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Effect of Different Concentrations of Irrigation Water Salinity and Potassium Humate on Productivity and Fruit Quality of the Prickly Pears Plants (*Opuntia ficus-indica* L.) (2)

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Sahar A. Farid and Fahmy E. Fahmy
Plant Production Department, Desert Research Center, Cairo, Egypt.

THIS investigation was carried out during two successive seasons (2020 and 2021) on a 9-year-old El-Shamia cactus pear cultivar grown in a private orchard located in the Alumni villages' area, along the "Cairo-Alexandria desert" road about 170 km from Cairo, Egypt. The effects of irrigation water salinity levels (control (orchard irrigation water), 1000, 2000, 3000, 4000 and 5000 ppm) and potassium humate (0, 50 and 100 g/tree/year) and their interactions on yield, fruit quality and root anatomy of El-Shamia cactus pear plants were studied. The best results were recorded with control treatment of salinity level and potassium humate at 100 g/tree/year, which improved fruit set, number of fruits per tree, yield, fruit weight, fruit length, fruit width, fruit volume, pulp weight, fruit T.S.S., fruit T.S.S./acid ratio and ascorbic acid. while reducing fruit drop, peel weight, the number of seeds, seeds weight and the fruit's total acidity content. So this treatment proved to be the most efficient in enhancing the yield and fruit quality of El-Shamia cactus pear plants.

Keywords: Prickly pears, (*Opuntia ficus-indica* L.), Salinity, Humate potassium, Productivity, Fruit quality.

Introduction

Opuntia ficus-indica is a species of cactus that is cultivated extensively and has long been a domesticated crop plant important in agricultural economies throughout the arid and semiarid highlands of the world. It is thought to have probably originated in Mexico. Some of the common English names for the plant and its fruit are Barbary fig, cactus pear, spineless cactus and prickly pear; this last name has also been applied to other less common Opuntia species. In Mexican and Spanish, the plant is called (nopal) while the fruit is called (tuna). The cactus is a succulent plant resistant to droughts and exhibits crassulacean acid metabolism, a photosynthetic mechanism to withstand limited availability of water from Co_2 (Cushman and Bohnert, 1999), and is also more efficient in producing dry matter per unit of water than C_3 and C_4 plants (Taiz and Zeiger, 2006).

Salinity is a major factor limiting the growth of fruit trees. It is abiotic stress that reduces the yield of a wide variety of crops all over the world (Tester & Davenport, 2003 and Ashraf & Foolad, 2007). The main problems of these soils are their poor structure, low availability of water and nutrients, low fertility, higher salinity and calcium carbonate content, and the possibility of forming a surface crust and indurate layers at shallow depths (El-Khawaga, 2013). Plants growing in saline media increase in osmotic stress due to the high salt concentration of the soil solution, which decreases the water potential of the soil and then increases the concentration of Na and Cl, exhibiting tissue accumulation of Na and Cl and inhibition of mineral nutrient uptake (Marschner, 1995). The effectiveness of humic acid and other anti-salinity agents in alleviating the adverse effects of salinity on the growth and fruiting of

Corresponding author: Fahmy E. Fahmy, E-mail: dr_fahmy85@yahoo.com, Tel. 01271141780
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Sewy, Zaghloul and Hayany date palm cultivars was studied by El-Khawaga (2013).

Some studies have reported that humic acid can be used as a growth regulator to regulate hormone levels, improve plant growth and enhance stress tolerance (Piccolo et al., 1992).

Foliar and soil application of humic acid treatments markedly increased the growth parameters, yield and quality of the "Canino" apricot (Fathy et al., 2010; Eissa, 2003).

The use of humic substances for removing negative effects of elements in toxic quantities and its effects on the growth of wheat plants were studied by Asik et al. (2009).

Also Humic substances and fulvic acid are essential in soil organic matter in addition, the natural stability of these substances affects carbon sequestration. Moreover, it can ameliorate the negative effect of salt on the plant's gross and uptake of nutrients (Demir et al., 1999; Casierra-Pasada et al., 2009).

The aim of this study was to investigate the effects of salinity at six levels (0, 1000, 2000, 3000, 4000, and 5000 ppm) and potassium humate at three treatments (0, 50 and 100 g) and their interactions on fruit set, fruit drop, yield, fruit properties and root anatomy observation on the roots of prickly pear plants (*Opuntia ficus-indica L.)* under different salinity levels.

Material and Methods

The present study was conducted during two successive seasons in 2020 and 2021 on a prickly pear cultivar, namely El-Shamia cactus pear (*Opunita ficus indica L.*). The trees were approximately 9 years old and were grown in an orchard located at km 107 Alex, namely Alumni Villages.Grown in sandy soil at 6 x 2 m spacing (approximately 350 plants per feddan) with drip irrigation systems. Physical and chemical analyses of the experimental soil and the chemical analysis of the used water for irrigation are shown in Tables 1 and 2.

Fifty-four healthy plants, nearly uniform in shape, size and productivity, received the same horticultural practices.

Drip irrigation system was designed with two drip lines, each one placed one meter from the trunk tree. Where trees were irrigated twice in February, March, April, May, June and July by 240 liters / tree / year. For traditional drip irrigation, a Gr dripper was used for 4 L/h/m of discharge, and four drippers for one tree were used for 20 liters per tree. Control irrigation uses the same rates as irrigation.

The present study was a factorial experiment with two factors. The first factor consisted of six levels of water salt (Nacl) (orchard irrigation water, 1000, 2000, 3000, 4000 and 5000 ppm) and the second involved three rates of potassium humate (0, 50 and 100 g/plant). The experiment was designed as a randomized complete block design with three replicates for each treatment and each replicate was represented by one plant.

Measurements

Fruit set (%) and fruit drop (%)

The number of flowers four cladode per each

TABLE 1. Analysis of experimental soil.

Soil Depth (cm)	Texture Class	pH Soil past	E.Ce (dSm^{-1})	Organic matter %	Soluble cations (meq/l)				soluble anions (meq/l)			
					Ca^{++}	K^{+}	Na^{+}	Mg^{++}	Cl^{-}	$SO_4^{=}$	HCO_3^{-}	$CO_3^{=}$
0-30	Sand	7.3	1.8	0.21	7.1	0.5	6	3.8	7	8	4	-
30-60	Sand	7.7	1.4	0.19	1.5	0.3	8	1.1	0.8	1.7	0.6	-

TABLE 2. Chemical analysis of water used for irrigation.

pH	E.C. dSm^{-1}	O.M %	Soluble cations (meq/l)				soluble anions (meq/l)			
			Ca^{++}	Mg^{++}	Na^{+}	K^{+}	$CO_3^{=}$	HCO_3^{-}	Cl^{-}	$SO_4^{=}$
7.81	0.53	0.8	1.50	1.52	1.32	0.19	0.00	1.42	1.42	1.71

replicate plant was counted and labelled at full bloom, the number of set fruitlets was recorded. Fruit set percentages were calculated at the beginning of May in the first and second seasons, as follows:

$$\text{Fruit set \%} = \frac{\text{No. of developing fruitlets}}{\text{Total No. of flowers at full bloom}} \times 100$$

Fruit drop (%)

Number of dropped fruits was counted at last week of June then fruit drop percentages were calculated as follows:

$$\text{Fruit drop \%} = \frac{\text{No. of dropped fruits}}{\text{The initial number of fruitlets}} \times 100$$

Yield

At harvest time (the last week of July), the number of fruits per each treated plant was counted, then the yield (kg per plant) was weighed and recorded.

Fruits physical and chemical properties

Ten fruits were taken at harvest time from each replicate for determination of the following physical and chemical properties: Fruit weight (g), fruit length (cm), fruit width (cm), fruit volume (cm^3), and seeds weight/fruit were determined by separating pulp from the peel and centrifuging the juice extracted from the pulp; pulp weight (g), total soluble solids (T.S.S.%) in fruit juice (expressed as citric acid per 100 ml juice); T.S.S./Acid ratio; and ascorbic acid (mg ascorbic acid/100 ml juice) according to A.O.

Anatomy

Root samples were taken (50 cm) from plants and (10 cm) from soil serface, the samples were collected from the roots (2 cm) at the end of the second season. For infiltration and embedding, samples were killed and fixed in formalin-acetic-alcohol F.A.A. solution (10% formalin, 5% glacial acetic acid, 85% ethyl alcohol, and 90% water, by volume dehydrated with normal butyl alcohol) and paraffin wax (56-58C).Serial transverse sections of 20 microns in thickness were obtained using a rotary microtome. Safranin and the fast green stain technique were followed, then the cross sections were washed in absolute ethanol, cleared in xylene and mounted in Canada balsam as described by Johansen (1940) and Nasser and El-Sahhar (1998).

The anatomy work aimed to know the effects of salinity levels on the root structure of prickly pear under the Cairo-Alexandria desert road condition.

Statistical Analysis

The obtained data in 2020 and 2021 seasons were subjected to an analysis of variance according to Clarke and Kempson (1997). Means were differentiated using the Range test at the 0.05 level Duncan, (1955).

Results and Discussion

Fruit set (%)

Concerning salinity levels, control treatment (orchard irrigation water) recorded the highest significant fruit set, followed by 1000 ppm and 2000 ppm. Meanwhile, the lowest significant fruit set was found at 5000 ppm for both seasons. Regarding potassium humate treatments, the highest significant value of fruit set was detected at 100 g/plant/year, followed by 50 g/plant/year in both seasons. The interaction between the two study factors showed that control of salinity water treatment with potassium humate at 100 g/plant/year gave the highest significant value of fruit set in both seasons. On the other hand, the lowest fruit set was recorded with zero potassium humate under 5000 ppm of irrigation water salinity.

Fruit drop

With respect to salinity levels, the control treatment (orchard irrigation water) showed the least significant fruit drop, whereas the largest fruit drop was discovered at 5000 ppm in both seasons. Regarding potassium humate treatments, 50 g/plant/year was shown to be the lowest significant value of fruit drop, which was observed in both seasons. According to the results of the interaction between the two research variables, the control treatment, which included potassium humate at a rate of 100 g per plant per year, had the lowest significant value of fruit drop during both seasons. On the other hand, the highest fruit drop was recorded with zero potassium humate under 4000 and/or 5000 ppm of irrigation water salinity.

Fruit weight

As for as the salinity levels, the control treatment (orchard irrigation water) recorded the highest significant fruit weight, followed by 1000 ppm and 2000 ppm. At 5000 ppm in both seasons, the lowest significant fruit weight was discovered. Regarding potassium humate treatments, 50 g/plant/year was shown to be the next-highest significant value of fruit weight, with 100 g/plant/

TABLE 3. Effect of irrigation water salinity and potassium humate on fruit set (%) and fruit drop (%) of prickly pear plants during 2020 and 2021 seasons.

Salinity of irrigation water (ppm)	Season 2020				Season 2021			
	Potassium humate (g/plant/year)							
	0	50	100	Mean	0	50	100	Mean
	Fruit set (%)							
Control	78.310 bc	81.350 ab	84.123 a	81.271 A	81.917 c	85.213 b	89.357 a	85.496 A
1000	75.543 c	77.377 c	77.843 c	76.921 B	69.897 f	76.793 d	80.917 c	75.869 B
2000	70.230 d	69.670 d	70.250 d	70.050 C	64.287 g	71.317 ef	72.827 e	69.477 C
3000	51.910 gh	61.810 ef	62.943 e	58.888 D	55.077 i	64.177 g	63.377 g	60.877 D
4000	43.350 j	54.853 g	58.953 f	52.386 E	49.833 k	55.377 i	60.237 h	55.149 E
5000	40.627 j	46.493 l	51.077 h	46.066 F	42.327 l	48.357 k	53.277 j	47.987 F
Mean	59.995 C	65.259 B	67.532 A	-	60.556 C	66.872 B	69.998 A	-
	Fruit drop (%)							
Control	21.710 hi	18.663 ij	15.883 j	18.752 F	18.083 j	14.787 k	10.643 l	14.504 F
1000	24.477 h	22.643 h	22.177 h	23.099 E	30.103 g	23.207 i	19.083 j	24.131 E
2000	29.777 g	30.337 g	29.76 g	29.959 D	53.713 f	27.173 h	28.683 gh	30.523 D
3000	48.110 cd	38.210 ef	37.077 f	41.132 C	44.943 d	35.847 f	36.643 f	39.143 C
4000	56.650 a	45.160 d	41.060 e	47.623 B	50.173 b	44.643 d	39.763 e	44.860 B
5000	59.373 a	53.513 b	48.937 c	53.941 A	57.683 a	51.653 b	46.743 c	52.027 A
Mean	40.016 A	34.754 B	32.483 C	-	39.450 A	32.884 B	30.260 C	-

Means having the same letter (s) in each row, column or interaction are insignificantly different at 5% level.

year being the greatest value in both seasons. The interaction between the two study variables revealed that the control treatments for salinity water (potassium humate at 50 or 100 g/plant/year in the first season and control treatment using orchard irrigation water at 100 g/plant/year in the second season) gave the highest significant value of fruit weight. On the other hand, the lowest fruit weight was recorded with zero potassium humate under 5000 ppm of irrigation water salinity.

Fruit length

With respect to salinity levels, the control treatment (orchard irrigation water) recorded the highest significant fruit length. On the other hand, in both seasons, 5000 ppm was the lowest significant fruit length. Regarding potassium humate treatments, 50 g/plant/year was shown to be the highest significant value of fruit length, which was observed in both seasons. The interaction of the two study parameters revealed that the control treatment, which included potassium humate at a rate of 100g per plant per year, produced the highest levels of fruit length that were statistically significant. The shortest fruit length was discovered, however, when irrigation water had a salt level of 5000 ppm and zero potassium humate.

Yield

Regarding salinity levels, the control treatment (orchard irrigation water) had the highest significant yield in terms of salinity, followed by 1000 ppm and 2000 ppm. However, the lowest yield was discovered in both seasons at 5000 ppm. Regarding potassium humate treatments, 50 g/plant/year in both seasons was found to be the yield with the highest significant value, which was 100 g/plant/year. According to the interaction of the two research variables, the control treatment, which used potassium humate at a rate of 100 g per plant per year, produced high values in the first season. The second season's yield was more favourably impacted by the control treatment at 50 g and/or 100 g rates. On the other hand, the lowest production was observed when irrigation water had a salinity of 5000 ppm and no potassium humate.

Number of fruits / plant

Regarding salinity levels, the orchard irrigation water used as the control treatment had

TABLE 4. Effect of irrigation water salinity and potassium humate on fruit weight (g) and fruit length (cm) of prickly pear plants 2020 and 2021 seasons.

Salinity of irrigation water ppm	Season 2020				Season 2021			
	Potassium humate (g/plant/year)							
	0	50	100	Mean	0	50	100	Mean
	Fruit weight (g)							
Control	110.83 b	144.70 a	151.23 a	135.59 A	104.83 c	137.07 b	155.33 a	132.41 A
1000	87.27 de	93.60 cd	94.90 c	91.92 B	83.53 fg	90.03 de	92.37 d	88.64 B
2000	72.43 fgh	72.60 fgh	77.73 f	74.26 C	80.90 g	86.57 ef	93.23 d	86.90 B
3000	70.03 ghi	65.03 i	85.77 e	73.61 C	64.57 i	75.23 h	84.77 fg	74.86 C
4000	55.20 j	76.87 fg	66.30 hi	66.12 D	53.47 j	68.73 i	74.50 h	65.57 D
5000	44.90 k	56.57 j	64.27 i	55.24 E	45.53 k	57.83 j	64.53 i	55.97 E
Mean	73.44 C	84.89 B	90.03 A	-	72.13 C	85.91 B	94.12 A	-
	Fruit length (cm)							
Control	8.43 abc	8.53 abc	9.30 a	8.75 A	8.63 a-d	9.03 ab	9.43 a	9.03 A
1000	8.06 bcd	7.83 bcd	8.83 ab	8.24 AB	8.23 b-f	8.50 b-e	8.70 a-c	8.47 B
2000	7.93 bcd	7.76 bcd	8.46 abc	8.05 B	7.96 c-g	8.36 b-f	8.43 b-f	8.25 BC
3000	7.96 bcd	7.66 cd	8.33 abc	7.98 B	7.86 c-g	7.56 fgh	7.83 c-g	7.75 CD
4000	7.70 cd	7.60 cd	7.66 cd	7.65 BC	7.13 gh	7.33 gh	7.80 d-g	7.42 D
5000	6.33 e	7.30 de	7.56 cd	7.06 C	6.83 h	7.23 gh	7.73 e-f	7.26 D
Mean	7.73 B	7.83 B	8.36 A	-	7.77 B	8.00 AB	8.32 A	-

Means having the same letter (s) in each row, column or interaction are insignificantly different at 5% level.

the largest significant number of fruits per plant, followed by other concentrations. At 5000 ppm, however, both seasons' lowest fruit concentration was discovered. The largest significant quantity of fruits per plant was found in the potassium humate treatments, at 100 g/plant/year, followed by 50 g/plant/year in both seasons. Using potassium humate at a rate of 100 g per plant per year, control of salt water treatment resulted in the largest number of fruits per plant during both seasons, according to the interaction between the two study components. However, 0% potassium humate was found in irrigation water with a salinity of 5000 ppm or less, which produced the fewest fruits per plant.

Fruit width

In relation to salinity levels, the control treatment (orchard irrigation water) had the largest significant fruit width, followed by 1000 ppm and 2000 ppm. Meanwhile, the lowest fruit width was discovered in both seasons at 5000 ppm. The greatest significant value of fruit width for potassium humate treatments was found to be 100 g/plant/year in both seasons. The interaction of the two study variables revealed that potassium humate control at 100 g/plant/year recorded the greatest significant value of fruit width in both seasons. The lowest fruit width, on the other hand, was discovered with zero potassium humate under 5000 ppm of irrigation water salinity.

Fruit volume

Concerning salinity levels, the control treatment (orchard irrigation water) recorded the highest significant fruit volume, followed by 1000 ppm and 2000 ppm. Meanwhile, the lowest fruit volume was found at 5000 ppm in both seasons. Regarding potassium humate treatments, the highest significant value of fruit volume was detected at 100 g/plant/year, followed by 50 g/plant/year in both seasons. The interaction between the two study factors showed that control of salinity water treatment with potassium humate at 100 g/plant/year gave the highest significant value of fruit volume in both seasons. On the other hand, the lowest fruit volume was recorded with zero potassium humate under 5000 ppm of irrigation water salinity.

Peel weight

Referring to salinity levels, the control

TABLE 5. Effect of irrigation water salinity and potassium humate on number of fruits / plant and yield (Kg) plant of prickly pear plants 2020 and 2021 seasons.

Salinity of irrigation water ppm	Season 2020				Season 2021			
	Potassium humate(g/plant/year)							
	0	50	100	Mean	0	50	100	Mean
	Yield (Kg) plant							
Control	10.940 c	12.517 b	14.180 a	12.546 A	9.427 b	12.587 a	13.127 a	11.713 A
1000	6.780 gh	6.333 ghi	9.433 d	7.516 B	6.807 d	6.950 d	7.567 c	7.108 B
2000	6.083 i	7.583 f	8.690 e	7.452 B	5.543 f	5.513 f	6.880 d	5.979 C
3000	5.070 j	6.107 hi	7.003 fg	6.060 C	4.403 ghi	4.943 g	6.247 e	5.198 D
4000	4.350 k	5.087 j	6.167 hi	5.201 D	3.670 jk	4.160 hij	4.663 gh	4.164 E
5000	3.467 l	4.107 kl	4.603 jk	4.059 E	2.533 l	3.543 k	4.007 ijk	3.361 F
Mean	6.115 C	6.955 B	8.346 A	-	5.397 C	6.282 B	7.081 A	-
	Number of fruits / plant							
Control	74.33 cd	87.67 b	102.00 a	88.00A	71.00 c	84.00 b	91.00 a	82.00 A
1000	66.67 e	55.00 gh	75.00 c	71.33 B	64.33 e	66.00 d	71.00 c	67.11 B
2000	65.33 ef	71.00 d	77.67 c	65.56 C	61.00 f	58.00 h	66.00 d	61.67 C
3000	57.00 g	62.33 f	64.00 ef	61.11 D	51.00 k	55.00 i	59.00 g	55.00 D
4000	52.67 hi	50.33 ij	54.00 ghi	52.33 E	44.00 n	48.00 l	52.00 j	48.00 E
5000	43.67 k	48.00 j	53.00 hi	48.22 F	38.00 o	44.00 n	46.00 m	42.66 F
Mean	59.94 C	62.39 B	70.94 A	-	54.88 C	59.17 B	64.88 A	-

Means having the same letter (s) in each row, column or interaction are insignificantly different at 5% level.

TABLE 6. Effect of irrigation water salinity and potassium humate on fruit width (cm) and fruit volume (cm^3) of prickly pear plants 2020 and 2021 seasons.

Salinity of irrigation water ppm	Season 2020				Season 2021			
	Potassium humate (g/plant/year)							
	0	50	100	Mean	0	50	100	Mean
	Fruit width (cm)							
Control	5.13 bc	5.16 bc	6.06 a	5.45 A	5.30 cd	5.50 b	6.60 a	5.80 A
1000	4.60 de	4.66 de	5.20 b	4.82 B	5.13 de	5.36 cd	5.80 b	5.43 B
2000	4.50 de	4.46 de	5.16 bc	4.71 BC	4.93 ef	4.46 h-j	5.33 cd	4.91 C
3000	4.36 de	4.40 de	4.76 cd	4.51 CD	4.80 fg	4.20 ij	4.70 f-h	4.56 D
4000	4.26 ef	4.43 de	4.46 de	4.38 D	4.50 g-i	4.30 ij	4.46 h-j	4.42 D
5000	3.93 fg	3.66 g	4.33 ef	3.97 E	4.46 h-j	3.66 k	4.16 j	4.10 E
Mean	4.46 B	4.46 B	5.00 A	-	4.85 B	4.58 C	5.17 A	-
	Fruit volume (cm^3)							
Control	75.00 cd	85.67 b	96.00 a	85.55 A	84.33 b	87.00 b	101.67 a	91.00 A
1000	72.00 cd	73.66 cd	75.67 c	73.78 B	70.00 e	79.33 c	83.00 bc	77.44 B
2000	65.00 e	63.66 e	70.66 d	66.44 C	64.67 fg	69.00 ef	74.67 d	69.44 C
3000	57.00 fg	57.00 fg	61.00 ef	58.33 D	56.67 h	61.32 g	70.66 de	65.22 D
4000	49.66 h	50.66 h	54.00 gh	51.45 E	51.00 i	72.01 de	72.67 de	62.88 D
5000	43.00 i	43.00 i	44.00 i	43.33 F	44.33 j	43.67 j	51.33 i	46.44 E
Mean	60.27 C	62.27 B	66.88 A	-	61.83 C	68.72 B`	75.66 A	-

Means having the same letter (s) in each row, column or interaction are insignificantly different at 5% level.

treatment (orchard irrigation water) recorded the highest significant peel weight, followed by 1000 ppm. Meanwhile, the lowest peel weight was found at 5000 ppm for both seasons. Regarding potassium humate treatments, the highest significant value of peel weight was detected at 100 g/plant/year, followed by 50 g/plant/year in both seasons. The interaction of the two study factors revealed that the control treatment with potassium humate at 100 g/plant/year produced high values in the first season. Meanwhile, control treatment at 50 g and/or 100 g rates produced a higher positive effect on peel weight in the second season. On the other hand, the lowest peel weight was recorded with zero potassium humate under 5000 ppm of irrigation water salinity.

Number of seeds/fruit

Regarding salt levels, the most significant number of seeds were found in the control treatment (orchard irrigation water), which was followed by 1000 and 2000 ppm. For both seasons, 5000 ppm was where the least amount of seeds were discovered. With respect to potassium humate treatments, 50 g/plant/year in both seasons was shown to be the lowest value for the number of seeds, with 100 g/plant/year being the maximum. The results of the interaction between the two research variables indicated that the salinity water treatment control using potassium humate at a rate of 100 g/plant/year resulted in the highest significant value of seeds in both seasons. On the other hand, the fewest number of seeds were recorded with zero potassium humate under 5000 ppm of irrigation water salinity.

Seeds weight

In case of salinity levels, the lowest significant seed weight was seen in both seasons at 5000 ppm. On the other hand, control had the highest weight of seeds, followed by other levels. Regarding potassium humate treatments, it was discovered that a high potassium humate application of 100 g per tree produced the highest values of seed weight in the first and second seasons. According to the interaction between the two study factors, salinity levels at 4000 and 5000 ppm with potassium humate at a 0 g rate in the first season and salinity at 5000 ppm levels with potassium humate at 0 g and 50 g/plant/year rates in the second season had the lowest significant values of seed weight.

TABLE 7. Effect of irrigation water salinity and potassium humate on peel weight (g) and number of seeds/fruit of prickly pear plants 2020 and 2021 seasons.

Salinity of irrigation water ppm	Season 2020				Season 2021			
	Potassium humate(g/plant/year)							
	0	50	100	Mean	0	50	100	Mean
	Peel weight (g)							
control	52.43 cd	53.46 bcd	68.80 a	58.23 A	54.16 b	70.56 a	73.70 a	66.14 A
1000	50.23 cde	56.40 bc	60.50 b	55.71 A	53.73 b	52.33 bc	54.66 b	53.57 B
2000	44.60 e-h	52.13 cd	57.30 bc	51.34 B	52.23 bcd	49.83 b-e	50.76 bcd	50.94 B
3000	42.63 f-i	48.13 d-g	50.46 cde	47.07 C	48.53 b-f	43.83 d-g	45.63 c-g	46.00 C
4000	40.93 ghi	39.83 hi	48.26 def	43.01 C	40.03 g-i	34.66 hi	45.23 c-g	39.97 D
5000	37.00 i	37.86 hi	41.03 f-i	38.63 D	33.23 i	41.13 f-h	42.40 e-g	38.92 D
Mean	44.63 C	47.97 B	54.39 A	-	46.98 B	48.72 B	52.06 A	-
	Number of seeds/fruit							
control	197.67 c	215.00 b	243.00 a	218.56 A	172.33 cd	195.00 b	220.00 a	195.78 A
1000	194.67 c	189.33 c	196.00 c	193.33 B	173.00 cd	178.00 c	202.67 b	184.56 B
2000	157.33 de	155.33 de	167.00 d	159.89 C	165.00 d	163.00 d	167.33 cd	165.11 C
3000	98.00 h	125.67 f	142.67 e	122.11 D	79.00 i	143.67	150.67 e	124.44 D
4000	77.00ij	113.67 fgh	117.33 fg	102.67 E	79.00 i	116.67 g	134.67 f	110.11 E
5000	65.00 j	81.67 i	108.67 gh	85.11 F	80.33 i	90.33 hi	101.33 h	90.67 F
Mean	131.61 C	146.78 B	162.44 A	-	124.78 C	147.78B	162.78 A	-

Means having the same letter (s) in each row, column or interaction are insignificantly different at 5% level.

Pulp weight

Regarding salinity levels, the control treatment (orchard irrigation water) recorded the highest significant pulp weight, followed by 1000 ppm and 2000 ppm. In contrast, both seasons revealed the lowest pulp weight of 5000 ppm. The highest value of pulp weight for potassium humate treatments was found at 50 g and 100 g/plant/year in the first season and 100 g rates in the second season. The interaction of the two research variables revealed that the control of salinity water treatment with potassium humate at 50 g and 100 g rates per plant per year in the first season and 100 g rates in the second season gave the highest significant value of pulp weight. On the other hand, the lowest pulp weight was recorded with zero potassium humate under 5000 ppm of irrigation water salinity.

Fruit T.S.S.

In relation to salinity levels, the control treatment (orchard irrigation water), which had the highest significant fruit total soluble solids content, was followed by 1000 ppm and 2000 ppm. The fruit with the lowest total soluble solids content was found to be 5000 ppm in both seasons. Regarding potassium humate treatments, the fruit's total soluble solids content was found to be 100 g/plant/year, followed by 50 g/plant/year in both seasons, which was the greatest significant value. According to the interaction between the two study variables, potassium humate treatment of salt water at a rate of 100 g per plant per year produced fruit with the highest levels of total soluble solids in both seasons. On the other hand, 0 g/plant/year potassium humate under 5000 ppm of irrigation water salinity was observed as having the lowest fruit total soluble solids content in both seasons.

Fruit total acidity content

Concerning salinity levels, the control treatment indicated the lowest significant fruit total acidity content in both seasons. Meanwhile, the highest value was found at 5000 ppm, followed by other levels. Regarding potassium humate treatments, the 100 g rate recorded the lowest significant values of fruit total acidity content compared

TABLE 8. Effect of irrigation water salinity and potassium humate on seeds weight (g) and pulp weight (g) of prickly pear plants 2020 and 2021 seasons.

Salinity of irrigation water ppm	Season 2020				Season 2021			
	Potassium humate (g/plant/year)							
	0	50	100	Mean	0	50	100	Mean
	Seeds weight (g)							
Control	28.70 c	31.21 b	35.27 a	31.73 A	25.81 cd	29.19 b	32.94 a	29.31 A
1000	28.26 c	27.47 c	28.44 c	28.06 B	25.90 cd	26.65 c	30.34 b	27.632 B
2000	22.83 de	22.53 de	24.24 d	23.20 C	24.70 d	24.40 d	25.05 cd	24.71 C
3000	14.23 h	18.23 f	20.71 e	17.72 D	11.83 i	21.51 ef	22.56 e	18.63 D
4000	11.17 ij	16.50 fgh	17.03 fg	14.90 E	11.82	17.47 g	20.16 f	16.48 E
5000	9.43 j	11.85 i	15.77 gh	12.35 F	12.03 i	13.52 hi	15.17 h	13.57 F
Mean	19.10 C	21.30 B	23.58 A	-	18.68 C	22.12 B	24.37 A	-
	Pulp weight (g)							
Control	58.46 b	91.30 a	82.50 a	77.42 A	50.66 c	66.53 b	81.63 a	66.27 A
1000	37.03 c	37.20 c	34.40 cd	36.21 B	29.80 fgh	37.70 def	37.70 def	35.96 B
2000	27.83 de	20.46 efg	20.43 efg	26.55 C	28.70 gh	36.73 d-g	42.46 cd	35.06 B
3000	27.46 def	16.90 gh	35.30 cd	23.12 C	16.23 ij	31.40 efg	39.16 de	28.93 C
4000	14.90 gh	37.03 c	18.06 g	22.91 C	13.46 ij	34.10 d-g	29.26 fgh	25.61 C
5000	7.90 h	18.76 fg	23.23 efg	16.63 D	12.30 j	16.73 ij	22.13 hi	17.05 D
Mean	28.82 B	36.94 A	35.65 A	-	25.19 C	37.20 B	42.06 A	-

Means having the same letter (s) in each row, column or interaction are insignificantly different at 5% level.

TABLE 9. Effect of irrigation water salinity and potassium humate on fruit T.S.S. (%) and fruit total acidity content (%) of prickly pear plants 2020 and 2021 seasons.

Salinity of irrigation water ppm	Season 2020				Season 2021			
	Potassium humate (g/plant/year)							
	0	50	100	Mean	0	50	100	Mean
	Fruit T.S.S. (%)							
control	9.713 c	9.856 b	9.966 a	9.884 A	9.636 c	9.870 b	9.926 a	9.811 A
1000	9.540 f	9.576 e	9.640 d	9.585 B	9.486 e	9.560 d	9.646 c	9.564 B
2000	9.070 i	9.143 h	9.220 g	9.144 C	8.963 h	9.053 g	9.110 f	9.042 C
3000	8.766 lm	8.810 k	8.866 j	8.814 D	8.653 l	8.766 j	8.836 i	8.752 D
4000	8.633 n	8.740 m	8.790 kl	8.721 E	8.603 m	8.656 l	8.696 k	8.652 E
5000	8.226 q	8.293 p	8.353 o	8.291 F	8.176 p	8.176 p	8.303 n	8.245 F
Mean	8.992 C	9.070 B	9.139 A	-	8.920 C	9.027 B	9.086 A	-
	Fruit total acidity content (%)							
control	0.516 l	0.503 m	0.486 n	0.502 F	0.566 k	0.540 l	0.520 m	0.542 F
1000	0.556 j	0.526 kl	0.530 k	0.537 E	0.620 i	0.563 k	0.550 l	0.577 E
2000	0.606 h	0.576 i	0.550 j	0.577 D	0.663 g	0.633 h	0.593 j	0.630 D
3000	0.663 de	0.633 g	0.583 i	0.626 C	0.706 e	0.683 f	0.656 g	0.682 C
4000	0.730 b	0.670 d	0.646 f	0.682 B	0.740 cd	0.730 d	0.713 e	0.727 B
5000	0.763 a	0.706 c	0.653 ef	0.707 A	0.783 a	0.763 b	0.743 c	0.763 A
Mean	0.639 A	0.602 B	0.575 C	-	0.680 A	0.652 B	0.629 C	-

Means having the same letter (s) in each row, column or interaction are insignificantly different at 5% level.

to the other concentrations in both seasons. The interaction between the two study factors showed that salinity levels at the control treatment with potassium humate at 100 g/plant/year recorded the lowest significant values of fruit total acidity content in both seasons. On the other hand, the highest fruit total acidity content was recorded with zero potassium humate under 5000 ppm of irrigation water salinity.

Fruit T.S.S. / Acid ratio

In case of salt levels, control treatment (orchard irrigation water) recorded the greatest significant fruit T.S.S. / Acid ratio, followed by 1000 ppm and 2000 ppm; in contrast, the lowest fruit T.S.S. / Acid ratio was discovered at 5000 ppm in both seasons. Regarding potassium humate treatments, the fruit T.S.S. / Acid ratio showed the highest significant value at 100g/plant/year, followed by 50g/plant/year in both seasons. The interaction between the two study variables revealed that potassium humate treatment of salt water at a rate of 100g per plant per year produced the fruit T.S.S./Acid ratio with the greatest significant value in both seasons. The lowest fruit T.S.S. / Acid ratio, on the other hand, was discovered with zero potassium humate under 5000 ppm of irrigation water salinity.

Ascorbic acid

Regarding salinity levels, control treatment (orchard irrigation water) recorded the greatest significant ascorbic acid values, followed by 1000 ppm and 2000 ppm, while the lowest ascorbic acid was discovered at 5000 ppm in both seasons. The highest significant value of ascorbic acid was found in the potassium humate treatments at 100 g/plant/year, followed by 50 g/plant/year in both seasons. According to the interaction between the two study variables, potassium humate treatment of salt water at a rate of 100 g per plant per year produced the ascorbic acid levels that were most significantly different in both seasons. The lowest concentration of ascorbic acid, on the other hand, was found in irrigation water with a salinity of 5000 ppm and no potassium humate.

Salinity is one of most important abiotic stresses and serious threat to agricultural sustainability in the arid to semi- arid regions. The

TABLE 10. Effect of irrigation water salinity and potassium humate on fruit T.S.S. / Acid ratio and Ascorbic acid of prickly pear plants 2020 and 2021 seasons.

Salinity of irrigation water ppm	Season 2020				Season 2021			
	Potassium humate (g/plant/year)							
	0	50	100	Mean	0	50	100	Mean
	Fruit T.S.S. / Acid ratio							
control	18.830 c	19.630 b	20.503 a	19.654 A	17.153 cd	18.290 b	19.210 a	18.218 A
1000	17.157 e	18.197 d	18.217 d	17.857 B	15.410 e	17.033 d	17.563 c	16.669 B
2000	14.970 g	15.863 f	16.783 e	15.872 C	13.697 g	14.453 f	15.577 e	14.576 C
3000	13.223 ij	13.927 h	15.220 g	14.123 D	12.427 i	12.907 h	13.513 g	12.949 D
4000	11.833 k	13.063 j	13.600 hi	12.832 E	11.680 k	11.983 jk	12.347 ij	12.003 E
5000	10.787 l	11.757 k	12.793 j	11.779 F	10.513 m	10.877 lm	11.250 l	10.880 F
Mean	14.467 C	15.406 B	16.186 A	-	13.480 C	14.257 B	14.910 A	-
	Ascorbic acid (mg ascorbic acid/100 ml juice)							
control	16.523 c	16.713 b	16.973 a	16.737 A	14.917 d	15.603 b	15.853 a	15.458 A
1000	16.213 f	16.330 e	16.420 d	16.321 B	14.760 f	14.843 e	15.160 c	14.921 B
2000	15.670 j	16.060 h	16.120 g	15.950 C	14.323 h	14.660 g	14.907 d	14.630 C
3000	15.483 l	15.640 k	15.707 i	15.610 D	13.810 l	14.120 j	14.257 i	14.062 D
4000	15.273 o	15.390 n	15.453 m	15.372 E	13.437 o	13.723 m	14.023 k	13.728 E
5000	14.857 q	15.160 p	15.273 o	15.097F	13.350 p	13.430 o	13.483 n	13.421 F
Mean	15.670 C	15.882 C	15.991 A	-	14.099 C	14.397 B	14.614 A	-

Means having the same letter (s) in each row, column or interaction are insignificantly different at 5% level.

results of fruit quality induced by salinity level and humic acid rates were emphasised by the findings by Eissa (2003) and Fathy et al. (2010), which revealed that humic acid treatments (foliar and soil applications) increased yield and fruit physical and chemical properties (fruit firmness, juice SSC and SSC/acidity ratio) of 'Canino" apricot. Furthermore, use of humic substances for removing negative effects of elements in toxic quantities, and effects on plant growth on Wheat (*Triticum durum cv. Salihli*) were studied under conditions water shortage and salt level by Asik et al., 2009). The enhancement of potassium on the fruit quality of cactus pear fruits may be attributed to the physiological role of potassium in enhancing many metabolic processes such as carbohydrate formation, translocation and accumulation (Ganeshamurthy et al., 2011). Furthermore, potassium humate increases the production and quality of a potato crop and increases plant tolerance to drought stress and salinity. Jalilm et al. (2013).

Root anatomy

Root anatomy investigation and observations reflected how the plant affected by saline water in different concentration with control and Tab water on the root ability to absorb by their tissue in root system Fig (1). The root system of cactus pear plant exhibited under water control treatment irrigation observed that vessels bundles were the least numbers phloem, xylem layers, least root diameter in the cross section; these were not affected by 1000 ppm concentration of irrigation water salinity.

Periderm layer

Periderm layer was increased under control orchard irrigation water less than 1000 ppm. This agreed with Abou taleb (2003), who reported that the cortex of the pecan root cross section was decreased by salin irrigation water.

The vascular bundle thickness

The vascular bundle thickness were affected by saline water 2000 ppm Fig.2 There was a beginning of increased xylem layer was observed. These results agree with those of Sourial et al. (1975) and more so with those of Abou taleb (2003). Meanwhile, Ahmed (1982) reported a decrease in xylem vessels under saline irrigation water.

Phloem thickness

Phloem layers in El-Shamia cactus pear were increased by increasing the concentration of saline irrigation water. The high concentration of 6000–7000 ppm exhibited more phloem cells and a large area of phloem and xylem cells. There was activity of precicle layer in cactus pear plants Walker et al., (1984) reported that hypodermal cells that developed and had large are under saline water & compared with control.

Xylem thickness

Differentiated cell of xylem layer was showed and affected by saline water at 3000 ppm as well as 4000 ppm of treatment irrigation was increased (Fig. 3 and 4) . The xylem layers and thickness of the endoderm layer were maximised at 6,000, in addition to the thickness of the cortex and cambium layer. Meanwhile, periderm was increasing under control and tap water contained less than 1000 ppm. These findings were agreed with (Taleb 2003) reported that the cortex of pear root cross section was decreased by irrigation water saline.

Conclusion

From the present study, it could be concluded that El-Shamia cactus pear cultivar gave the best results with orchard irrigation water treatment and potassium humate at 100g where improved natural and chemical properties of fruits. On the other side, reduced fruit drop, peel weight, number of seeds, seeds weight and fruit total acidity content. Potassium humate is considered as a plant growth bio- stimulate used for alleviating the inferior effects of soil salinity of cactus pear plants under salinization conditions. In addition, all of root tissue affected by salt solution and mutated to adapt with high concentrations.

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Conflicts of interest

Authors have declared that no conflicts of interest.

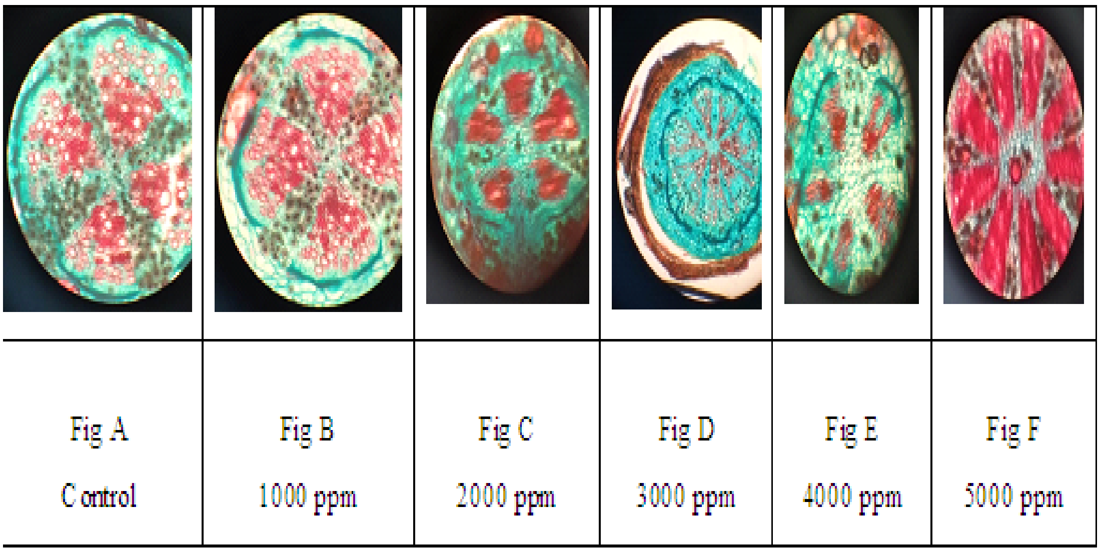

Fig. 1. root anatomical structure of El-shamia cuctus pear cultivar roots influenced by salinity stress levels. (X = 40)

References

Abou Taleb (2003) Increasing salt Tolerance in two Pecan Rootstocks (Desirable and Graking) by Mycorrhizal, *Egypt. J. Hort.,* **30**(1-2), 83- 109.

Ahmed, R.B. (1982) Studies on physiological and histological responses of Ficus carica L., itransplants to salinity. *M.Sc. Thesis*, Hort. Dept., Fac. Agric., Zagazig Univ., Egypt.

Ashraf, M. and Foolad, MA. (2007) Improving plant abiotic- stress resistance by exogenous application of osmoprotectants glycine betaine and proline. *Environ. Exp. Bot.,* **59**, 206-216.

Asik, BB., Turan, MA., Celik, H. and Katkat, AV. (2009) Effects of humic substances on plant growth and mineral nutrients uptake of wheat *(Thiticum durum* c.v. Salihli) under conditions of salinity. *Asian Journal of Cropsciencem*, **1**(2), 87-95.

Association of Official Agricultural Chemists, (2000) *Official Methods of Analysis* (A.O.A.C.) 12th ed. ,Benjamin Franklin Station, Washington D.C.U.S.A. pp: 490-510.

Casierra-Posada, F., Rodriguez, C.A. and Fischer, G. (2009) Reducing negative effects of salinity in tomato (Solanum lycopersicum L.) plants by adding leonardite to soil. *Acta Hort.,* **821**, 133-140

Clarke, G.M. and Kempson, R.E. (1997) *Introduction to the Design and Analysis of Experiments*. Arnold, 1st ed., A Member of the Holder Headline Group, London, UK.

Cushman, JC., and Bohnert, H.J. (1999) Crassula sean acid metabolism: molecular genetics. Ann. Rev. Plant Physiol. *Plant Mol. Biotechnol.,* **50**, 305-352.

Demir, K., Gunes, A. and Alpasan, M. (1999) Effects of humic acid on the yield and mineral nutrition of cucumber (*Cucmis sativus L.*) grown with different salinity levels. *Acta Hor.,* **492**, 95-104.

Duncan, D.B. (1955) Multiple range and multiple F test. *Biometrics*, **11**,1–24.

Eissa F.M. (2003) Use of some biostimulants in activation of soil microflora for yield and fruit quality improvement of “Canino” apricot. *Agric. Res. Tanta Univ.,* **29** (1).

El- Khawaga, A.S. (2013) Effect of Anti-salinity Agents on growth and fruiting of different date palm cultivars. *Asian Journal of Crop Science,* **5**(1), 65-80.

Fathy, M.A., Gaber, M.A. and El Shall, S.A. (2010) Effect of humic acid treatments on “Canino” apricot growth, yield and fruit quality. *New York Sci. J.,* **3**(12), 109-115.

Ganeshamurthy, A.N., Satisha, G.C. and Patil, P. (2011) Potassium nutrition on yield and quality of fruit crops special emphasis on banana and grapes. *Karnataka J. Agric. Sci.,* **24**(1),29 –38

Jalilm, A., Saeid, F.P., Mohammad, R.A. and Ali, K. (2013) Effect of potassium humate on yield and yield components of different potato varieties as a second crop after barley harvest in Ardabil region, Iran. *Ann. of Bio.I Res.,* **4**(2), 85-89.

Johansen, D.A. (1940). *Plant Micro Technique*. McGraw-Hill, New York.

Marschner, H. (1995) *Mineral Nutrition of Higher Plants.* 2nd ed. Academic Press. Inc. London, G.B. 446 p.

Nassar, M. A. and El-Sahhar, K.F. (1998) *Botanical Preparations and Microscopy (Microtechniqie)* Academic Bookshop, Dokki, Giza, Egypt., 219 p. (In Arabic).

Piccolo. A., Nardi S. and Concheri, G. (1992) Structural characteristics of humic substance as related to nitrate uptake and growth regulation in plant systems. *Soil Biol. Biochem*. **24**, 373-380.

Sourial, G.F., Helal, M.H. and El- Shahat, H. (1975) Effect of salinity on the growth, Free amino- N and Protein- N content in the leaves of some grape cultivar. *Zagazig J. Agric. Res.,* **1** (1), 45-56.

Taiz and zeiger, (2006) Plant physiology. Fourth ed. Sunder land, MA, pp. 764p.

Tester, M. and Davenport, R. (2003) Na^+ tolerance and Na^+ transport in higher plants. *Ann. Bot.,* **91**,503-527.

Walker, Sedgly, M., Blesing, T.J. and Douglas, M.A. (1984) Anatomy ultrastructural and assimilate concentrations of roots of citrus genotypes differing in ability for salt exclusion, *J. Exp. Bot.,* **35** (159).

تأثير تركيزات مختلفة من ملوحة ماء الرى وهيومات البوتاسيوم على إنتاجية وجودة ثمار التين الشوكى

سحر على فريد و فهمى إبراهيم فهمى
قسم الإنتاج النباتى - مركز بحوث الصحراء - القاهرة - مصر.

أجريت هذه الدراسة خلال موسمى ٢٠٢٠ و ٢٠٢١ على نباتات التين الشوكى عمر ٩ سنوات صنف الشامية والمنزرعة بقرى الخريجين طريق مصر - إسكندرية الصحراوى الكيلو ١٠٧ من القاهرة.

الصلبة الذائبة الكلية إلى الحموضة وحامض الإسكوربيك. وقللت نسبة تساقط الثمار ووزن القشرة وعدد البذور ووزن البذور ونسبة الحموضة فى الثمرة. وقد أثبتت هذه المعاملة تفوقها فى تحسين الإنتاجية والمحصول وجودة الثمار فى التين الشوكى صنف الشامية.