J. of Soil Sciences and Agricultural Engineering, Mansoura Univ., Vol. 14 (3):103 - 112, 2023

Journal of Soil Sciences and Agricultural Engineering

Journal homepage & Available online at: www.jssae.journals.ekb.eg

Potassium Humate and Silicate Combined with Compost Application to Reduce the Harmful Effects of the Irrigation Water Salinity on Potato Plants and on the Soil Available Nutrient Npk

Cross Mark

Shabana, M. M. A.[1]; Kholoud[1] A. A. El-Naqma; M. G. Zoghdan[1] and R. M. Khalifa[2*]

[1] Soil, Water, and Environment Research Institute; A.R.C., Egypt.
[2] Soil and water Dept. Fac. of Agric. Damietta Univ.

ABSTRACT

Afield experiment was conducted to evaluate the effect of two compounds of potassium humate and silicate, combined with compost to decrease the harmful effects of water salinity on potato crop yield and quality, also, the soil available nutrient NPK. The main plots were assigned for the irrigation treatments; 0.5 (W_1), 2.25 (W_2) and 5.7 ds m^{-1} (W_3). The sub-plots treatments were; F_0 (without compost applying), F_1 (compost applying to soil), F_2 (compost applying to soil plus foliar spraying by potassium silicate solution (10 cm^3.L)), F_3 (applying compost to soil plus coated tubers with potassium silicate, F_4 (compost applying to soil plus foliar spraying with potassium humate) and F_5 (compost applying to soil plus coated tubers with potassium humate) . The findings demonstrated that the majority of vegetative growth characteristics, tuber quality and tuber yield were impacted by increasing the salinity of irrigation water in both seasons. Spraying potato plants twice with potassium humate or silicate solutions had a notable positive impact on all of the studied characteristics. Comparing to the control treatment, results showed spraying potassium silicate had a high significant influence on growth characters, yield and yield components of potato in both seasons. It could be concluded that, spraying potato plants twice with potassium silicate solution in the presence of the applied compost to the soil (F_2) is the most efficient treatment for reducing the harmful effects of irrigation water salinity on potato and yield quality, and improving the available nutrient levels, NPK, in the soil

Keywords: potato, compost, potassium humate, potassium silicate, foliar spraying, irrigation water salinity and salt stress.

INTRODUCTION

Abiotic stresses, particularly salinity have a negative impact on crop productivity and food security, necessitating special attention in arid areas (Aiad *et al.*, 2021; Kheir *et al.*, 2021b). The Middle East has the most salt-affected land (189 Mha), followed by Australia (169 Mha), North Africa (144 Mha), and South Asia (52 Mha) (Wicke *et al.*, 2011). As saline soil spreads, it is anticipated that by 2050, the existing area under salinity stress would nearly quadruple (Shrivastava and Kumar, 2015). Salt stress has no effect on crop yield until a certain salinity threshold (ECt) is exceeded in the soil. (Zörb *et al.*, 2019). As a result of their salt sensitivity, the majority of vegetables, such as beans, carrots, eggplants, potatoes, muskmelon, onions, peas, celery, lettuce, okra, and tomato, have very low values of this threshold, which ranges from 1 to 2.5 dS m^{-1}. (Chourasia *et al.*, 2021b). Plants have evolved various mechanisms to tolerate saline conditions in response to salinity stress. These mechanisms are classified broadly as osmotic tolerance, ion exclusion, and tissue tolerance. (Gupta and Huang, 2014a). Plant cells' primary regulating mechanisms for adaptation under salinity conditions are osmotic adjustment and toxic ion compartmentalization. Under salt stress conditions, plant species that can tolerate salt retain their typical metabolic processes, such as water use efficiency (WUE). On the other hand, latter species lack inherent metabolic systems to handle high salt concentrations. (Gupta and Huang, 2014b).

In semi-arid and growing regions, salinity is one of the abiotic factors that has an impact on potato growth and productivity by changing plant metabolism and significantly affecting biochemical and molecular process (Sanwal *et al.*, 2022). All plant systems and enzymatic processes can be severely disrupted by the accumulation of Na+ and Cl- in cells, which is exceedingly poisonous (Flowers *et al.*, 2015). Because different potato cultivars react differently to salinity stress, it is crucial to identify and test commercial cultivars for salt stress production utilizing an in vitro system (Chourasia *et al.*, 2021a). Nonetheless, the negative effects of salinity on potato productivity continue to grow, necessitating close attention.

Potato is a plant with high nutritional value in food security and nutrition, ranking fifth in the world in terms of production and consumption after wheat, corn, rice, and barley. Its production is increasing due to its high productivity and compatibility with a wide range of climates, as well as its nutritional value (Devaux *et al.*, 2021; Ding *et al.*, 2021a). In 2018 and beyond, Egypt ranked fifth in potato exports, shipping over 759,200 tones to Russia and the European Union. However, addressing the salinity stress issue will increase total production, helping to alleviate the current global food crisis.

Bagasse ash and thiourea (Seleiman and Kheir, 2018), organic amendments (Ding *et al.*, 2020), vermicompost (Ding *et al.*, 2021b), biochar (Kheir *et al.*, 2021a; Liu *et al.*, 2021), and nanoparticles (Saad Kheir *et al.*, 2019) are just a few of the techniques and methods that have recently been used to

*** Corresponding author.**
E-mail address: dr_ramykhalifa@yahoo.com
DOI: 10.21608/jssae.2023.190455.1141

reduce soil salinity and increase crop productivity in salt-affected soils. However, such methods have not been used with potatoes before, and there are other methods that may improve crop yield resistance to salinity stress. Exploring the effect of added compost in irrigation water salinity, even when potassium humate and potassium silicate spraying potato plants or coated tubers is very important in alleviating salinity stress, has received less attention thus far. The need for improved genotypes, potassium depletion from soil, and low buffering capacity of soils to supply this element all contribute to the need for research into soils where potassium consumption is less than critical (Fontana *et al.*, 2022). Humates are used in soil or sprayed on plants (foliar application) primarily due to their high humic acid content, which ranges from 30 to 60% and is easily absorbed by the roots (Leite *et al.*, 2020). Therefore, The purpose of the current study is to evaluate how compost, potassium humate, and potassium silicate can help potatoes tolerate the damaging effects of salinity.

MATERIALS AND METHODS

During the winter seasons 2020/2021 and 2021/2022, a field experiment was conducted in a clayey textured soil at the Sakha Agricultural Research Station farm in Kafr El-Sheikh Governorate, Egypt (30º56N latitude and 31º 05 E longitude). The main objective was to investigate the effects of humate compounds in the presence of compost added to the soil on decreasing the harmful effects of the irrigation water salinity on potato crop (c.v. spunta) growth, yield and yield quality, as well as, the soil available nutrient NPK. Three replicates of a split plot design were employed. The main plots were assigned for the irrigation treatments; 0.5 (W_1), 2.25 (W_2) and 5.7 ds m^{-1} (W_3), (Table 1). For one treatment, the experiment was conducted in lysimeters made of concrete basins each lysimeter has 2m in wide, 6m in long and 1m in depth, which was filled the clay soil used in the experiments. Each lysimeter was connected to the others at the bottom by shared drainage pipes. Source of the saline irrigation water is an artesian well next to the cement basins and represents the salinity water (W_3) and is mixed with fresh water which represents the normal salinity water (W_1) to give water of medium salinity (W_2). The salinity (Ec) was measured for each type of aforementioned water as shown in (Table 1).

The sub-plots were; F_0 (without compost applying), F_1 (compost applying to soil), F_2 (compost applying to soil plus foliar spraying by potassium silicate solution (10 cm^3.L)), F_3 (applying compost to soil plus coated tubers with potassium silicate, F_4 (compost applying to soil plus foliar spraying with potassium humate) and F_5 (compost applying to soil plus coated tubers with potassium humate). Each sub plot's area was 12 m^2 (6 m × 2 m).

The compost was obtained from the agricultural research center in Sakha, kfr Elsheikh, Egypt, and it was prepared using the agricultural post-harvest wastes of rice straw, cotton and corn stalks (60%), farmyard manure (35%), and fertile soil (5%).

Regarding the preparation of coated tubers, the tubers were immersed in a potassium silicate solution and a potassium humate solution for 10 cm^3 L^{-1} each, stirred, and then manually planted.

Compost was added to the soil before sowing at the level of 10 m^3acre^{-1}. Natural humate powder (a mixture of humic acid and fulvic acid) and potassium silicate were coated at 10 cm^3.L (10 % K_2O, 25% SiO2). After planting the same volume (10 cm^3.L of all fertilizers types was added as a foliar one dose. All treatments had been acquisitive Ammonium sulfate (20%N) at rate of 150 kg N acre^{-1} (75 kg $(NH_4)_2SO_4$), taking three doses before the first and second irrigations, apply 20% with planting and the 80% was doubled to two equal doses). Potassium sulphate (48% K_2O) at rate of 48 kg K_2O acre^{-1} on one dose with the planting and phosphate fertilizer at rate of 30 kg P_2O_5 acre^{-1} as single calcium superphosphate (15.5 % P_2O_5) on one dose with soil preparation. Calcium nitrate (17 % Ca) 7.5 kg Ca acre^{-1} on two times (4 kg. acre^{-1} at the 34th day and 3.5 Kg. acre^{-1} at the 43th day after planting). Magnesium sulfate (10 % Mg) 5 kg $MgSo_4$. 7 H_2O acre^{-1}, (2.5 kg. acre^{-1} was added at 34 and 43 days after planting).

The calcium nitrate and Magnesium sulphate were both added at the previously times as a powder and sprayed by manual sprayer on potato plants. Planting tuber toke place on 22 and 24 October in both growing seasons. Tuber between hills were planted in rows, 70 cm in wide, 4.0 m in long and spacing of 25 cm.

All agricultural practices were implemented in accordance with the Ministry of Agriculture and Land Reclamation recommendation in Egypt. Before soil preparation, soil samples were collected from the upper layers (0-30 cm), and some chemical and physical properties of the soil were analyzed and are shown in Table 2. The international pipette method was used to determine particle size distribution. The soil's available nitrogen was extracted with 1N potassium chloride and determined using the Kjleldhl method, while phosphorus was extracted with 0.5N sodium bicarbonate and colorimetrically measured using a spectrophotometer. 1N ammonium acetate was used to extract available potassium, which was then measured using a flame photometer. In soil paste extract, the pH, EC, and soluble cations and anions were determined. All determinations were performed according to (Buurman, 1997). Compost was added at rate of 10 m^3acre^{-1}. Some chemical properties of the compost are presented in Table 3.

For the first season, potatoes (cv. spunta) were planted on 22 October 2020 and harvested on 2 March 2021, and for the second season were planted on 24 October 2021 and harvested on 3 March 2022. After 90 days, a random sample of five plants from each plot were chosen, and their height, number of leaves, leaf area, and levels of chlorophyll A, B, and total chlorophyll were all measured.

Table 1. Chemical properties of irrigation water used in the study

Treatments	pH	Ec_w	Soluble cations, meq L^{-1}				Soluble anions, meq L^{-1}			
			Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{-}-	HCO_3^{-}	CL^{-}	SO_4^{--}
W1	6.85	0.5	0.335	0.13	0.38	0.21	-	0.23	0.39	0.435
W2	7.25	2.25	0.730	0.35	2.18	0.40	-	0.82	1.96	0.88
W3	7.42	5.7	1.400	0.82	2.94	0.67	-	2.24	2.27	1.32

W1, W2, and W3 are water types. Ecw: water salinity

Table 2. Soil physical and chemical characteristics of the experimental site (0-30 cm) before cultivation of potato plants for two seasons

Properties	Particle size distribution				Bd	Tp	pH*	EC**	SAR	OM	$CaCO_3$	Available NPK (mg kg^{-1})		
Season	Sand %	Silt %	Clay %	Texture class	(kg m^{-3})	(%)		(dS m^{-1})		(%)	(%)	N	P	K
1st	19.90	30.2	49.85	Clayey	1.33	53.0	7.76	3.25	9.58	1.89	2..53	31.85	5.97	268
2nd	20.20	28.4	51.39	Clayey	1.32	49.2	8.03	3.89	10.54	1.88	2.41	28.83	4.30	238

***it was determined in soil water suspension (1:2.5) ** it was detected in soil paste extract**

Table 3. Some chemical properties of the compost over two growing seasons

Seasons	pH (1:10)	EC (1:10) dSm^{-1}	N %	C %	C:N	P %	K %	Mn ppm	Fe ppm	Zn ppm
1st	6.65	4.92	1.45	26.5	18.28	0.76	1.98	490	526	25
2nd	6.62	5.04	1.36	25.7	18.89	0.83	1.75	498	531	52

- Leafe area (m^2 $plant^{-1}$) = dry weight of leaves x disk area x No .of disks/dry weight of disks (Strachan *et al.*, 2005).
- Tuber weight (g. $plant^{-1}$), number of tubers plant-1, fresh tuber yield (tonne $acre^{-1}$), (dry matter%, starch%, and protein%) were measured 130 days after planting.
- Starch % = (17.547+ {0.89 x (dry matter-24)}). Was determined according to (Wang *et al.*, 2021).

At harvest, samples of leaves and tubers which taken, were oven dried at 70oC until constant weight, then ground to a fine powder, and subsamples of 0.5 g were digested with a mixture of sulfuric and perchloric acids to determine nitrogen, phosphorus, potassium, calcium, and magnesium. (A.O.A.C., 1990).

Fresh irrigation water (W_1) was applied through a weir installed in the source of irrigation water adjacent the lysimeters and the amount of water was calculated according to the following equation:

$$Q = 1.84\ LH^{1.5}$$

where: Q is rated discharge (m3/sec.), L is length of weir (cm) and H is the head of water above edge of weir crust (cm). Potato was irrigated when 40% of available water was depleted. ?????

Before the experiments and after potatoes harvesting for the first and second season soil samples were taken from 3 depths namely; 0-15, 15-30 and 30-45cm , respectively, and prepared to determined; EC and (Na^+, Ca^{++} and Mg^{++} to calculate SAR= Na^+ meq/l/ $\sqrt{(Ca^{++}+Mg^{++})/2}$ meq/l) in soil paste extract according to (Page et al., 1982), also soil bulk density was measured by (Campbell, 1994).

The obtained data were statistically analysed using the methods described by (Gomez and Gomez 1984).

The differences in treatment means were tested using (L.S.D.) at a 5% level of probability. All statistical analysis were performed with SAS computer software.

RESULTS AND DISCUSSION

1. Effect of various treatments on potato plant growth

Data in Table 4 show that irrigation water salinity has significant effects on growth parameters such as plant height (cm), leaf number $plant^{-1}$, and leaf area (m^2 $plant^{-1}$). In both seasons, W1 (normal irrigation water) produced the highest values for plant height (33.88 and 31.66 cm), number of leaves $plant^{-1}$ (20.88 and 19.44), and leaf area (0.247 and 0.245 m^2 $plant^{-1}$). Significant difference between the fertilizer treatments on plant height (cm), leaves number $plant^{-1}$, leaf area (m^2 $plant^{-1}$) were found where the control treatments had the lowest values. (F2) Compost + foliar potassium silicate treatment gave the highest values of the studied parameters. The values of the plant height (cm); leaves number $plant^{-1}$and leaf area (m^2 $plant^{-1}$) had the descending order of F2 >F3 > F4 >F5 >F1 > F0.

These results agree with (Jha *et al.*, 2017) who demonstrated that vegetative growth of potato plants decreased with increasing water salinity level. Under salinity stress circumstances, plant growth is reduced, which is accompanied by the truth that salinity causes ion buildup and insufficiency in others, as well as reducing the external water potential in the cell. Furthermore, this could be due to a disruption in metabolic activities caused by a decrease in water absorption and a disturbance in water balance (Fahad et al., 2015).

Table 4. Influence of irrigation water salinity and fertilizers sources treatments on potato growth parameters after 90 days from planting

Treatments	Plant height (cm)		Leaves No. $plant^{-1}$		Leaf area (m^2 $plant^{-1}$)	
	1st	2nd	1st	2nd	1st	2nd
Water salinity (dsm^{-1})						
(W1)	33.88	31.66	20.88	19.44	0.247	0.245
(W2)	31.16	28.83	16.22	14.72	0.229	0.221
(W3)	27.33	23.66	12.55	12.00	0.130	0.129
L.S.D at 5%	0.1259	3.161	0.999	1.174	0.007	0.001
Fertilizers forms						
F0	26.77	24.66	10.66	10.33	0.187	0.185
F1	29.00	26.88	15.55	14.11	0.197	0.194
F2	35.00	32.55	20.55	19.00	0.215	0.213
F3	34.33	29.22	18.88	17.33	0.211	0.208
F4	30.33	28.00	17.55	16.77	0.207	0.195
F5	29.33	27.00	16.11	14.77	0.197	0.194
L.S.D at 5%	0.1310	3.528	0.582	0.920	0.010	0.002

W1= 0.5 dsm-1, W2= 2.25 dsm-1 , W3= 5.7 dsm-1

F0= without compost, F1= compost applied to soil,f2= compost +foliar potassium silicate, F3= compost + coated tuber with potassium silicate, f4= compost + foliar potassium humate, f5= compost +coated tuber with potassium humate

Potato growth parameters were significantly affected by the interaction of irrigated water salinity and fertilizer treatments (Table 5). In the two seasons, the highest values of plant height (39.00 and 37.00 cm), number of leaves $plant^{-1}$ (25.0 and 22.66), and leaves area (0.260 and 0.259 m^2 $plant^{-1}$) were obtained with (W1+F2) normal irrigation water containing compost + foliar potassium silicate. All growth parameters were decreased with increasing salinity of irrigation water under all fertilizer treatments. But the F_2 treatment still the highest values with all irrigation water salinity. Data show that all growth parameters decreased as the salinity of irrigation water increased (10.25% and 13.51 %) for plant height, (29.36 and 26.48%) for leaves No. and (46.92 and 20.85%) for leaf area with F2 (compost + potassium silicate) treatments compared with the better treatments (F2).

(Xu *et al.*, 2020) illustrated that potassium influences photosynthesis, which has a positive impact on vegetative characteristics. The authors explained that the rise in vegetative development of potato plants sprayed with potassium sources could be attributed to potassium's function in plant nutrition, such as enhancing assimilate translocation, protein synthesis, and enzyme activity promotion. The increase in vegetative growth caused by spraying potato plants with potassium silicate could be attributed to potassium's role in plant nutrition and enhancing assimilate and protein synthesis (Ali *et al*., 2021).Also, (Hasanuzzaman *et al.*, 2018) outlined the importance of potassium as a nutrient for a number of physiological processes in plants, such as regulating gas and water exchange, protein synthesis, enzyme activation, and photosynthesis. In addition, similar results were recorded by Abd EL-Gawad et al., (2017).

Table 5. Effect of interaction between the irrigation water salinity and fertiliser sources treatments on potato growth parameters 90 days after planting

Treatments		Plant height (cm)		Leaves No. Plant^{-1}		Leaf area (m^2 plant^{-1})	
		1st	2nd	1st	2nd	1st	2nd
W1	F0	31.33	29.66	12.33	12.00	0.231	0.228
	F 1	32.00	30.33	22.33	20.33	0.243	0.241
	F2	39.00	37.00	25.00	22.66	0.260	0.259
	F3	35.00	32.66	23.00	21.00	0.255	0.252
	F4	33.00	30.33	22.33	22.00	0.249	0.247
	F5	33.00	30.00	20.33	18.66	0.247	0.243
W2	F0	22.00	23.33	11.33	10.33	0.207	0.204
	F 1	28.00	26.00	15.00	13.33	0.251	0.218
	F2	37.00	35.00	19.33	17.66	0.246	0.244
	F3	33.00	30.00	19.00	17.33	0.244	0.240
	F4	31.00	29.00	16.33	22.00	0.215	0.212
	F5	29.00	27.66	16.33	18.66	0.212	0.211
W3	F0	21.00	18.33	8.33	8.66	0.124	0.124
	F 1	24.00	22.00	9.33	8.66	0.128	0.125
	F2	35.00	32.00	17.66	16.66	0.138	0.136
	F3	29.00	28.66	14.33	13.66	0.133	0.131
	F4	27.00	24.66	14.00	13.66	0.131	0.130
	F5	26.00	23.33	11.66	10.66	0.129	0.127
L.S.D at 5%		0.22	6.11	1.00	1.59	0.01	.003

W1= 0.5 dsm-1, W2= 2.25 dsm-1 , W3= 5.7 dsm-1

F0= without compost, F1= compost applied to soil, f2= compost +foliar potassium silicate,F3= compost + coated tuber with potassium silicate, f4= compost + foliar potassium humate, f5= compost +coated tuber with potassium humate.

2. Effect of different treatments on potato shoots uptake of N, P, K (kg acre^{-1}) and chlorophyll content.

values of N, P, and K uptakes have been influenced by salinity of the irrigation water, as illustrated in Table 6. For two seasons, the obtained data clearly indicate that increasing salinity levels of irrigation water negatively affected potato shoots uptakes of NPK and chlorophyll content, whereas the highest values were obtained with normal irrigation water (W1), while the lowest values were obtained with irrigation water salinity (W3). For the first season, the obtained decreases in N, P, and K uptakes were 24.92%, 21.61% and 32.71%, respectively, compared to normal irrigation water (W1). The decreases in the second season followed the same pattern. Furthermore, control treatment (W1) had the highest chlorophyll values, while W3 had the lowest. When compared to the control treatment, the highest values of all components were obtained with F2 (foliar potassium silicate) rather than coated tuber with potassium silicate (F3) compared to (F0).These results are agreeable with (Wilmer *et al.*, 2022)who explained that adding potassium raises the sugar content of potato tubers to a certain level, and then begins to decrease. Similarly, data in Table 6 reveals that The greatest uptake values of N, P, and K were attained by spraying potassium silicate in addition to compost in soil (F2) (19.19 and 19.16) ; (2.52 and 2.46) and (31.32 and 30.31) for N, P and K (kg.acre^{-1}) in potatoes shoot. In the contrast, (Zou *et al.*, 2020) found that salt stress increased the amount of nitrogen in the tubers, perhaps as a result of the tubers' decreased carbohydrate content, the antagonistic interactions between Na+ and K+ at uptake sites in the roots, the impact of Na+ on K+ transport into the xylem, or the suppression of uptake processes could all be contributing factors to the declines in K+. In a saline environment. Plants absorb far too much sodium at the expense of K+ and Ca++, the Na+ content of the leaves, stems, and tubers increased as the salt level increased. Sodium buildup occurred preferentially in the stems, especially when the plants were stressed by high salinity. High Na+ accumulation in plants may be one of the major causes of growth reduction at high salt levels. Furthermore, as the salinity of irrigation water increases, salt accumulates in the soil, reducing availability and phosphorus uptake by plant roots.

Table 6. Influence of irrigation water salinity and fertilizer forms on potato shoots uptakes of N, P and K (kg.acre-1) and chlorophyll content at 90 days in potato shoots at harvest

Treatments	N-shoot kg acre^{-1}		P-shoot kg acre^{-1}		K-shoot kg acre^{-1}		Total Chlorophyl	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Water salinity (dsm^{-1})								
(W1)	20.26	19.93	2.73	2.64	30.90	29.35	31.39	31.10
(W2)	18.12	18.06	2.32	2.25	26.02	25.17	24.36	23.82
(W3)	15.21	15.20	2.14	2.07	20.79	19.79	18.47	18.01
L.S.D at 5%	0.128	0.110	0.090	0.027	0.323	0.342	0.564	0.251
Fertilizers forms								
F0	15.58	15.35	2.11	2.07	18.16	16.95	15.33	15.06
F1	17.46	17.24	2.33	2.27	22.76	21.31	26.38	25.55
F2	19.19	19.16	2.52	2.46	31.32	30.31	30.95	30.52
F3	19.12	18.95	2.51	2.41	29.26	27.76	28.85	28.19
F4	18.28	18.12	2.48	2.39	27.84	27.25	24.57	24.31
F5	17.57	17.57	2.42	2.32	26.08	25.04	22.35	22.22
L.S.D at 5%	0.192	0.109	0.052	0.034	0.183	0.248	0.423	0.155

W1= 0.5 dsm-1, W2= 2.25 dsm-1 , W3= 5.7 dsm-1

F0= without compost, F1= compost applied to soil, f2= compost +foliat potassium silicate, F3= compost + coated tuber with potassium silicate, f4= compost + foliar potassium humate, f5= compost +coated tuber with potassium humate

Table 7 showed that the interaction between irrigation water salinity and fertilizer treatments had significant impacts on N, P and K uptake, and total chlorophyll content. Treatments of ($W_{1+}F_2$) yielded the highest N uptake values, while the same treatments yielded the highest values with ($W_{2+}F_2$). With parallel increases of (28.41% and 32.89%) from N content and (21.07% and 20.65%), but the values were lower with ($W_{3+}F_3$), with parallel changes of (-6.95% and -3.25%) when compared to the control treatment, respectively, in the two seasons. The values of parameters decreased as water salinity increased in W_2 and W_3, but F_2 treatment still produced the highest values of chlorophyll. Also; the same trend has been replicated with P-uptake with the same treatments. As for the K- uptake; all treatments of potassium content have been increased with the same treatments which the highest values were resulted by ($W_{1,2,3}$+F_2). While the uptake of K were decreased in potatoes shoot with W_2 and W_3 treatments, but the decreased was a positive effected with related increments (39.70 and 34.15 kg acre^{-1}); (30.86 and 30.59 kg acre^{-1}) and (23.40 and 22.55 kg acre^{-1}) of $W_{(1,2,3)}$ + F2 compared with the control treatments (20.32 and 18.25 kg acre^{-1}), respectively, in both season. These results are in the same line with those of (Sameh et al., 2019 and Sanwal et al., 2022), they reported that spraying potato plants with potassium silicate gave the best values for the estimated elements in leaves of potato plants.

Table 7. Effect of the interaction between irrigation water salinity and fertilizers forms on potato shoots uptakes of N, P and K (kg.acre-1) and chlorophyll content (mg/dm2 LA) at 90 days in potato shoots at harvest

Treatments		N-shoot		P-shoot		K-shoot		Total Chlorophyl	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd
W1	F0	17.39	16.63	2.35	2.28	20.32	18.25	12.05	11.98
	F1	19.19	19.04	2.62	2.54	25.5	24.28	14.24	14.07
	F2	22.33	22.10	2.92	2.77	39.7	34.15	18.36	18.11
	F3	21.73	21.55	2.88	2.85	35.40	32.76	15.42	15.14
	F4	20.49	20.21	2.83	2.76	33.54	28.50	14.91	14.29
	F5	20.45	20.05	2.77	2.62	30.95	18.19	13.27	13.10
W2	F0	15.90	15.93	2.08	2.05	18.70	17.50	10.29	10.11
	F1	16.89	16.74	2.25	2.21	22.91	20.89	12.26	12.08
	F2	19.25	19.22	2.43	2.35	30.86	30.59	16.22	16.07
	F3	19.11	19.68	2.39	2.30	28.09	27.86	13.19	13.06
	F4	19.06	19.04	2.46	2.34	29.02	27.60	15.14	15.02
	F5	18.51	18.79	2.34	2.27	26.54	26.57	14.12	12.24
W3	F0	13.44	13.49	1.91	1.90	15.45	15.11	8.44	8.19
	F1	15.00	14.93	2.12	2.07	19.88	18.77	10.48	10.16
	F2	16.37	16.35	2.22	2.17	23.40	22.55	14.08	13.10
	F3	16.18	16.09	2.19	2.11	23.36	21.55	12.71	12.23
	F4	15.29	15.35	2.40	2.10	21.89	21.14	12.07	12.03
	F5	15.00	14.99	2.40	2.09	20.75	20.05	11.91	11.31
L.S.D at 5%		0.333	0.188	0.090	0.059	0.318	0.430	0.1316	0.2706

W1= 0.5 dsm-1, W2= 2.25 dsm-1 , W3= 5.7 dsm-1
F0= without compost, F1= compost applied to soil, f2= compost +foliat potassium silicate, F3= compost + coated tuber with potassium silicate, f4= compost + foliar potassium humate, f5= compost +coated tuber with potassium humate

3. Effect of various treatments on potato yield and components

According to the data in Table 8 and Fig.1 water salinity significantly reduces potato quality (tuber length cm; tuber diameters cm and tuber fresh weight (ton acre^{-1}). The results of the two seasons appeared that there is a clear inverse relationship between increasing the salinity levels of irrigation water and potato quality, therefore the best values were recorded at low salinity water (W_1), and it gradually decreased with increasing salinity of irrigation water (W_2 and W_3). Therefore, the reduction of potato yield and its components can be attributed to the fact that the vegetative characters were negatively, affected by the high salinity of irrigation water (Table 4). When compared to mixed irrigated water (W_2) and salinity water(W_3), normal irrigated water (W_1) has the highest values for all parameters. In both seasons, the lowest values were observed with W3 (salinity water). These results are agreement with those reported with Sameh and Mostafa (2019) Furthermore, data in Table 8 and Fig.(2) demonstrated a difference in fertilizer effect on potato tuber yield and its parameters compared to F_0 (control) and the other treatments in both seasons . The F_2 treatment recorded the highest average potato yield and parameters. In this respect, (Hasanuzzaman *et al.*, 2018) concluded that potassium had a favorable effect on wheat growth metrics, yield, and yield components through enhancing plant hydration status and reducing the harmful effects of Na+.

Table 8. Effect of irrigation water salinity and fertilizers forms on potato yield and its components

Treatments	Tuber length (cm)		Tuber diameters (cm)		Tuber fresh weight (Ton.acre^{-1})	
	1st	2nd	1st	2nd	1st	2nd
Water salinity, dsm^{-1}						
(W1)	13.01	12.91	10.02	9.67	15.66	15.61
(W2)	11.83	11.72	7.54	7.29	13.72	13.26
(W3)	9.57	9.49	6.2	5.95	12.39	11.92
L.S.D at 5%	0.0935	0.0432	0.0415	0.1126	0.927	0.1511
Fertilizers forms						
F0	6.27	6.20	5.56	5.16	9.88	9.73
F1	11.04	10.97	7.05	6.79	11.95	11.47
F2	13.96	13.84	9.69	9.45	16.25	15.60
F3	13.29	13.14	9.05	8.81	15.10	14.47
F4	12.40	12.29	8.41	8.15	15.52	15.22
F5	11.86	11.81	7.77	7.48	14.85	15.08
L.S.D at 5%	0.1280	0.0831	0.0601	0.1920	0.14386	0.0970

W1= 0.5 dsm-1, W2= 2.25 dsm-1 , W3= 5.7 dsm-1
F0= without compost, F1= compost applied to soil, f2= compost +foliar potassium silicate F3= compost + coated tuber with potassium silicate, f4= compost + foliar potassium humate, f5= compost +coated tuber with potassium humate

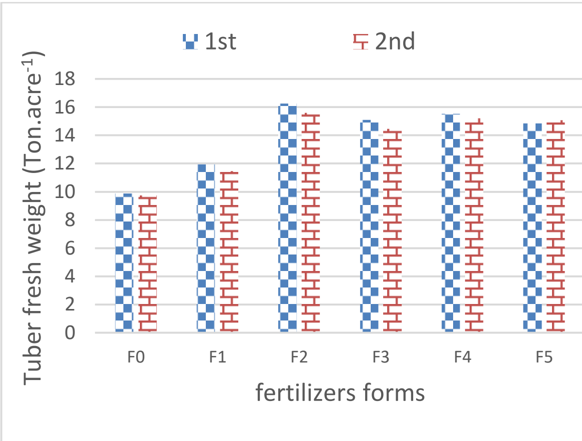

Fig. 2. influence of fertilizers forms on Tuber fresh weight (Ton.acre-1) in the two growing seasons

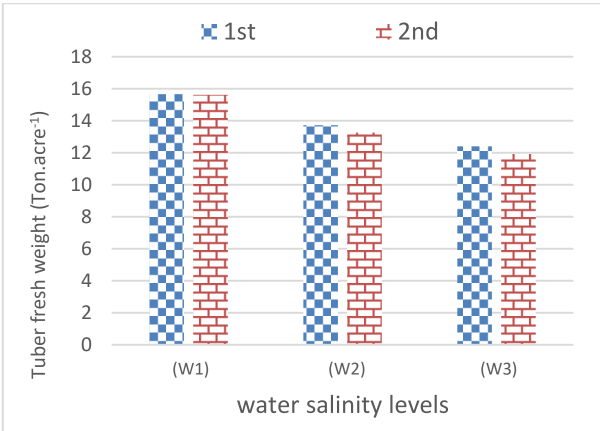

Fig. 1. influence of water salinity levels on Tuber fresh weight (Ton.acre-1) in the two growing seasons

Table 9 showed that the interaction between irrigation water salinity and fertilizers forms was significant on potato yield, where the lowest average values were recorded with F_0 (control treatment) under W_3 (salinity irrigated water) while the highest average values were with potassium silicate application with W_1 followed by W_2 and W_3.

W_1 outperformed all other parameters. Irrigation with mixed water (W_2) or drainage water (W_3) reduced yield and quality, but foliar potassium silicate or potassium humate with adding compost to soil before planting increased tuber yield and parameters compared to the control treatment F0 with W_2 or W_3. This could be attributed to changes in osmotic capacity caused by decreased water content, as well as the specific toxic effects caused by the buildup of sodium and chloride ions observed in many plants. Salinity was found to gradually reduce the size and number of marketable tubers per plant. Similarly, (Dahal *et al.*, 2019) found that, the lower yield of salt-treated plants may be attributed to the decrease in both of the number of tubers per plant and the weight of the marketable tubers. The authors explained that salt stress reduced yield because of nutritional imbalance, resulting in the inactivation of enzymes such as nitrate reductase (NR).

Table 9. Influence of interaction between irrigation water salinity and fertilizers forms on potato yield and its component

Treatments		Tuber length (cm)		Tuber diameters (cm)		Tuber fresh weight (ton.acre^{-1})	
		1st	2nd	1st	2nd	1st	2nd
W1	F0	7.06	7.02	9.05	6.07	12.24	12.03
	F1	13.11	13.08	10.27	9.05	13.68	13.2
	F2	15.15	15.08	15.36	12.03	18.00	17.72
	F3	14.78	14.55	12.42	11.32	17.43	17.21
	F4	14.22	14.12	11.91	10.25	16.54	17.11
	F5	13.75	13.62	11.24	09.33	16.10	16.38
W2	F0	6.24	6.16	7.29	5.29	09.13	9.09
	F1	11.71	11.62	9.26	6.21	11.41	11.1
	F2	14.34	14.17	13.22	9.04	15.82	15.02
	F3	13.81	13.66	12.14	8.10	14.95	11.09
	F4	12.74	12.60	11.48	8.06	15.79	15.23
	F5	12.14	12.13	10.19	7.08	15.25	15.03
W3	F0	5.50	5.43	5.44	4.13	08.28	8.06
	F1	8.29	8.21	7.48	5.11	10.78	10.12
	F2	12.40	12.28	10.08	7.29	14.94	14.07
	F3	11.29	11.21	9.71	7.02	12.92	12.10
	F4	10.24	10.16	9.07	6.16	14.23	14.05
	F5	09.70	9.86	8.91	6.03	13.21	13.11
L.S.D at 5%		0.2217	0.1440	0.1316	0.3325	0.167	0.168

W1= 0.5 dsm-1, W2= 2.25 dsm-1 , W3= 5.7 dsm-1
F0= without compost, F1= compost applied to soil, f2= compost +foliar potassium silicate F3= compost + coated tuber with potassium silicate, f4= compost + foliar potassium humate, f5= compost +coated tuber with potassium humate

Data in Table 10 and Figs. (3 and 4) show that irrigation water salinity has a significant impact on potato quality (dry matter and starch%) in both seasons. The results clearly showed a gradual decline in the mean values of the quality traits from normal salinity water (W_1) up to medium salinity water (W_2) and high salinity (W_3) in both seasons. The control treatment (W1) had the highest values of potato quality, while W_3 had the lowest. In this respect (Sameh et al., 2019) illustrated that the decrease of dry matter production as a result of increasing salinity of irrigation water was relatively more pronounced in tubers than in the other parts of the plant. Additionally, data in the same table and fig. showed that spraying with potassium silicate as humate + compost had a positive effect on the quality characteristics where the mean values of all the test quality characteristics increased. When compared to the standard treatment, the highest values of all components were obtained with F_2 (foliar potassium silicate) rather than coated tuber with potassium silicate (F_3). In this respect, similar results were obtained by Ali et al., (2021)

Table 10. Influence of irrigation water salinity and fertilizers forms on potato tuber quality

Treatments	Dry matter %		Starch %	
	1st	2nd	1st	2nd
Water salinity, dsm^{-1}				
(W1)	22.73	22.36	14.71	14.45
(W2)	21.30	20.98	13.59	13.43
(W3)	18.35	18.13	11.61	11.33
L.S.D at 5%	0.1684	0.1367	0.073	0.1241
Fertilizers forms				
F0	19.04	18.80	10.26	10.09
F1	19.57	19.20	12.00	11.78
F2	22.43	22.15	16.22	16.07
F3	21.82	21.49	14.42	14.13
F4	21.25	20.84	13.82	13.52
F5	20.66	20.46	13.11	12.81
L.S.D at 5%	0.0958	0.1802	0.0737	0.1562

W1= 0.5 dsm-1, W2= 2.25 dsm-1, W3= 5.7 dsm-1, F0= without compost, F1= compost applied to soil, f2= compost +foliar potassium silicate F3= compost + coated tuber with potassium silicate, f4= compost + foliar potassium humate, f5= compost +coated tuber with potassium humate

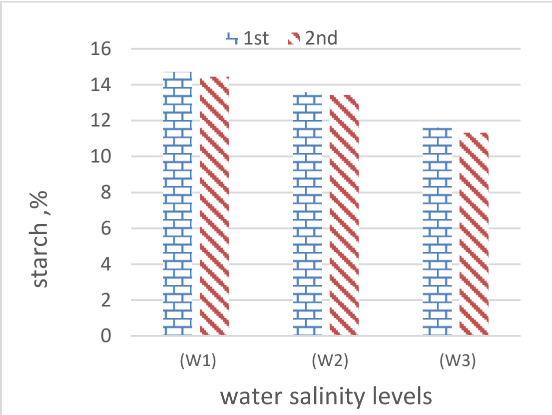

Fig. 3. influence of water salinity on starch, % in potato tubers in both seasons

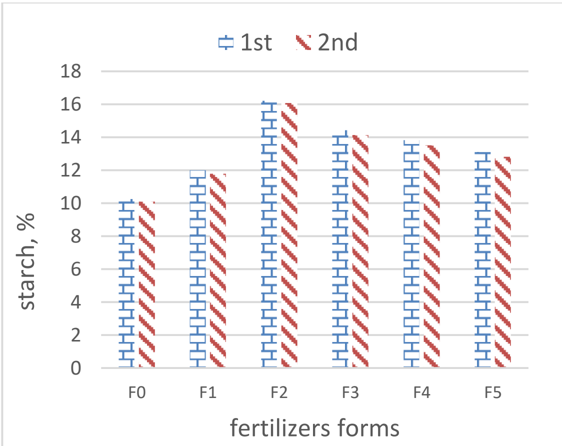

Fig. 4. Influence of fertilizers forms on starch, % in potato tubers in both seasons

According to the data in Table 11, the interaction of irrigation water salinity and fertilisers increased potato quality (dry matter and starch contents%). In comparison to the control treatments (W1+F0), the best treatment with all treatments of water salinity that had the highest values of dry matter and starch contents was F2 (compost with foliar potassium silicate) in both seasons, respectively. In the first and second seasons, the highest values of dry matter and starch% with (W1+F2) were (24.63 and 24.21%) and (18.36 and 18.11%), respectively. These results are agreeable with those reported by Sameh et al., (2019), who concluded that spraying potato plants with potassium silicate solution (10 $cm^3 L^{-1}$) significantly alleviate the adverse effects of irrigation water salinity throw improving the marketable tuber yield and tubers quality characteristics.

Table 11. Influence of interaction between irrigation water salinity and fertilizer forms on potato tuber quality

Treatments		Dry matter %		Starch %	
		1st	2nd	1st	2nd
W1	F0	21.22	21.10	12.05	11.98
	F1	22.11	22.26	14.24	14.07
	F2	24.63	24.21	18.36	18.11
	F3	23.96	23.33	15.42	15.14
	F4	22.79	22.56	14.91	14.29
	F5	21.68	21.22	13.27	13.10
W2	F0	19.83	19.29	10.29	10.11
	F1	20.21	20.07	12.26	12.08
	F2	22.51	22.18	16.22	16.07
	F3	22.18	22.04	13.19	13.06
	F4	21.92	21.22	15.14	15.02
	F5	21.19	21.10	14.12	12.24
W3	F0	16.08	16.02	8.44	8.19
	F1	16.84	16.32	10.48	10.16
	F2	20.15	20.06	14.08	13.10
	F3	19.31	19.11	12.71	12.23
	F4	19.04	19.03	12.07	12.03
	F5	18.69	18.23	11.91	11.31
L.S.D at 5%		0.1659	0.3121	0.1316	0.2706

W1= 0.5 dsm-1, W2= 2.25 dsm-1 , W3= 5.7 dsm-1F0= without compost, F1= compost applied to soil, f2= compost +foliat potassium silicate F3= compost + coated tuber with potassium silicate, f4= compost + foliar potassium humate, f5= compost +coated tuber with potassium humate

4. Effect of different treatments on N, P, and K uptakes in tuber at harvest

Table 12 displays the (N, P, K uptake) of tubers at harvest. Data show that water salinity had a significant effect on N and K uptake in the two seasons. Normal Irrigation water (W_1) gave the highest values of N, P and K- uptake (41.92 and 40.72 kg $acre^{-1}$), (6.73 and 6.25 kg $acre^{-1}$) and (69.08 and 67.51 kg $acre^{-1}$), in 1^{st} and 2^{nd} seasons, respectively. Also, data in Table 12 indicate the effect of the fertilizer application, where the control treatment(F_0) had the lowest values in tuber yield in 1^{st} and 2^{nd} seasons respectively. (F_2) treatment had the highest values of N, P and K-uptake (38.06 and 37.71 kg $acre^{-1}$), (6.37 and 6.20 kg $acre^{-1}$) and (59.15 and 57.46 kg $acre^{-1}$) in the 1^{st} and 2^{nd} season, respectively, compared with the control treatment. These findings are harmony with those obtained by Salim et al., (2014), who reported that foliar application with potassium silicate increased mineral components (N, P and K) in potato tubers. It is known that plants absorb an excessive amount of sodium in a saline environment at the expense of K^+ and Ca^{++}. The Na+ content of leaves, stems, and tubers increased as the salt level increased. Under high salinity stress, sodium accumulation occurred preferentially in the stems. High Na+ accumulation in plants may be one of the major causes of growth reduction at high salt levels.

In general, the data in Table 13 illustrate the values of N, P, and K -uptake in tuber at harvest in the two seasons as influenced by the interaction of irrigation water salinity and fertilizer application forms treatments. In the 1^{st} and 2^{nd} seasons, foliar addition of potassium silicate (F_2)+ (W_1) treatments yielded the highest values of N, P, and K-uptake. W2 and W3 irrigated potatoes had lower N, P, and K-uptake values, but treatments F2 and F3 had the highest N, P, and K-uptake values. Moreover, increasing salinity concentration in irrigation water increases the accumulation of salts in the soil resulting in reduction the availability of phosphorus uptake by plant roots. Similar results were obtained by (Ali et al., 2021) Foliar potassium silicate fertilisation may be more advantageous for silica deposition in the necessary key areas, enabling highly healthy roots and improved water, macronutrient, and micronutrient absorption. (González-Moscoso *et al.*, 2022).

Table 12. Influence of irrigation water salinity and fertilizers forms on uptakes of N, P and K (kg acre-1) in tuber at harvest

Treatments	N-tuber		P- tuber		K- tuber	
	1st	2nd	1st	2nd	1st	2nd
Water salinity dsm^{-1}						
(W1)	41.92	40.72	6.73	6.25	69.08	67.51
(W2)	34.72	33.07	5.69	5.36	49.10	47.08
(W3)	27.00	25.95	4.70	4.65	43.45	42.77
L.S.D at 5%	0.138	0.317	0.209	0.309	0.378	0.329
Fertilizers forms						
F0	29.41	27.87	4.50	4.47	47.45	46.06
F1	33.71	31.78	5.01	4.70	50.61	48.15
F2	38.06	37.71	6.37	6.20	59.15	57.46
F3	37.90	35.44	6.13	5.74	58.72	56.92
F4	34.36	33.45	6.45	5.81	54.14	53.69
F5	33.84	33.23	5.77	5.62	53.20	52.44
L.S.D at 5%	0.214	0.505	0.170	0.571	0.252	0.422

W1= 0.5 dsm-1, W2= 2.25 dsm-1 , W3= 5.7 dsm-1
F0= without compost, F1= compost applied to soil, f2= compost +foliat potassium silicate F3= compost + coated tuber with potassium silicate, f4= compost + foliar potassium humate, f5= compost +coated tuber with potassium humate

Table 13. Influence of interaction between irrigation water salinity and fertilizers forms on uptakes of N, P and K (kg $acre^{-1}$) in tuber at harvest

Treatments		N-tuber		P-tuber		K-tuber	
		1st	2nd	1st	2nd	1st	2nd
W1	F0	35.61	32.06	5.4	5.1	60.24	58.16
	F1	38.58	37.80	5.97	5.8	64.39	60.16
	F2	46.20	45.81	7.89	7.52	76.99	76.77
	F3	46.14	43.09	7.44	7.08	77.31	75.20
	F4	42.60	43.03	7.07	6.09	68.00	67.66
	F5	42.38	42.55	6.60	5.95	67.53	67.11
W2	F0	30.32	29.16	4.77	4.11	43.22	40.89
	F1	34.60	31.90	5.30	4.81	45.53	41.50
	F2	39.00	39.03	6.32	6.19	54.97	52.10
	F3	38.24	35.36	6.11	5.78	53.47	50.73
	F4	33.40	31.76	6.5	5.8	49.22	48.10
	F5	32.70	31.20	5.18	5.48	48.23	46.66
W3	F0	22.28	22.39	3.35	3.49	41.91	40.89
	F1	27.96	25.66	3.77	4.21	38.88	38.52
	F2	29.23	28.30	4.91	4.89	45.50	43.53
	F3	28.97	27.86	4.85	4.36	45.39	44.84
	F4	27.31	26.03	5.79	5.53	45.19	45.30
	F5	26.23	25.46	5.53	5.44	43.85	43.56
L.S.D at 5%		0.370	0.875	0.290	0.989	0.437	0.594

W1= 0.5 dsm-1, W2= 2.25 dsm-1 , W3= 5.7 dsm-1
F0= without compost, F1= compost applied to soil, f2= compost +foliar potassium silicate F3= compost + coated tuber with potassium silicate, f4= compost + foliar potassium humate, f5= compost +coated tuber with potassium humate

5. Effect of different treatments on available N, P and K in soil (mg kg-1) after harvest potatoes yields

Significant differences in soil N, P, and K among irrigation water salinity were found in both seasons (Table

14). The highest values of N, P, and K were observed with the W_3 treatment in the first and second seasons, respectively (42.09 and 40.38 mg kg-1), (11.56 and 11.58 mg kg-1), and (358.97and 364.66 mg kg^{-1}). Coated potassium humate fertilizers (F_5), on the other hand, increased the values of N, P, and K in soil after harvesting when compared to the control treatment. This could be due to increased potato yield, which caused the soil to more nutrients absorption. These results are accompanied with (Wang *et al.*, 2013) who indicated that the drought stress conditions led to lowering the N, P and K available in soil.

Table 14. Influence of water salinity and fertilizers forms on available N, P and K in soil (mg kg-1) after harvest potatoes yields.

Treatments	1st			2nd		
	N	P	K	N	P	K
Water salinity (dsm-1)						
(W1)	33.94	9.06	303.77	33.01	8.78	310.58
(W2)	37.54	10.89	323.99	35.08	10.39	326.63
(W3)	42.09	11.56	358.97	40.38	11.58	364.66
L.S.D at 5%	1.2794	0.2529	1.3205	0.3116	0.2018	2.8643
F. test	**	**	**	**	**	**
Fertilizer forms:						
F0	43.01	11.30	333.44	40.74	10.62	336.88
F1	37.39	10.36	327.22	36.50	9.97	331.31
F2	32.65	9.61	326.00	31.69	9.47	330.51
F3	33.51	9.85	327.30	32.07	9.63	331.50
F4	40.00	10.69	329.45	38.34	10.86	335.00
F5	40.48	11.22	330.06	39.03	10.96	338.55
L.S.D 0.05	1.2026	0.2265	1.1775	0.3401	0.073	1.5862
F. test	**	**	**	**	**	**

W1= 0.5 dsm-1, W2= 2.25 dsm-1, W3= 5.7 dsm-1
F0= without compost, F1= compost applied to soil, f2= compost +foliar potassium silicate F3= compost + coated tuber with potassium silicate, f4= compost + foliar potassium humate, f5= compost +coated tuber with potassium humate

Data in table 15 illustrate the interaction between irrigated water salinity and fertiliser forms on N, P, K $mg.kg^{-1}$ in the soil, with all combinations of treatments having a significant effect on N, P and K in the two seasons. The highest values in N, P, and K mg kg^{-1} were obtained with ($W_3 + F_0$) treatments in the 1st and 2nd seasons, respectively, and found to be (55.15 and 52.75 mg kg^{-1}), (13.50 and 13.1 mg kg^{-1}) and (376.66 and 377 mg kg^{-1}), compared to the control (W_1+ F_0) and before experiment. On the other hand, both foliar potassium humate (F_4+ W_3) and coated tuber with potassium humate (F_5+ W_3) treatments gave greater available N, P and K in soil in both seasons compared to (F_5+ W_1) treatments. This is due to an increase in soil salinity, which prevents plants from absorbing water and nutrients. These results fall in line with findings of (Fouda et al., 2014) who reported that application of potassium silicate gave greater available N,P and K in saline soil. Also, Linjin (2013) indicated that available N, P and K were significantly different among soils after potassium silicate application.

Data in Table 16 demonstrated that the salinity of irrigated water effectively increased soil salinity (ECe) and sodicity (SAR) (0-45 cm depth). Before the experiment, the mean values of EC and SAR in surface soil were (3.25 and 3.89 dSm-1) and (9.58 and 10.54), respectively in 1st and 2nd seasons. The highest increment of ECe values through the two growing seasons (in depth 30-45 cm) were recorded under W3 as comparing with other W_1 and W2. EC_e values with W_3 increased by 33.44 and 34.96 % compared with W_1 treatments in third depth, whereas it increased by 37.75 and 36.53% in surface soil (first depth) in first and second season, respectively. In the same Table the results show the percentage increase in SAR with W_3 in all depth as compared with SAR before experiment, respectively. Also shown in this Table is a decrease in soil bulk density with saline water W2, W3, in second and third soil depths. These results fall in line with findings of (Li *et al.*, 2020) who found the same trend. These results could be due to soil salinity which increase aggregates of particles and decrease soil bulk density (Bless *et al.*, 2022).

Table 15. Influence of interaction between irrigation water salinity and fertilizers forms on available N, P and K of soil (mg kg-1) before experiment and after harvest in two seasons

Treatments		1st			2nd		
		N	P	K	N	P	K
Before exp.		31.85	5.97	268	28.83	4.30	238
After two seasons							
W1	F0	25.18	6.38	280.00	24.80	5.76	285.00
	F1	36.26	8.26	309.43	35.26	7.86	311.16
	F2	41.16	12.17	321.33	41.25	11.83	331.66
	F3	38.96	10.31	318.56	37.50	10.15	329.66
	F4	33.38	9.85	303.66	31.66	9.07	309.33
	F5	28.71	7.37	289.63	27.60	8.03	296.66
W2	F0	48.96	14.02	343.66	44.67	13.00	348.66
	F1	35.5	10.84	318.33	34.53	10.19	324.43
	F2	27.85	7.77	309.33	26.26	7.71	311.53
	F3	28.70	8.91	313.00	27.20	8.25	313.83
	F4	41.15	11.76	323.83	40.56	11.39	325.33
	F5	43.06	12.06	335.80	41.56	11.79	336.00
W3	F0	55.15	13.50	376.66	52.75	13.10	377.00
	F1	40.41	11.98	353.90	39.71	11.86	358.33
	F2	28.95	8.90	347.33	27.57	8.86	348.33
	F3	32.87	10.32	350.33	31.53	10.50	351.00
	F4	46.92	12.05	360.86	44.85	12.13	370.33
	F5	48.24	12.63	364.76	45.86	13.06	383.00
LSD at 0.05		2.0829	0.3908	2.0396	0.5892	0.5026	2.7474

W1= 0.5 dsm-1, W2= 2.25 dsm-1, W3= 5.7 dsm-1
F0= without compost, F1= compost applied to soil, f2= compost +foliat potassium silicate F3= compost + coated tuber with potassium silicate, f4= compost + foliar potassium humate, f5= compost +coated tuber with potassium humate

Table 16. Effect of irrigation water salinity on ECe and SAR of soil, and rate of change before experiment and after potatoes harvesting

Water salinity levels	ECe (ds.m-1)			SAR			Bulk density		
	Soil depth (cm)			Soil depth (cm)			Soil depth (cm)		
	0-15	15-30	30-45	0-15	15-30	30-45	0-15	15-30	30-45
Before exp.	3.25	3.76	4.12	9.58	10.05	11.11	1.2	1.33	1.28
After one season									
W1	3.33	3.89	4.32	9.68	10.34	11.23	1.24	1.33	1.27
W2	3.88	4.35	4.72	10.29	10.94	11.42	1.21	1.27	1.24
W3	5.35	5.82	6.15	12.45	13.24	13.95	1.18	1.24	1.22
Before exp.	3.89	4.10	4.27	10.54	10.87	11.21	1.32	1.30	1.27
After two seasons									
W1	3.44	3.75	4.37	10.77	11.43	11.52	1.31	1.29	1.25
W2	3.95	4.54	4.85	11.38	11.98	11.93	1.28	1.26	1.23
W3	5.42	5.99	6.36	12.50	13.89	14.40	1.18	1.15	1.14

W1= 0.5 dsm-1, W2= 2.25 dsm-1, W3= 5.7 dsm-1

CONCLUSION

Based on the current study's findings, it is possible to conclude that spraying growing potato plants twice with potassium silicate solution (10 cm3.L-1) in the presence of compost (10 m3 acr-1) applied to the soil is the most efficient treatment for reducing the hazardous effects of irrigation water salinity on potato tuber quality, tuber yield, and available contents (N, P, and K) in soil, which it reflected on increasing potato tuber yield, tuber quality, and available content of element in soil.

REFERENCES

A.O.A.C., 1990. Official Methods of Analysis of the Association of Official Analytical Chemists". 15th (edition, published by Association of Official Analytical Chemists Arlington, Virginia U.S.A.

Abd EL-Gawad, H. G., Nashwa, A. I. A., Hikal, M. S., 2017. Effect of potassium silicate on tuber yield and Biochemical constituents of potato plants Grown under drought stress conditions. Middle East. J. Agric. Res. 6:718-731.

Aiad, M.A., Amer, M.M., Khalifa, T.H.H., Shabana, M.M.A., Zoghdan, M.G., Shaker, E.M., Eid, M.S.M., Ammar, K.A., Al-Dhumri, S.A., Kheir, A.M.S., 2021. Combined Application of Compost, Zeolite and a Raised Bed Planting Method Alleviate Salinity Stress and Improve Cereal Crop Productivity in Arid Regions. Agronomy 11, 2495.

Ali, M.M.E., Petropoulos, S.A., Selim, D.A.F.H., Elbagory, M., Othman, M.M., Omara, A.E.-D., Mohamed, M.H., 2021. Plant Growth, Yield and Quality of Potato Crop in Relation to Potassium Fertilization. Agronomy 11, 675.

Bless, A.E.S., Colin, F., Crabit, A., Follain, S., 2022. Soil Aggregate Stability in Salt-Affected Vineyards: Depth-Wise Variability Analysis. Land 11, 541.

Buurman, P., van Lagen, B and Velthorst, E. J. , 1997. Manual For Soil and Water Analysis. Backhuys Publishers, Leiden, The Netherlands.

Campbell, D. J., 1994. Determination and use of bulk density in relation to soil compaction. In Soane and Ou werk (Ed.). soil compaction in crop production. Elsevier, London and Amsterdam.

Chourasia, K.N., Lal, M.K., Tiwari, R.K., Dev, D., Kardile, H.B., Patil, V.U., Kumar, A., Vanishree, G., Kumar, D., Bhardwaj, V., Meena, J.K., Mangal, V., Shelake, R.M., Kim, J.-Y., Pramanik, D., 2021a. Salinity Stress in Potato: Understanding Physiological, Biochemical and Molecular Responses. Life 11, 545.

Chourasia, K.N., Lal, M.K., Tiwari, R.K., Dev, D., Kardile, H.B., Patil, V.U., Kumar, A., Vanishree, G., Kumar, D., Bhardwaj, V., Meena, J.K., Mangal, V., Shelake, R.M., Kim, J.Y., Pramanik, D., 2021b. Salinity Stress in Potato: Understanding Physiological, Biochemical and Molecular Responses. Life (Basel) 11.

Dahal, K., Li, X.Q., Tai, H., Creelman, A., Bizimungu, B., 2019. Improving Potato Stress Tolerance and Tuber Yield Under a Climate Change Scenario - A Current Overview. Front Plant Sci 10, 563.

Devaux, A., Goffart, J.P., Kromann, P., Andrade-Piedra, J., Polar, V., Hareau, G., 2021. The Potato of the Future: Opportunities and Challenges in Sustainable Agri-food Systems. Potato Res 64, 681-720.

Ding, Z., Ali, E.F., Aldhumri, S.A., Ghoneim, A.M., Kheir, A.M.S., Ali, M.G.M., Eissa, M.A., 2021a. Effect of Amount of Irrigation and Type of P Fertilizer on Potato Yield and NH3 Volatilization from Alkaline Sandy Soils. Journal of Soil Science and Plant Nutrition 21, 1565-1576.

Ding, Z., Kheir, A.M.S., Ali, M.G.M., Ali, O.A.M., Abdelaal, A.I.N., Lin, X.e., Zhou, Z., Wang, B., Liu, B., He, Z., 2020. The integrated effect of salinity, organic amendments, phosphorus fertilizers, and deficit irrigation on soil properties, phosphorus fractionation and wheat productivity. Scientific Reports 10, 2736.

Ding, Z., Kheir, A.M.S., Ali, O.A.M., Hafez, E.M., ElShamey, E.A., Zhou, Z., Wang, B., Lin, X.e., Ge, Y., Fahmy, A.E., Seleiman, M.F., 2021b. A vermicompost and deep tillage system to improve saline-sodic soil quality and wheat productivity. Journal of Environmental Management 277, 111388.

Fahad, S., Hussain, S., Matlob, A., Khan, F. A., Khaliq, A., Saud, S. Faiq, M., 2015. Phytohormones and plant responses to salinity stress: a review. PI. Grow. Regul., 75:391-404.

Flowers, T.J., Munns, R., Colmer, T.D., 2015. Sodium chloride toxicity and the cellular basis of salt tolerance in halophytes. Ann Bot 115, 419-431.

Fontana, M., Hirte, J., Bélanger, G., Makowski, D., Elfouki, S., Sinaj, S., 2022. Long-term K fertilization effects on soil available K, grain yield, and plant K critical value in winter wheat. Nutrient Cycling in Agroecosystems 123, 63-82.

Fouda, S. S., Shaban, Kh. A. and Moussa, S. A., 2014. Evaluation of some potassium fertilizer and postassium biofertilization with bacillus circulans on potatoes productivity under saline soil conditions. Minufia, J. Agric. Res, 39(4):1467-1494.

Gomez, K. A. and Gomez, A.G., 1984. Statistical Procedures for Agriculture Research". 2nd Ed., John Wiley and Sons.

González-Moscoso, M., Martínez-Villegas, N., Cadenas-Pliego, G., Juárez-Maldonado, A., 2022. Effect of Silicon Nanoparticles on Tomato Plants Exposed to Two Forms of Inorganic Arsenic. Agronomy 12, 2366.

Gupta, B., Huang, B., 2014a. Mechanism of Salinity Tolerance in Plants: Physiological, Biochemical, and Molecular Characterization. International Journal of Genomics 2014, 701596.

Gupta, B., Huang, B., 2014b. Mechanism of salinity tolerance in plants: physiological, biochemical, and molecular characterization. Int J Genomics 2014, 701596.

Hasanuzzaman, M., Bhuyan, M.H.M.B., Nahar, K., Hossain, M.S., Mahmud, J.A., Hossen, M.S., Masud, A.A.C., Moumita, Fujita, M., 2018. Potassium: A Vital Regulator of Plant Responses and Tolerance to Abiotic Stresses. Agronomy 8, 31.

Jha, G., Choudhary, O.P., Sharda, R., 2017. Comparative effects of saline water on yield and quality of potato under drip and furrow irrigation. Cogent Food & Agriculture 3, 1369345.

Kheir, A.M.S., Ali, E.F., Ahmed, M., Eissa, M.A., Majrashi, A., Ali, O.A.M., 2021a. Biochar blended humate and vermicompost enhanced immobilization of heavy metals, improved wheat productivity, and minimized human health risks in different contaminated environments. Journal of Environmental Chemical Engineering 9, 105700.

Kheir, A.M.S., Ali, E.F., He, Z., Ali, O.A.M., Feike, T., Kamara, M.M., Ahmed, M., Eissa, M.A., Fahmy, A.E., Ding, Z., 2021b. Recycling of sugar crop disposal to boost the adaptation of canola (Brassica napus L.) to abiotic stress through different climate zones. Journal of Environmental Management 281, 111881.

Leite, J.M., Pitumpe Arachchige, P.S., Ciampitti, I.A., Hettiarachchi, G.M., Maurmann, L., Trivelin, P.C.O., Prasad, P.V.V., Sunoj, S.V.J., 2020. Co-addition of humic substances and humic acids with urea enhances foliar nitrogen use efficiency in sugarcane (Saccharum officinarum L.). Heliyon 6, e05100.

Li, L., Liu, H., He, X., Lin, E., Yang, G., 2020. Winter Irrigation Effects on Soil Moisture, Temperature and Salinity, and on Cotton Growth in Salinized Fields in Northern Xinjiang, China. Sustainability 12, 7573.

Linjin, Y., 2013.Potassium silicate drilling fluid as a land reclamation amendement. ph.D. Thesis of faculty of Graduate studies and Research.Department of renewable Resources.Edmonyon, Alberta.

Liu, D., Ding, Z., Ali, E.F., Kheir, A.M.S., Eissa, M.A., Ibrahim, O.H.M., 2021. Biochar and compost enhance soil quality and growth of roselle (Hibiscus sabdariffa L.) under saline conditions. Scientific Reports 11, 8739.

Saad Kheir, A.M., Abouelsoud, H.M., Hafez, E.M., Ali, O.A.M., 2019. Integrated effect of nano-Zn, nano-Si, and drainage using crop straw–filled ditches on saline sodic soil properties and rice productivity. Arabian Journal of Geosciences 12, 471.

Sameh, A., Moussa, M., Shama, M. A., 2019. Mitigation the adverse effects of irrigation water salinity on potato crop using potassium silicate foliar application. Middle East J. of Applied Sci., 9(3):804-819.

Sanwal, S.K., Kumar, P., Kesh, H., Gupta, V.K., Kumar, A., Kumar, A., Meena, B.L., Colla, G., Cardarelli, M., Kumar, P., 2022. Salinity Stress Tolerance in Potato Cultivars: Evidence from Physiological and Biochemical Traits. Plants (Basel) 11.

Salim, B. B. M., Abd. EL-Gawad, H. G., Abou EL-Yazied A. 2014. Effect of foliar spray of different potassium sources on growth, yield and mineral composition of potato. Middle East J. Appl. Sci., 4(4):1197-1204.

Seleiman, M.F., Kheir, A.M.S., 2018. Saline soil properties, quality and productivity of wheat grown with bagasse ash and thiourea in different climatic zones. Chemosphere 193, 538-546.

Shrivastava, P., Kumar, R., 2015. Soil salinity: A serious environmental issue and plant growth promoting bacteria as one of the tools for its alleviation. Saudi J Biol Sci 22, 123-131.

Strachan, I.B., Stewart, D.W., Pattey, E., 2005. Determination of Leaf Area Index in Agricultural Systems. Micrometeorology in Agricultural Systems, pp. 179-198.

Wang, F., Wang, C., Song, S., Xie, S., Kang, F., 2021. Study on starch content detection and visualization of potato based on hyperspectral imaging. Food Science & Nutrition 9, 4420-4430.

Wang, M., Zheng, Q., Shen, Q., Guo, S., 2013. The critical role of potassium in plant stress response. Int J Mol Sci 14, 7370-7390.

Wicke, B., Smeets, E., Dornburg, V., Vashev, B., Gaiser, T., Turkenburg, W., Faaij, A., 2011. The global technical and economic potential of bioenergy from salt-affected soils. Energy & Environmental Science 4, 2669-2681.

Wilmer, L., Pawelzik, E., Naumann, M., 2022. Comparison of the Effects of Potassium Sulphate and Potassium Chloride Fertilisation on Quality Parameters, Including Volatile Compounds, of Potato Tubers After Harvest and Storage. Front Plant Sci 13, 920212.

Xu, X., Du, X., Wang, F., Sha, J., Chen, Q., Tian, G., Zhu, Z., Ge, S., Jiang, Y., 2020. Effects of Potassium Levels on Plant Growth, Accumulation and Distribution of Carbon, and Nitrate Metabolism in Apple Dwarf Rootstock Seedlings. Frontiers in Plant Science 11.

Zörb, C., Geilfus, C.-M., Dietz, K.-J., 2019. Salinity and crop yield. Plant Biology 21, 31-38.

Zou, H.X., Zhao, D., Wen, H., Li, N., Qian, W., Yan, X., 2020. Salt stress induced differential metabolic responses in the sprouting tubers of Jerusalem artichoke (Helianthus tuberosus L.). PLoS One 15, e0235415.

هيومات وسيليكات البوتاسيوم بالتداخل مع اضافة الكمبوست للتربة لتقليل التأثيرات الضارة لملوحة مياه الري علي نباتات البطاطس والمغذيات الميسرة في التربة

محمود شبانة[1]، خلود النقمة[1]، مدحت زغدان[1] و رامي محمد خليفة[2]

[1] معهد بحوث الاراضي والمياه والبيئة ، المركز القومي للبحوث
[2] قسم الاراضي والمياه -كلية الزراعة – جامعة دمياط

الملخص

أجريت تجربة حقلية بمحطة البحوث الزراعية بمحافظة كفر الشيخ خلال موسمين شتويين متتاليين 2020/2021&2021/2022 لدراسة التأثيرات المتداخلة لمستويات ملوحة مياه الري (0.5، 2.25، 5.7 ديسمنز/متر) كمعاملات رئيسية وست معاملات تحسين(كمعاملات تحت رئيسية) كما يلي: F_0 (بدون اضافة الكمبوست للتربة (كنترول) ، F_1 (اضافة الكمبوست للتربة)، F_2 (اضافة الكمبوست للتربة + الرش بمحلول سيليكات البوتاسيوم (10 سم^3/لتر)، F_3 (اضافة الكمبوست للتربة + تغليف الدرنات بسيليكات البوتاسيوم)، F_4 (اضافة الكمبوست للتربة + الرش بمحلول هيومات البوتاسيوم (10 سم^3/ لتر) و F_5 (اضافة الكمبوست للتربة + تغليف الدرنات بهيومات البوتاسيوم) أظهرت النتائج ان زيادة ملوحة مياه الري كانت ذات تأثير معنوي علي معظم خصائص النمو، جودة الدرنات ، انتاج الدرنات (طن/فدان) في كلا الموسمين. الرش لنباتات البطاطس مرتين بكل من محلول سيليكات وهيومات البوتاسيوم كانتا ذات تأثير معنوي موجب علي كل الصفات المدروسة مقارنة بالكنترول، أظهرت النتائج ايضا ان الرش بمحلول سيليكات البوتاسيوم كان ذات تأثير عالي المعنوية علي طول النبات (سم)، عدد التفريعات /نبات و تحسن الانتاج الكلي للدرنات، متوسط الوزن للدرنة (g)، عدد الدرنات والانتاج / نبات في كلا الموسمين مقارنة بالكنترول. وفي النهاية يمكن التوصية بأن رش النباتات النامية للبطاطس مرتين بمحلول سيليكات البوتاسيوم + اضافة الكومبست للتربة هي المعاملة الاكثر فاعلية لتقليل التأثيرات الضارة لملوحة مياه الري علي خصائص و جودة الدرنات للبطاطس ، انتاج الدرنات و العناصر الميسرة في التربة (NPK).