	5.49	6.75	0.99	1.13	1.29	17.55	24.44	26.20
S_3	28.00	53.43	68.60	3.83	5.09	6.34	0.85	0.97	1.17	16.62	23.36	25.13
LSD at 5 %	0.18	0.11	0.19	0.06	0.08	0.10	0.01	0.02	0.03	0.25	0.29	0.30

Control = 0.5 dS/m. S_1 = EC 6 dS/m. S_2 = EC 9 dS/m. S_3 = EC 12 dS/m.

The results in Table (4) illustrate that application of K-humate to soil at rates (4 and 8 kg/fed.) and K-silicate as foliar spray at (500 and 1000 ppm) added separately or as duality treatment significantly increased the growth parameters including; plant height, fresh and dry weights of shoot and leaf area of wheat plants grown under normal irrigation at three growth stages; 45 days (tillering stage), 65 days (heading stage) and 90 days (anthesis stage) after sowing. It could be concluded that the duality treatment especially the high concentration seemed to be the most effective treatment compared to other ones. Kulikova *et al.* (2005) also pointed out that humic substances may enhance the uptake of nutrients and reduce the uptake of some toxic elements. Silicon positively influences wheat plant growth and biomass production, as a consequence of improved tissue rigidity and improving photosynthetic rate (Gong and Chen, 2012).

The applications of K-humate and K-silicate as separately or alternatively caused significant increases in plant height, fresh and dry weights of shoot as well as leaf area of salinity stressed wheat plants at different growth stages as compared to those of the untreated stressed plants (Table 5). The highest values of the increments of aforementioned growth parameters were obtained by duality treatments especially at low concentrations compared to other treatments. This could be attributed to that humic substances might show anti-stress effects under abiotic stress conditions, thus humic substances may enhance the uptake of nutrients and reduce the uptake of some toxic elements and consequently improved the growth of wheat plants. The protective effect of humic substances was attributed to the increase of cell membrane permeability, respiration, photosynthesis, oxygen and phosphorus uptake and supplying root cell growth under moderate salinity conditions of pepper plant (Pizzeghello *et al*., 2013). Moreover, the enhancement effect of silicon could be attributed to activating antioxidant defense system or through their protective effect on the photosynthetic pigments in salt stressed plant (Ashraf *et al*., 2010).

Table 4. Effect of potassium humate and potassium silicate treatments on some growth parameters of wheat plants at different growth stages.

Parameters	Plant height (cm)			Fresh weight (g/plant)			Dry weight (g/plant)			Leaf area (cm^2)		
Treatments	45 Days	65 days	90 Days	45 Days	65 Days	90 Days	45 days	65 days	90 days	45 Days	65 days	90 Days
Control	29.73	54.99	70.73	3.97	5.39	6.53	0.94	1.1	1.34	18.62	24.96	26.71
Kh_1	32.29	58.50	73.09	5.18	7.04	8.29	1.17	1.35	1.63	21.7	28.5	30.32
Kh_2	32.37	58.66	73.55	5.33	7.14	8.72	1.17	1.37	1.63	21.6	28.8	30.4
Ksi_1	32.62	58.87	73.66	5.32	7.25	8.61	1.21	1.39	1.67	22.12	28.97	30.66
Ksi_2	32.43	58.70	73.43	5.26	7.09	8.63	1.17	1.35	1.63	21.74	28.61	30.43
Kh_1+ksi_1	35.13	62.33	76.73	6.13	8.54	10.28	1.39	1.65	2.07	26.67	34.43	35.5
Kh_2+ksi_2	39.37	68.9	82.03	8.74	11.29	14.7	1.84	2.13	2.48	31.25	39.4	42.35
LSD at 5%	0.14	0.17	0.14	0.03	0.07	0.04	0.01	0.01	0.02	0.13	0.16	0.26

Kh_1= 4 kg potassium humate /feddan. **Ksi_1 = 500 ppm potassium silicate solution.**
Kh_2= 8 kg potassium humate /feddan. **Ksi_2 = 1000 ppm potassium silicate solution.**

Table 5. Effect of interaction between different concentrations of salinity, potassium humate and potassium silicate on some growth parameters of wheat plants at different growth stages.

Parameters		Plant height (cm)			Fresh weight (g)			Dry weight (g)			Leaf area (cm^2)		
Treatments		45 days	65 days	90 days	45 days	65 days	90 days	45 days	65 days	90 days	45 days	65 days	90 days
Control (without Kh and Ksi)	S_0	31.4	56.0	73.9	4.48	6.30	7.11	0.96	1.28	1.74	21.3	29.2	30.1
	S_1	30.5	53.7	70.8	4.15	5.01	6.09	0.916	1.15	1.32	17.30	23.53	27.0
	S_2	27.0	51.4	68.2	2.77	3.80	5.01	0.793	0.893	1.03	15.10	20.17	22.5
	S_3	24.7	50.8	65.8	2.50	3.22	4.54	0.653	0.706	0.886	14.40	18.43	21.1
S_1	Kh_1	32.2	58.8	72.6	5.00	6.52	7.65	1.10	1.28	1.49	21.40	27.57	28.6
	Kh_2	30.6	56.8	70.9	4.25	5.57	6.65	1.00	1.17	1.34	19.05	26.20	27.0
	Ksi_1	31.7	57.2	71.4	4.27	5.78	6.93	1.07	1.19	1.37	20.5	26.3	27.4
	Ksi_2	32.2	59.3	72.9	5.06	6.87	7.89	1.14	1.31	1.59	22.3	27.7	29.4
	Kh_1+ksi_1	35.3	62.8	77.1	6.78	9.02	10.6	1.39	1.65	2.02	26.3	30.4	33.0
	Kh_2+ksi_2	34.3	60.8	75.0	5.91	8.17	9.16	1.31	1.52	1.81	24.3	29.4	32.1
S_2	Kh_1	27.7	51.9	68.3	3.06	4.33	5.40	0.810	0.903	1.08	15.1	21.5	23.2
	Kh_2	29.6	53.7	70.1	3.88	5.13	6.38	0.923	1.12	1.21	16.9	23.5	25.2
	Ksi_1	28.4	52.5	70.0	3.15	4.75	5.63	0.883	0.990	1.11	16.1	22.1	23.8
	Ksi_2	30.1	54.5	72.0	3.93	5.27	6.62	0.973	1.13	1.24	17.0	24.6	25.8
	Kh_1+ksi_1	33.6	60.1	73.4	5.80	7.78	9.05	1.31	1.43	1.78	22.1	29.1	31.4
	Kh_2+ksi_2	30.2	54.8	70.2	3.98	5.54	6.97	0.986	1.14	1.25	17.2	25.0	26.4
S_3	Kh_1	25.4	51.3	66.2	2.87	3.98	5.21	0.673	0.710	0.926	14.9	20.3	22.0
	Kh_2	27.4	52.8	67.9	3.54	4.83	6.10	0.783	0.890	1.11	15.4	22.7	24.1
	Ksi_1	26.6	51.4	66.6	3.02	4.50	5.54	0.706	0.796	0.990	15.1	21.6	23.1
	Ksi_2	28.0	53.1	68.2	3.68	4.93	6.29	0.80	0.896	1.12	16.5	23.1	25.0
	Kh_1+ksi_1	31.7	57.9	72.7	5.47	7.13	8.08	1.22	1.39	1.61	20.6	27.9	29.8
	Kh_2+ksi_2	28.3	53.2	68.4	3.89	5.03	6.70	0.806	0.920	1.14	16.5	24.1	25.16
LSD at 5 %		0.47	0.50	0.47	0.1	0.2	0.18	0.03	0.04	0.06	0.50	0.60	0.81

S_0 = tap water (0.5 dS/m). **S_1 = EC 6 dS/m.** **S_2 = EC 9 dS/m.** **S_3 = EC 12 dS/m.**
Kh_1 = 4 kg potassium humate /feddan. **Kh_2 = 8 kg potassium humate /feddan.**
Ksi_1 = 500 ppm potassium silicate solution. **Ksi_2 = 1000 ppm potassium silicate solution.**

II. Yield Components:

Results in (Table 6) show that the different yield components involved spike length, weight of 100 grain, number of grains per spike and weight of grains per spike of salinity stressed wheat plants were significantly reduced with increasing salinity in irrigation water. Similar results were reported by Daneshmand *et al.* (2012) on wheat plants. These results could be attributed to changes in osmotic potential resulting from reducing water content and specific toxic effects caused by the accumulation of sodium and chloride ions as observed in many plants (Abu-Muriefah, 2015).

Under normal irrigation, the effect of both K-humate and K-silicate applied separately or together caused a pronounced increment in the studied yield components compared to corresponding control values (Table 7). The duality treatments especially at high level seemed to be the most effective treatments compared to other treatments in increasing the different yield components. The results obtained in the present investigation concerning the effect of K-humate on yield components agree well with previous data by Bakry *et al.* (2013) on wheat plant and Atoosa *et al.* (2017) on olive fruit. The positive influences of humic acids on yield components could be mainly due to increasing endogenous cytokinins and auxin levels which probably lead to improve yield (Moraditochaee, 2012). Furthermore, Si treatments, probably due to a reduction in lipid peroxidation, and an increase in catalase activity and potassium silicate significantly improved fruit quality through an increased anti-oxidant pool in fruit (Tesfay *et al.*, 2011).

Table 6. Effect of different concentrations of irrigation water salinity on different yield components of wheat plants.

Yield components Treatments	Length of spikes (cm/ spike)	Weight of 100 grain (g)	Number of grains/ spike	Weight of grains/ spike (g/ spike)
Control	12.24	6.00	34.52	1.84
S_1	11.06	5.43	30.45	1.39
S_2	9.04	4.96	26.00	1.04
S_3	8.73	4.76	24.55	0.940
LSD at 5 %	0.14	0.03	0.31	0.01

Control = 0.5 dS/m. S_1 = EC 6 dS/m. S_2 = EC 9 dS/m. S_3 = EC 12 dS/m.

Table 7. Effect of potassium humate and potassium silicate treatments on different yield components of wheat plants.

Yield components Treatments	Length of spike (cm/ plant)	Weight of 100 grain (g)	Number of grains/ spike	Weight of grains/ spike (g)
Control	8.8	4.78	25.83	1.06
Kh_1	10.79	5.53	30.31	1.42
Kh_2	11.06	5.52	30.25	1.39
Ksi_1	11.15	5.59	30.64	1.46
Ksi_2	11.00	5.53	30.42	1.41
Kh_1+ Ksi_1	12.20	6.03	34.66	1.95
Kh_2+ Ksi_2	16.20	6.66	43.00	2.42
LSD at 5 %	0.13	0.02	0.2	0.01

Kh_1 = 4 kg potassium humate /feddan.
Ksi_1 = 500 ppm potassium silicate solution.
Kh_2= 8 kg potassium humate /feddan.
Ksi_2 = 1000 ppm potassium silicate solution.

The interactive effect among salinity levels, K-humate and K-silicate treatments separately or alternatively on yield components of wheat plants was recorded in Table (8). All treatments markedly improved yield components of plants under saline conditions compared to saline untreated plants. The application of K-humate and K-silicate treatments, especially the duality treatment at low concentrations ameliorated the harmful effect of salinity concentrations on yield components. Application of humic acid has been identified to reduce salinity and increase crop productivity (Canellas and Olivares, 2014), the improving of yield and its components may be due to the indirect positive effect of humic acid on chlorophyll content. The increase in chlorophyll content promotes photosynthetic activities which, in turn, diverts more photo-assimilates towards higher yield of wheat (Tahir *et al*., 2011). Moreover, Bozorgi *et al.* (2011) reported that humic acid application resulted in increasing endogenous cytokinins and auxin levels which probably leads to improve yield. Additionally, Si possibly played a role in maintaining fruit moisture and photosynthetic activities under stress of wheat plants (Gong *et al*., 2003).

Table 8. Effect of interaction among different concentrations of irrigation salinity, potassium humate, potassium silicate and their duality on yield components of wheat crop.

Yield components Treatments		Length of spike (cm/ plant)	Weight of 100 grain (g)	Number of grains/ spike	Weight of grains/ spike (g)
Reference control	S_0	9.10	5.51	27.6	1.33
	S_1	8.40	3.97	23.7	0.903
	S_2	7.00	3.66	21.7	0.750
	S_3	6.50	3.43	20.3	0.680
S_1	Kh_1	10.6	5.32	30.0	1.24
	Kh_2	9.27	5.03	25.7	1.06
	Ksi_1	9.43	5.16	27.7	1.15
	Ksi_2	10.7	5.43	30.3	1.34
	Kh_1+ Ksi_1	13.3	6.13	35.3	1.79
	Kh_2+ Ksi_2	12.2	5.93	33.0	1.61
S_2	Kh_1	7.50	4.62	23.0	0.826
	Kh_2	8.60	4.83	25.0	0.922
	Ksi_1	7.93	4.71	24.3	0.879
	Ksi_2	8.77	4.96	25.3	0.981
	Kh_1+Ksi_1	11.8	5.81	32.0	1.52
	Kh_2 +Ksi_2	8.97	5.13	26.0	1.01
S_3	Kh_1	7.20	4.33	22.0	0.713
	Kh_2	8.30	4.63	24.0	0.840
	Ksi_1	7.70	4.51	22.3	0.740
	Ksi_2	8.70	4.72	24.3	0.880
	Kh_1+ Ksi_1	11.3	5.71	30.0	1.42
	Kh_2 +Ksi_2	8.90	4.94	24.7	0.900
LSD at 5 %		0.4	0.1	0.70	0.05

S_0 = Fresh water (0.5 dS/m) S_1 = EC 6 dS/m. S_2 = EC 9 dS/m. S_3 = EC 12 dS/m.
Kh_1 = 4 kg potassium humate /feddan.
Ksi_1 = 500 ppm potassium silicate solution.
Kh_2 = 8 kg potassium humate /feddan.
Ksi_2 = 1000 ppm potassium silicate solution.

It can be concludedthat salinity levels had a depressive effect on growth and yield components. Application of K-humate and K-silicate alone or together can play an important role in alleviating the adverse effect of salinity on growth parameters and wheat yield components.

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تاثير هيومات البوتاسيوم وسليكات البوتاسيوم على نمو وانتاجية نباتات القمح النامية تحت الظروف الملحية.

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أجريت تجربة ليزيمترية في مزرعة محطة البحوث الزراعية بسخا – كفر الشيخ في الموسم الزراعي٢٠١٣-٢٠١٤ بهدف دراسة إستجابة نباتات القمح لملوحة مياه الري وذلك بري النباتات بتركيزات مخففة من ماء البحر بالإضافة إلي الكنترول وكذلك دراسة تطبيق هيومات البوتاسيوم (٤- ٨ كجم/ فدان) للتربة قبل الزراعة أو سيليكات البوتاسيوم (٥٠٠- ١٠٠٠ جزء فى المليون) رشاً علي النباتات ثلاث مرات أثناء فترة النمو سواء للنباتات التي تنمو في الظروف الطبيعية أو النامية في ظروف الملوحة بغرض التغلب على التأثير الضار للملوحة ، وقد طبقت هذه المواد فى صورة منفردة أومعا. وأخذت ثلاث عينات أثناء فترة نمو النباتات، عند عمر ٤٥، ٦٥، ٩٥ يوماَ علي التوالي. وتم دراسة الإستجابة الفسيولوجية بقياس صفات النمو (طول النبات، الوزن الغض والجاف للمجموع الخضري ومساحة الورقة) وفى النهاية أخذ المحصول عند عمر ١٥٠ يوما لدراسة طول السنبلة، وزن ١٠٠ حبة، عدد الحبوب/ سنبلة ووزن الحبوب/سنبلة. ويمكن تلخيص أهم النتائج فيما يلي:. ١- أدت زيادة تركيزات ملوحة ماء البحرفى مياة الرى الى حدوث نقص معنوى فى قياسات النموالخضرية (طول النبات، الوزن الغض والجاف للمجموع الخضري ومساحة الورقة) والمحصول (طول السنبلة، وزن ١٠٠ حبة، عدد الحبوب/ سنبلة ووزن الحبوب/سنبلة)، و يزداد هذا النقص بزيادة تركيز ماء البحر فى مياة الرى. ٢- أشارت النتائج الى وجود زيادة معنوية واضحة فى قياسات النمو الخضرية والمحصول لنباتات القمح النامية تحت ظروف الري الطبيعية مع تطبيق كلا من هيومات البوتاسيوم عند (٤و٨ كجم/ فدان) وسيليكات البوتاسيوم عند (٥٠٠و ١٠٠٠ جزء فى المليون) كلاً علي حده أو معاً وكانت المعاملات المشتركة بينهما اكثر المعاملات فعالية خاصة عند التركيز المرتفع. ٣- أظهرت نتائج التفاعل المشترك بين تركيزات الملوحة و إستخدام هيومات البوتاسيوم وسيليكات البوتاسيوم سواء كلاً علي حده أو معاً ، وجود زيادة معنوية واضحة في قياسات النمو الخضرية والمحصول مقارنة بالنباتات المعاملة بالملوحة فقط. وسجلت المعاملات المشتركة بين السيلكات والهيومات خاصة عند التركيز المنخفض أعلي القيم للقياسات الخضرية والمحصول للنباتات التي تنمو تحت الإجهاد الملحي. وعموما أثبتت نتائج الدراسة الحالية مدي فاعلية إستخدام السيلكات والهيومات فى صورة منفردة أو متبادلة في تقليل الأثار الضارة الناجمة من الإجهاد الملحي على قياسات النمو الخضرية ومحصول نباتات القمح.