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INFLUENCE POTASSIUM HUMATE ON ROSEMARY PLANTS GROWN IN SANDY SOIL UNDER IRRIGATION WITH SALINE WATER

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ABSTRACT: To examine the ability of potassium humate (0, 1000, 2000 and 3000 ppm) for lessening the deleterious impacts of saline water (0, 1.4, 2.8 and 4.2 dS/m) on *Rosmarinus officinalis* plant, a pot study was undertaken at the Nursery of Ornamental Plants, Fac. Agric., Minia Univ. during the two experimental seasons 2022 and 2023. Data showed that all examined traits of vegetation development (plant height, branches number/plant, and herb fresh and dry weights) were decreased by increasing salinity levels (2.8 and 4.2 dS/m) compared with control in both cuts during both seasons. Opposite trend was obtained with the low concentration (1.4 dS/m). It was found that, while the essential oil (%) and its yield/plant were increased under (1.4 and 2.8 dS/m), the essential oil (%) and yield were significantly decreased under (4.2 dS/m) in both cuts during both seasons. The pigments content and NPK (%) took the same trend of the vegetative growth. While both Na (%) and proline content (µg/g) in dry leaves were increased by increasing salinity levels during the second cut in both seasons. All of the aforementioned characteristics of vegetation development, essential oil output and some chemical compositions were significantly improved by potassium humate treatments, with the exception of Na% and proline content (µg/g) over both seasons. In this concern, 3000 ppm potassium humate was the most effective treatment. There was a notable interaction impact between the two parameters under investigation for all examined parameters, with the best interaction treatment recorded with 1.4 dS/m in combination with potassium humate (3000 ppm). In conclusion, the negative effects of salinity stress may be mitigated by spraying plants with 3000 ppm of potassium humate.

Keywords: Rosemary, salinity, water quality, potassium humate

INTRODUCTION

The perennial herb plant rosemary, *Rosmarinus officinalis* L. is a member of the Lamiaceae family (Abdelkader *et al*., 2019). Rosemary is growing well in all areas of the Mediterranean Sea (Al-Fraihat *et al*. 2023). Rosemary plants and their essential oil are utilized in flavor, fragrance, and medicinal industries (Lee *et al*. 2011).

Because of the impacts, nutritional imponderables, low osmotic potential of soil solution, and assimilation of these agents, water salinity has a detrimental impact on plant growth and development as well as yield (Ashraf and Harris, 2004). According to studies by Abdelkader *et al*. (2019), Chetouani *et al*. (2019), and El-Kholy *et al*. (2020), salinity stress considerably decreased the total chlorophylls content, volatile oil percentage, and growth features of rosemary. By strengthening the cohesive interactions between the tiny soil particles, humates lessen soil erosion. By boosting buffering characteristics and exchange capacity, humate improves the chelation of several nutrients and increases their availability to plants, so it improves the physical properties of the soil structure. It is also employed in situations when salt has detrimental effects on plant development and nutrient absorption. It frequently serves as a key ingredient in formulations of biostimulants like auxin and cytokinin. It has been suggested that potassium humate is a workable and affordable solution for restoring damaged land resources. Additionally, studies by Said-Al Ahl *et al*. (2009), Badran *et al*. (2019), Shyala *et al*. (2019), Wei *et al*. (2021), and Shalaby *et al*. (2023) have shown that potassium humate is a common organic fertilizer that may be improved.

Therefore, this study aimed to evaluate the response of rosemary plants to potassium humate under irrigation with saline water.

MATERIALS AND METHODS

The goal of this investigation was to determine how potassium humate affected the growth parameters, essential oil productivity, and chemical composition of *Rosmarinus officinalis* plants irrigated with salinized water. The study was carried out at the Ornamental Plants Nursery, Faculty of Agriculture, Minia University during the 2022 and 2023 growing seasons.

Terminal rooted cuttings of *Rosmarinus officinalis* plant averaging 8 cm in height, 2 mm in diameter and have 9 leaves were cultivated on 20th February of the two seasons of 2022 and 2023 in plastic pots of 15-cm-diameter filled with 1.50 kg of sandy soil (one cutting/pot). The physical and chemical analyses of the used soil were performed according to the methods described by ICARDA (2013) as presented in Table (a).

A split plot in a complete randomized block design with three replicates was used and included 16 treatments (4 × 4). There were 6 pots (6 plants) in each plot, so the total number of used plants was 288 plants. Four salinized water treatments (0, 1.4, 2.8 and 4.2 dS/m, NaCl) and four potassium humate (0, 1000, 2000, and 3000 ppm) were allocated in the sub-plots and the main plots, respectively. The sodium chloride was obtained from El-Gomhouria Co. for Trading Drugs, Chemicals and Medical Supplies (Al Amiriyyah, Egypt) and humic acid was released from Star Gold for Agricultural Development, Assiut District, Assiut Governorate, Egypt.

The soluble potassium humate employed in this experiment had the following chemical constituents: humic acid 82%, K_2O 10-12%, moisture 5-6%, density of 0.83 g/ml, and more than 98% water solubility.

The plants were irrigated (with 300 cm^3 each/pot) two times weekly. All treatments were irrigated with tab water for two weeks (20th February - 5th March), after that the plants were irrigated with examined salinized water starting from 6th March according to the

Table a. The physical and chemical analysis of the used soil in the study during the first and second seasons (2022 and 2023).

Soil character	Values		Soil character	Values	
	2022	2023		2022	2023
Physical properties			**Nutrients**		
Sand (%)	88.50	89.50	**Total N (%)**	0.01	0.01
Silt (%)	7.90	7.10	**Available P (ppm)**	2.71	2.86
Clay (%)	3.60	3.40	**Na^+ (mg/100 g soil)**	2.35	2.46
Soil type	Sandy	sandy	**K^+ (mg/100 g soil)**	0.72	0.76
Chemical properties			**DTPA-Extractable nutrients**		
pH (1:2.5)	8.18	8.21	**Fe (ppm)**	1.04	1.10
E.C. (dS/m)	1.09	1.11	**Cu (ppm)**	0.32	0.36
O.M.	0.02	0.03	**Zn (ppm)**	0.35	0.32
$CaCO_3$	11.35	11.63	**Mn (ppm)**	0.55	0.62

assigned concentration till the end of the experiment. All plants were sprayed six times (3 times on 21st March, 6th April, and 21st April before the first cut and 3 times later on 21st June, 6th July and 21st July). The plants were harvested twice in both seasons by cutting plants at 4 cm above the soil surface. The two cuts were done in the first week of June and September in both seasons.

The following data were recorded for each cut of plant, vegetative growth [plant height (cm), branches number/plant, and herb fresh and dry weights (g)], essential oil production (percent and yield/plant) in both cuts during both seasons, as well as some chemical constituents of photosynthetic pigments in fresh leaves (chlorophyll a, b and carotenoids; mg/g), proline content (µg/g) and NPK (%), while Na percentages in dry leaves were measured in second cut only during both seasons.

The pigment contents were measured colorimetrically according to Fadl and Sari El-Deen (1979). Macro-elements (N, P, K and Na) percentages in dry leaves were measured as defined by ICARDA (2013). Proline (µg/g) was measured in the second cut defined by Bates *et al*. (1973).

Statistical analysis:

The LSD test at 0.05 was used to compare the treatment means after our data were tabulated and exposed to statistical analysis by MSTAT–C (1986).

RESULTS

1. Vegetative growth parameters:

Data shown in Tables (1 and 2) revealed that irrigation with saline water led to a significant increase under (1.4 dS/m), and decreased by upper concentrations (2.8 and 4.2 dS/m) for all characteristics of vegetative development (plant, branches number, and weights of fresh and dry shoots) as relative to control (tab water) in the two cuttings during both experimental seasons. Irrigated plants with 4.2 dS/m recorded the highest reduction compared with other salinity levels.

The gained findings are in harmony with those described by Aziz and Youssef (2001), Kiarostami *et al*. (2010), Langroudi and Sedaghathoor (2012), Ali and Attia (2015), Abdelkader *et al*. (2019), and El-Kholy *et al*. (2020) on *Rosmarinus officinalis*; Hendawy and Khalid (2005) on sage plant; and Shalan *et al*. (2006), Massoud *et al*. (2009), Jelali *et al*. (2011) on marjoram plants. In contrast, Hendawy *et al*. (2019) revealed that chamomile plants were highly resistant to salinity stress as increased flower yields were observed under high-salinity stress.

As for potassium humate treatments, data in Tables (1 and 2) proved that all treatments (1000, 2000 and 3000 ppm) significantly increased all studied vegetative growth parameters facing untreated plants during both cuttings throughout the two experimental seasons. Generally, the treatment of 3000 ppm proved more successful than other treatments in improving abovementioned vegetative growth parameters.

Our findings are similar to those obtained by Said-Al Ahl *et al*. (2009) on oregano; Zaghloul *et al*. (2009) on shrubs Thuja; Mohsen *et al*. (2017) and Abdelkader (2019) on garlic; and Shyala *et al*. (2019) and Shalaby *et al*. (2023) on marigold (*Tagetes erecta*).

For every investigated vegetative growth parameter in both cuttings during the course of the two growing seasons, there was a substantial interaction between the potassium humate and water salinity treatments. Generally, the greatest values were achieved with the interaction treatment of salinized water at 1.4 dS/m in combination with potassium humate at 3000 ppm.

Similar findings were recorded by Burhan and Al-Taey (2018) on dill and Badran *et al*. (2019) on calendula plant.

2. Essential oil productivity:

a. Essential oil percentage:

Data presented in Table (3), indicated that salinized water (1.4 and 2.8 dS/m)

Table 1. Response of plant height and number of branches/plant of *Rosmarinus officinalis* to salinized water and potassium humate treatments in the two cuts during 2022 and 2023 seasons.

Potassium humate treatments (ppm)	Salinized water treatments (dS/m) (A)									
	0.0	**1.2**	**2.8**	**4.2**	**Mean (B)**	**0.0**	**1.2**	**2.8**	**4.2**	**Mean (B)**
			The 1st cut					**The 2nd cut**		
					The first growing season (2022)					
					Plant height (cm)					
Control	26.0	27.2	22.1	19.2	23.6	26.0	27.2	22.1	19.1	23.6
Humic acid 1000	27.2	28.6	23.2	20.2	24.8	27.4	28.9	23.3	20.4	25.0
Humic acid 2000	28.1	29.5	25.3	21.2	26.1	28.6	30.0	25.8	21.5	26.5
Humic acid 3000	28.6	31.5	25.8	21.6	26.9	29.4	32.3	26.5	22.1	27.6
Mean (A)	27.5	29.2	24.1	20.5	25.4	27.8	29.6	24.4	20.8	25.7
L.S.D. at 5%	A: 1.6		B: 0.9	AB: 1.8		A: 1.7		B: 1.1	AB: 2.2	
					Number of branches/plant					
Control	2.9	3.1	2.4	2.1	2.6	3.1	3.3	2.5	2.3	2.8
Humic acid 1000	3.1	3.3	2.5	2.2	2.8	3.2	3.5	2.6	2.4	2.9
Humic acid 2000	3.2	3.4	2.6	2.3	2.9	3.4	3.7	2.8	2.5	3.1
Humic acid 3000	3.4	3.6	2.7	2.5	3.0	3.6	3.8	2.9	2.6	3.2
Mean (A)	3.2	3.4	2.5	2.3	2.8	3.3	3.6	2.7	2.5	3.0
L.S.D. at 5%	A: 0.19		B: 0.08	AB: 0.16		A: 0.23		B: 0.0.4	AB: 0.08	
					The second growing season (2023)					
					Plant height (cm)					
Control	29.9	31.4	25.5	22.1	27.2	30.2	31.7	25.8	22.2	27.4
Humic acid 1000	31.4	32.9	26.7	23.2	28.5	31.9	33.6	27.1	23.7	29.1
Humic acid 2000	32.3	33.9	29.1	24.3	29.9	33.3	34.9	30.0	25.0	30.8
Humic acid 3000	32.9	36.2	29.6	24.8	30.9	34.2	37.6	30.8	25.8	32.1
Mean (A)	31.7	33.6	27.7	23.6	29.1	32.4	34.5	28.4	24.2	29.9
L.S.D. at 5%	A: 2.0		B: 1.0	AB: 2.0		A: 1.9		B: 1.2	AB: 2.4	
					Number of branches/plant					
Control	3.0	3.2	2.4	2.1	2.7	3.3	3.5	2.6	2.4	3.0
Humic acid 1000	3.1	3.4	2.5	2.3	2.8	3.5	3.7	2.8	2.5	3.1
Humic acid 2000	3.3	3.6	2.7	2.4	3.0	3.7	3.9	3.0	2.7	3.3
Humic acid 3000	3.5	3.8	2.8	2.6	3.2	3.9	4.2	3.2	2.9	3.5
Mean (A)	3.3	3.5	2.6	2.3	2.9	3.6	3.8	2.9	2.6	3.2
L.S.D. at 5%	A: 0.20		B: 0.09	AB: 0.18		A: 0.20		B: 0.09	AB: 0.18	

Table 2. Response of herb fresh and dry weights/plant of *Rosmarinus officinalis* to salinized water and potassium humate treatments in the two cuts during 2022 and 2023 seasons.

Potassium humate treatments (ppm)	Salinized water treatments (dS/m) (A)									
	0.0	1.2	2.8	4.2	Mean (B)	0.0	1.2	2.8	4.2	Mean (B)
	The 1st cut					The 2nd cut				
	The first growing season (2022)									
	Herb fresh weight/plant (g)									
Control	11.66	12.23	9.94	8.60	10.60	11.77	12.35	10.05	8.67	10.71
Humic acid 1000	12.26	12.88	10.43	9.08	11.16	12.50	13.14	10.61	9.27	11.38
Humic acid 2000	12.68	13.29	11.41	9.53	11.73	13.06	13.68	11.76	9.80	12.07
Humic acid 3000	12.94	14.21	11.63	9.74	12.13	13.45	14.79	12.09	10.13	12.61
Mean (A)	12.39	13.15	10.85	9.24	11.41	12.69	13.48	11.13	9.47	11.69
L.S.D. at 5 %	A: 0.77		B: 0.45		AB: 0.90	A: 0.80		B: 0.54		AB: 1.08
	Herb dry weight/plant (g)									
Control	6.42	6.72	5.47	4.73	5.83	6.48	6.79	5.53	4.77	5.89
Humic acid 1000	6.75	7.10	5.74	5.01	6.15	6.89	7.24	5.85	5.11	6.27
Humic acid 2000	7.00	7.34	6.30	5.26	6.47	7.21	7.56	6.49	5.41	6.66
Humic acid 3000	7.15	7.86	6.43	5.39	6.70	7.44	8.17	6.68	5.61	6.98
Mean (A)	6.83	7.25	5.99	5.10	6.29	7.00	7.44	6.13	5.22	6.45
L.S.D. at 5%	A: 0.41		B: 0.25		AB: 0.50	A: 0.43		B: 0.30		AB: 0.60
	The second growing season (2023)									
	Herb fresh weight/plant (g)									
Control	10.13	10.62	8.63	7.49	9.22	10.13	10.62	8.63	7.46	9.21
Humic acid 1000	10.65	11.19	9.08	7.89	9.70	10.73	11.30	9.12	7.97	9.78
Humic acid 2000	11.03	11.56	9.91	8.30	10.20	11.22	11.76	10.10	8.41	10.37
Humic acid 3000	11.25	12.37	10.13	8.48	10.55	11.55	12.71	10.40	8.70	10.84
Mean (A)	10.76	11.44	9.44	8.04	9.92	10.91	11.60	9.56	8.13	10.05
L.S.D. at 5%	A: 0.68		B: 0.38		AB: 0.76	A: 0.71		B: 0.45		AB: 0.90
	Herb dry weight/plant (g)									
Control	5.58	5.84	4.75	4.12	5.07	5.58	5.84	4.75	4.11	5.07
Humic acid 1000	5.87	6.16	5.01	4.35	5.35	5.91	6.22	5.03	4.39	5.39
Humic acid 2000	6.09	6.38	5.47	4.59	5.63	6.19	6.49	5.58	4.65	5.72
Humic acid 3000	6.22	6.84	5.61	4.68	5.84	6.39	7.03	5.75	4.81	6.00
Mean (A)	5.94	6.31	5.20	4.43	5.47	6.02	6.40	5.27	4.49	5.55
L.S.D. at 5%	A: 0.37		B: 0.21		AB: 0.42	A: 0.39		B: 0.25		AB: 0.50

Table 3. Response of essential oil (%) and its yield/plant of *Rosmarinus officinalis* to salinized water and potassium humate treatments in the two cuts during 2022 and 2023 seasons.

Potassium humate treatments (ppm)	Salinized water treatments (dS/m) (A)									
	0.0	1.2	2.8	4.2	Mean (B)	0.0	1.2	2.8	4.2	Mean (B)
	The 1st cut					The 2nd cut				
	The first growing season (2022)									
	Essential oil (%)									
Control	1.01	1.15	1.17	0.88	1.05	1.02	1.16	1.18	0.89	1.06
Humic acid 1000	1.06	1.20	1.21	1.00	1.12	1.08	1.22	1.23	1.02	1.14
Humic acid 2000	1.12	1.25	1.27	1.09	1.19	1.14	1.28	1.30	1.11	1.21
Humic acid 3000	1.17	1.32	1.34	1.11	1.23	1.21	1.36	1.38	1.14	1.27
Mean (A)	1.09	1.23	1.24	1.02	1.15	1.11	1.25	1.27	1.04	1.17
L.S.D. at 5%	A: 0.06		B: 0.03		AB: 0.06	A: 0.07		B: 0.03		AB: 0.06
	Essential oil yield (ml/plant)									
Control	0.058	0.069	0.057	0.037	0.055	0.068	0.080	0.067	0.043	0.065
Humic acid 1000	0.064	0.075	0.062	0.044	0.061	0.075	0.090	0.074	0.053	0.073
Humic acid 2000	0.070	0.081	0.072	0.051	0.069	0.083	0.099	0.086	0.061	0.082
Humic acid 3000	0.074	0.092	0.076	0.053	0.074	0.091	0.114	0.094	0.065	0.091
Mean (A)	0.066	0.079	0.067	0.046	0.065	0.079	0.096	0.080	0.056	0.077
L.S.D. at 5%	A: 0.015		B: 0.005		AB: 0.010	A: 0.016		B: 0.007		AB: 0.014
	The second growing season (2023)									
	Essential oil (%)									
Control	1.03	1.17	1.19	0.90	1.07	1.04	1.18	1.20	0.91	1.08
Humic acid 1000	1.09	1.23	1.24	1.03	1.15	1.12	1.26	1.27	1.06	1.18
Humic acid 2000	1.17	1.30	1.32	1.13	1.23	1.20	1.35	1.37	1.17	1.26
Humic acid 3000	1.23	1.39	1.41	1.17	1.29	1.27	1.44	1.46	1.21	1.35
Mean (A)	1.13	1.27	1.29	1.06	1.19	1.16	1.31	1.32	1.09	1.22
L.S.D. at 5%	A: 0.07		B: 0.04		AB: 0.08	A: 0.06		B: 0.04		AB: 0.08
	Essential oil yield (ml/plant)									
Control	0.058	0.07	0.057	0.037	0.056	0.059	0.071	0.058	0.038	0.056
Humic acid 1000	0.065	0.077	0.064	0.046	0.063	0.068	0.080	0.066	0.047	0.065
Humic acid 2000	0.073	0.085	0.074	0.053	0.071	0.075	0.089	0.078	0.055	0.074
Humic acid 3000	0.077	0.097	0.08	0.056	0.078	0.083	0.103	0.085	0.059	0.083
Mean (A)	0.068	0.082	0.069	0.048	0.067	0.071	0.086	0.072	0.050	0.070
L.S.D. at 5%	A: 0.012		B: 0.006		AB: 0.012	A: 0.015		B: 0.007		AB: 0.014

significantly increased the essential oil (%) in the herb in both cuttings throughout both seasons facing the control. In contrast, the essential oil percentage significantly decreased under 4.2 dS/m during both cuttings and seasons relative to irrigation with tab water.

Aziz and Youssef (2001), Tounekti *et al*. (2008), Ali and Attia (2015), Abdelkader *et al*. (2019), Sarmoum *et al*. (2019), El-Kholy *et al*. (2020) on *Rosmarinus officinalis*; Hendawy and Khalid (2005) on *Salvia officinalis* and Baâtour *et al*. (2011) and Mohsen *et al*. (2017) on *Majorana hortensis* highlighted the influence of salinized water on essential oil percentage, concluding that essential oil (%) was significantly lessened by rising salinity level. However, Bidgoli *et al*. (2019) and Al-Fraihat *et al*. (2023) on *Rosmarinus officinalis*, mentioned that essential oil percentage was increased under low salinity concentration. In addition, Hendawy *et al*. (2019) on chamomile observed high essential oil contents under high-salinity stress compared to normal conditions.

In light of the impact of potassium humate, listed data in Table (3) proved that all three used concentrations of potassium humate (1000, 2000 and 3000 ppm) considerably enhanced essential oil percentage compared with untreated plants during both cuts throughout both seasons.

Potassium humate treatments had positive effect on essential oil percentage as reported by Said-Al Ahl *et al*. (2009) on oregano; Zaghloul *et al.* (2009) on shrubs Thuja; Abou-Sreea *et al*. (2017) on coriander; El-Sawy *et al*. (2021) on sweet fennel; Retab *et al*. (2022) on roselle; and Shyala *et al*. (2019) and Shalaby *et al*. (2023) on marigold (*Tagetes Erecta*).

For essential oil percentage, the relationship between the main and subplot treatments was substantial in both cuts during both seasons. The high overall percentages were achieved with plants watered with 1.4 or 2.8 dS/m and sprayed with 3000 potassium humate.

Similar results were reported by Said-Al Ahl and Hussein (2010) on oregano, and Burhan and Al-Taey (2018) on dill.

b. Essential oil yield (ml/plant):

Regarding the effect of water salinity stress, data presented in Table (3) proved that the essential oil yield (ml/plant) in the rosemary herb significantly increased in both cuts during both seasons facing the control (tab water) for 1.4 dS/m. While, under 2.8 dS/m, it was slightly increased, moreover, 4.2 dS/m significantly decreased essential oil yield relative to the control.

The damaging effect of high levels of saline water on essential oil yield was obtained by Aziz and Youssef (2001), Ali and Attia (2015), Abdelkader *et al*. (2019), Sarmoum *et al*. (2019), and El-Kholy *et al*. (2020) on *Rosmarinus officinalis*; Hendawy and Khalid (2005) on *Salvia officinalis* and Baâtour *et al*. (2011) and Mohsen *et al*. (2017) on *Majorana hortensis*.

The data in Table (3) on the effects of potassium humate on essential oil yield showed that when compared to the control, the three potassium humate concentrations (1000, 2000, and 3000 ppm) significantly boosted the output of essential oil. In this sense, the 3000 ppm worked better than the other treatments.

Application of potassium humate increased essential oil yield as proved by Said-Al Ahl *et al*. (2009) on oregano; Zaghloul *et al.* (2009) on Thuja; Abou-Sreea *et al*. (2017) on coriander; El-Sawy *et al*. (2021) on sweet fennel; and Shyala *et al*. (2019) and Shalaby *et al*. (2023) on marigold (*Tagetes Erecta*).

In both cuttings over both seasons, there was a substantial interaction between the salinized water and potassium humate treatments on essential oil yield/plant. In every instance, plants that were treated with 2000 or 3000 ppm potassium humate and watered by 1.4 dS/m had the highest values.

Similar findings were recorded by Said-Al Ahl and Hussein (2010) on oregano; Burhan and Al-Taey (2018) on dill, Badran *et al*. (2019) on calendula plant, and Reyes-Pérez *et al*. (2021) on basil.

3. Chemical constituents:

a. Chlorophylls and N, P and K%:

Data displayed in Tables (4 and 5) demonstrated that irrigation water salinity at 1.4 dS/m during the second cut throughout both seasons confronting the control resulted in a significant enhancement of photosynthetic pigments content (carotenoids, chlorophyll a, and chlorophyll b) and NPK%. Conversely, relative to controls, irrigated plants with 2.8 and 4.2 dS/m dramatically decreased the aforementioned metrics in the second cut of both experimental seasons.

Salinity stress has been found to have detrimental impacts on photosynthetic pigments and NPK% as mentioned by Aziz and Youssef (2001), Tounekti *et al*. (2011), Langroudi and Sedaghathoor (2012), Chetouani *et al*. (2019), and El-Kholy *et al*. (2020) on rosemary; Nazarbeygi *et al*. (2011) on canola plants; and Kamkari *et al*. (2016) on pot marigold.

Table 4. Response of photosynthetic pigments of *Rosmarinus officinalis* fresh leaves to salinized water and potassium humate treatments in the second cut during 2022 and 2023 seasons.

Potassium humate treatments (ppm)	Salinized water treatments (dS/m) (A)									
	0.0	1.2	2.8	4.2	Mean (B)	0.0	1.2	2.8	4.2	Mean (B)
	The first growing season (2022)					The second growing season (2023)				
	Chlorophyll a (mg/g f.w.)									
Control	3.068	3.223	3.062	2.908	3.065	3.167	3.326	3.160	3.002	3.163
Humic acid 1000	3.283	3.447	3.119	3.093	3.235	3.388	3.557	3.219	3.193	3.340
Humic acid 2000	3.447	3.653	3.288	3.124	3.378	3.557	3.771	3.394	3.224	3.487
Humic acid 3000	3.619	3.800	3.420	3.250	3.522	3.772	3.960	3.565	3.387	3.671
Mean (A)	3.346	3.521	3.213	3.086	3.292	3.471	3.653	3.334	3.202	3.415
L.S.D. at 5%	A: 0.105		B: 0.070		AB: 0.140	A: 0.115		B: 0.095		AB: 0.190
	Chlorophyll b (mg/g f.w.)									
Control	1.019	1.074	1.020	0.969	1.021	1.053	1.108	1.054	1.001	1.054
Humic acid 1000	1.094	1.150	1.038	0.987	1.067	1.129	1.186	1.072	1.018	1.102
Humic acid 2000	1.150	1.205	1.085	1.030	1.117	1.186	1.244	1.120	1.063	1.153
Humic acid 3000	1.206	1.266	1.140	1.083	1.174	1.257	1.320	1.188	1.128	1.223
Mean (A)	1.114	1.171	1.068	1.014	1.092	1.156	1.214	1.108	1.053	1.133
L.S.D. at 5%	A: 0.038		B: 0.030		AB: 0.060	A: 0.055		B: 0.035		AB: 0.070
	Carotenoids (mg/g f.w.)									
Control	1.012	1.094	1.041	0.989	1.034	1.025	1.106	1.053	1.001	1.046
Humic acid 1000	1.113	1.168	1.058	1.005	1.086	1.127	1.182	1.071	1.016	1.099
Humic acid 2000	1.169	1.225	1.104	1.051	1.137	1.183	1.240	1.118	1.062	1.151
Humic acid 3000	1.227	1.287	1.159	1.103	1.194	1.241	1.301	1.173	1.115	1.207
Mean (A)	1.127	1.191	1.088	1.034	1.109	1.144	1.207	1.103	1.049	1.126
L.S.D. at 5%	A: 0.035		B: 0.030		AB: 0.060	A: 0.038		B: 0.030		AB: 0.060

Table 5. Response of nitrogen, phosphorus and potassium (%) of *Rosmarinus officinalis* dry leaves to salinized water and potassium humate treatments in the second cut during 2022 and 2023 seasons.

Potassium humate treatments (ppm)	Salinized water treatments (dS/m) (A)									
	0.0	1.2	2.8	4.2	Mean (B)	0.0	1.2	2.8	4.2	Mean (B)
	The first growing season (2022)					The second growing season (2023)				
	Nitrogen (%)									
Control	2.349	2.470	2.208	2.098	2.281	2.377	2.499	2.234	2.124	2.309
Humic acid 1000	2.467	2.590	2.319	2.203	2.395	2.521	2.647	2.370	2.251	2.447
Humic acid 2000	2.615	2.745	2.458	2.335	2.538	2.698	2.833	2.536	2.410	2.620
Humic acid 3000	2.798	2.940	2.630	2.499	2.717	2.916	3.063	2.741	2.604	2.831
Mean (A)	2.557	2.686	2.404	2.284	2.482	2.582	2.713	2.427	2.307	2.508
L.S.D. at 5%	A: 0.130	B: 0.094	AB: 0.188			A: 0.142	B: 0.115	AB: 0.230		
	Phosphorus (%)									
Control	0.244	0.259	0.230	0.208	0.235	0.246	0.262	0.232	0.210	0.237
Humic acid 1000	0.256	0.271	0.240	0.217	0.246	0.259	0.274	0.243	0.220	0.249
Humic acid 2000	0.269	0.284	0.253	0.227	0.259	0.273	0.290	0.258	0.232	0.264
Humic acid 3000	0.282	0.299	0.265	0.238	0.271	0.291	0.309	0.273	0.246	0.279
Mean (A)	0.263	0.278	0.247	0.222	0.253	0.266	0.281	0.250	0.224	0.255
L.S.D. at 5%	A: 0.008	B: 0.006	AB: 0.012			A: 0.009	B: 0.008	AB: 0.016		
	Potassium (%)									
Control	2.265	2.401	2.129	2.001	2.199	2.287	2.432	2.161	2.045	2.231
Humic acid 1000	2.378	2.522	2.270	2.133	2.326	2.402	2.554	2.304	2.181	2.360
Humic acid 2000	2.498	2.648	2.383	2.240	2.442	2.523	2.682	2.419	2.289	2.478
Humic acid 3000	2.622	2.780	2.502	2.353	2.565	2.675	2.817	2.539	2.405	2.609
Mean (A)	2.441	2.588	2.321	2.182	2.383	2.466	2.614	2.344	2.204	2.407
L.S.D. at 5%	A: 0.102	B: 0.015	AB: 0.030			A: 0.110	B: 0.017	AB: 0.034		

As demonstrated in Tables (4 and 5), data on the impact of potassium humate spraying at 1000, 2000, and 3000 ppm revealed that pigment contents and NPK% were significantly raised in the second cut throughout both seasons. Spraying plants with 3000 ppm potassium humate produced the highest contents overall.

Comparable outcomes were attained by Zaghloul *et al.* (2009) on *Thuja orientalis*; Abou-Sreea *et al*. (2017) on coriander plant; Shyala *et al*. (2019) and Shalaby *et al*. (2023) on marigold (*Tagetes erecta*); El-Sawy *et al*. (2021) on sweet fennel; and Retab *et al*. (2022) on roselle.

The interaction effect between the two variables treatments was significant for photosynthetic pigments (chlorophyll a, b and carotenoids) as well as NPK% in the second cut during the two seasons (Tables, 4 and 5). The interaction treatment of 1.4 dS/m with 3000 ppm potassium humate produced the highest values.

Close results were obtained by Burhan and Al-Taey (2018) on dill, Badran *et al*. (2019) on calendula plant, and Reyes-Pérez *et al*. (2021) on basil plant.

b. Sodium (%) and proline content (µg/g):

The findings in Table (6) showed that, in contrast to the prior chemical components, salinized water (1.4, 2.8, and 4.2 dS/m) considerably increased the proline content (µg/g) and sodium (%) in both seasons relative to the control treatment.

These outcomes are in the line with those noted by Aziz and Youssef (2001), Langroudi and Sedaghathoor (2012), Chetouani *et al*. (2019) Al-Fraihat *et al*. (2023) on *Rosmarinus officinalis*; Hendawy and Khalid (2005) on sage plant and Nazarbeygi *et al*. (2011) on canola plants

According to Table (6), potassium humate treatments were beneficial in lowering the proline content (µg/g) and Na (%) relative to untreated plants in the second cut during the two seasons. It has been observed that the application of a high concentration of potassium humate (3000 ppm) proved to be more efficacious than that of 2000 or 1000 ppm.

Said-Al Ahl *et al*. (2009) on oregano and Mohsen *et al*. (2017) on marjoram produced findings that were comparable.

For both Na (%) and proline (µg/g) in the second cut throughout the two experimental seasons, there was a substantial interaction between the salinized water and potassium humate treatments. Plants that were watered with 4.2 dS/m without any humic acid spray throughout both seasons had the greatest amounts of Na and proline. Conversely, the plants that were sprayed with 3000 ppm potassium humate and watered with tab water had the lowest values of both features.

Many authors stated that salt stress increased Na concentration and proline content and found that potassium humate ameliorate the harmful impacts of salinity, such as Burhan and Al-Taey (2018) on dill, Hassan (2019) on caraway, Hegazy *et al*.

Table 6. Response of sodium (%) and proline content (µg/g) of Rosmarinus officinalis dry leaves to salinized water and potassium humate treatments in the second cut during 2022 and 2023 seasons.

Potassium humate treatments (ppm)	Salinized water treatments (dS/m) (A)									
	0.0	1.2	2.8	4.2	Mean (B)	0.0	1.2	2.8	4.2	Mean (B)
	The first growing season (2022)					The second growing season (2023)				
	Sodium (%)									
Control	1.843	1.954	2.091	2.279	2.042	1.862	1.974	2.112	2.302	2.063
Humic acid 1000	1.751	1.837	1.966	2.142	1.924	1.772	1.858	1.989	2.168	1.947
Humic acid 2000	1.646	1.744	1.868	2.035	1.824	1.670	1.769	1.894	2.064	1.849
Humic acid 3000	1.581	1.675	1.793	1.954	1.751	1.615	1.712	1.833	1.997	1.789
Mean (A)	1.705	1.802	1.930	2.103	1.886	1.723	1.821	1.949	2.124	1.904
L.S.D. at 5%	A: 0.095		B: 0.040		AB: 0.080	A: 0.098		B: 0.023		AB: 0.046
	Proline content (µg/g)									
Control	252.8	268.5	283.2	308.7	278.3	255.8	271.5	286.2	311.6	281.3
Humic acid 1000	238.1	253.8	266.6	290.1	262.6	243.0	258.7	271.5	296.0	267.5
Humic acid 2000	223.4	240.1	249.9	272.4	247.0	230.3	247.0	257.7	280.3	253.8
Humic acid 3000	205.8	220.5	226.4	235.2	222.5	213.6	229.3	235.2	245.0	231.3
Mean (A)	230.3	246.0	256.8	276.4	251.9	232.3	247.9	258.7	279.3	254.8
L.S.D. at 5%	A: 11.0		B: 7.0		AB: 14.0	A: 13.0		B: 9.0		AB: 18.0

(2021) on *Salvia officinalis* and Reyes-Pérez *et al*. (2021) on basil plant.

DISCUSSION

Salinity reduces leaf water potential and modifies a number of metabolic processes, including ionic imbalances, changes in solute buildup, and the inhibition of enzyme activity, all of which impede growth (Vinocur and Altman, 2005; Munns *et al*., 2006). Reactive oxygen species have been shown to cause oxidative damage to plant cells under salt stress, which can lower plant yield (Azevedo-Neto *et al*., 2006). Proline accumulation in plants under salt stress may be the cause of the notable rise in proline content seen in water as NaCl concentration rose (Ali and Attia, 2015). Soliman *et al*. (2018) suggested that salinity tolerance and avoidance mechanisms contribute towards salinity resistance, and that variation in salinity stress resistance is attributed to differences in proline content.

When applied as an organic potash (K) fertilizer, potassium humate may provide plants with large, easily absorbed amounts of soluble potassium, allowing them to quickly absorb and use potassium within their tissues. Plant growth and productivity are enhanced by potassium humate due to its improvements in photosynthesis, chlorophyll density, and plant root respiration (Hashish *et al*., 2015 and Shajari *et al*., 2016).

CONCLUSION

It is possible to draw the conclusion that potassium humate can boost growth and production under normal conditions in addition mitigating the harmful effects of saline water.

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تأثير هيومات البوتاسيوم علي نباتات الحصالبان النامية في الأرض الرملية تحت الري بماء مالح

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لإختبار قدرة هيومات البوتاسيوم (٠ ، ١٠٠٠ ، ٢٠٠٠ ، ٣٠٠٠ جزء في المليون) علي تقليل الآثار الضارة لماء الري المملح (ماء الصنبور ، ١,٤ ، ٢,٨ ، ٤,٢ ديسيسيمنز/متر) علي نباتات الحصالبان، أجريت تجربة أصص بمشتل نباتات الزينة، كلية الزراعة، جامعة المنيا، خلال موسمي ٢٠٢٢ و ٢٠٢٣. أظهرت النتائج أن جميع الصفات المختبرة للنمو الخضري (ارتفاع النبات، عدد الأفرع/نبات، والأوزان الطازجة والجافة للعشب) قد انخفضت بزيادة مستوي الملوحة (٢,٨ و ٤,٢ ديسيسيمنز/متر) مقارنة بالكنترول في الحشتين خلال موسمي النمو. وفي الاتجاه المضاد، وُجد أن الصفات المذكورة قد زادت مع المستوى المنخفض من الملوحة (١,٤ ديسيسيمنز/متر). وقد وُجد أن النسبة المئوية للزيت وإنتاجية الزيت الطيار قد زادت مع تركيزات (١,٤ و ٢,٨ و ديسيسيمنز/متر)، فقد انخفضا معنوياً تحت تركيز (٤,٢ ديسيسيمنز/متر) مقارنة بالكنترول في الحشتين خلال موسمي النمو. والمحتوي من الصبغات والنسبة المئوية للنيتروجين، الفوسفور والبوتاسيوم قد أخذت نفس اتجاه صفات النمو الخضري، بينما النسبة المئوية للصوديوم ومحتوي البرولين (ملجم/جم) في الأوراق الجافة قد زادا نتيجة لارتفاع تركيز الملوحة في الحشة الثانية خلال موسمي النمو. كل الصفات المدروسة للنمو الخضري وإنتاجية الزيت الطيار، وكذلك العديد من المكونات الكيميائية المذكورة أعلاه، قد تحسنت معنوياً نتيجة معاملات هيومات البوتاسيوم، ماعدا النسبة المئوية للصوديوم والمحتوى من البرولين (ملليجم/جم) في الأوراق الجافة خلال موسمي النمو. وفي هذاالشأن، تركيز ٣٠٠٠ جزء في المليون من هيومات البوتاسيوم كان أكثر تأثيراً. وكان تأثير التداخل معنوياً لكل الصفات المدروسة، مع أفضل معاملة تداخل هي الري بماء مملح (١,٤ ديسيسمنز/متر) مع الرش بهيومات البوتاسيوم (٣٠٠٠ جزء في المليون). ويمكن تلخيص أن التأثير السلبي للملوحة من الممكن تقليله برش النبات بهيومات البوتاسيم بتركيز ٣٠٠٠ جزء في المليون.