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Response of Anise Plant to Arginine Under Different Saline Irrigation Water Levels

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Abstract: Salinity is one of the most crucial variables that limits crop productivity and quality. A field experiment was conducted in 2020/2021 and 2021/2022 to evaluate the efficiency of foliar application of arginine on reducing the harmful effects of saline irrigation water on anise plants. Anise plants were irrigated with various water salinity levels 1664, 2000, 2500, 3000 and 3500 ppm, the plant were sprayed with different rates of arginine *i.e.* 0, 100, 200 and 300 ppm. Salinity treatments decreased growth characteristics, fruits yield and nutrient contents. Salinity promoted the accumulation of volatile oil and its major component (Anethole). Spray application of arginine at rate 100 ppm was less effective on growth characteristics, fruits and oil yield under high salinity levels (3000 and 3500 ppm). However, the foliar application of arginine at rate 300 ppm resulted in positive increases in growth, fruits yield, essential oil yield and chemical constituents of anise under different saline irrigation levels, subsequently reduced the harmful effect of salinity.

Key words: Anise (*Pimpinella anisum* L.), saline irrigation water, essential oil, fruit yield, chemical constituents.

INTRODUCTION

Anise, *Pimpinella anisum* L (Family, Apiaceae). is one of the common and important medicinal plants cultivated in Egypt and is considered as a source of raw material for the cosmetic, perfumery, pharmaceutics and food industries **(Das *et al.*, 2021).** In recent years, anise has gained more popularity and value as an antifungal, antimicrobial, insecticidal, and antioxidant **(Tirapelli *et al.*, 2007).** Anise seeds contain approximately 1.5 - 3.5% volatile oil primarily composed of trans-anetholes and cis-anetholes. Transanethole, the main component of anise, is used in the synthesis of various pharmaceuticals **(Kosalec *et al.*, 2005).**

Salinity is the most serious water quality problem in agriculture. Water salinity is an environmental stress factor that inhibits growth and yield of different crops in many regions of the world. Throughout the world, more than 800 million ha of land are salt-affected **(FAO, 2008).**

The effect of salinity on crops production is becoming increasingly important worldwide problem creating a pressing need for improved salt tolerant plants. Many researchers from throughout the world have noted that salinity inhibits seed germination, plant growth, nutrient intake, and metabolism. **(Balasubramaniam *et al.*, 2023).** Crops vary in their ability to tolerate salinity, so research into the tolerance of various plants for salinity and the potential alterations in their physiological activity under saline irrigation necessary.

Different physiological and biochemical traits are influenced by salinity in different ways, such as reducing water uptake, causing osmotic stress, and increasing respiration rate. The accumulation of Na^+ and Cl^- ions caused cytotoxicity, nutritional imbalance, and excessive production of reactive oxygen species (ROS) which led to oxidative stress. **(Roy *e. al.*, 2014).** ROS caused damage to macromolecules, such as proteins, lipids, nucleic acids. **(Hasan *et al.*, 2020).** Plants have defense systems that maintain ROS concentrations substantially lower to prevent their damaging effects. The antioxidant and glyoxalase systems are the mechanisms that eliminate ROS **(Hasanuzzaman *et al.*, 2014)**.

The mechanisms of salt tolerance in plants have been the focus of recent investigations **(Munns and Tester, 2008).** One of the essential amino acids is arginine, which is also the main precursor of polyamines (putrescine is formed when arginine is decarboxylated by the enzyme arginine decarboxylase). Polyamines and their precursor arginine have been implicated as vital modulators in a variety of growth, physiological and developmental processes in higher plants**.** Cell cycle, cell division, morphogenesis in phytochrome and plant hormone-mediated processes, control of plant senescence, and plant response to various stress stimulus are all regulated by polyamines. **(Ramadan *et al.*, 2019).**

Therefore, the main objective of this study was to evaluate the role of Arginine on mitigating the harmful effect of salinity on growth characteristics, Fruits yield and essential oil content as well as some chemical characteristics of Anise plant.

MATERIAL AND METHODS

The present study was carried out during the two successive seasons; 2020/2021 and 2021/2022 at Ali Mubarak Experimental Farm, located in Bustan region, El-Beheira Governorate, Egypt (coordinates 33°30' 1.4"N latitude and 30°19' 10.9"E longitude, 21 m MSL) to investigate the effect of different arginine rates on vegetative growth, fruit yield, oil production and chemical composition of anise (*Pimpinella anisum* L.) plants under different saline irrigation water levels.

Treatments

Saline irrigation water treatments:

1. S1 (Farm water well) 1664 ppm.
2. S2 2000 ppm.
3. S3 2500 ppm.
4. S4 3000 ppm.
5. S5 3500 ppm.

Arginine treatments:

1. A0 Control (without Arginine).
2. A1 100 ppm.
3. A2 200 ppm.
4. A3 300 ppm.

Plants were sprayed during vegetative growth (at 45, 60 and 75 days after sowing).

Soil preparation and all culture practices (irrigation, fertilization and weed control) were carried at according to the recommended practices of **MALR (2004)**.

Fruits of *Pimpinella anisum* L. plant were obtained from Agricultural Research Station in Assiut, Governorate, Egypt. Fruits were sown on 15^{th} and 17^{th} October 2020/2021 and 2021/2022, at distances of 25 cm between hills (thinned to be two plants/hill) and 75 cm between rows. Drip irrigation system was applied in the whole experiment using droppers (4 l/h) for one hour every 3 days, salinity solution treatments were applied through vacuum injection according to the method described by **Dehghanisanij *et al.* (2007)** as shown in Fig. 1.

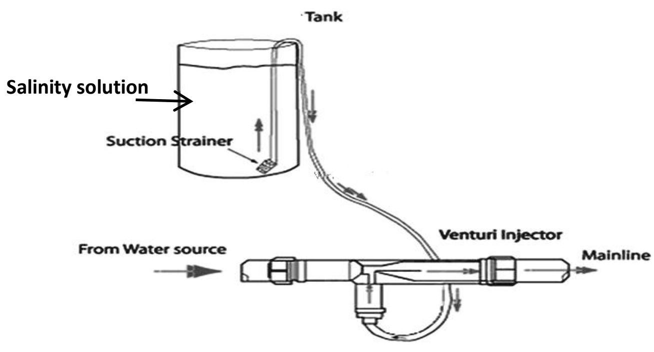

Fig.1. Addition of salt levels to irrigation water with venturi injector

Saline irrigation treatments were prepared by dissolving NaCl, $MgCl_2$ and $CaCl_2$ at ratio of 9:2:1 which identical to the same ratio of farm water well.

Soil and water well analyses of the experimental farm are shown in Tables (1 and 2). Both soil and water samples were analyzed in Soil, Water and Environment Research Institute.

Table (1). Chemical and physical analysis of the soil at experimental field

Physical properties	
Soil layer depth (cm)	0-30
Texture	Sandy
Course sand (%)	48.66
Fine sand (%)	48.83
Silt+ clay (%)	2.51
Field Capacity (%)	13.0
Wilting Point (%)	4.6
Available water (%)	8.3
Bulk density (t m^{-3})	1.69
Chemical properties	
$EC_{1:5}$ (dS m^{-1})	0.45
pH (1:2.5)	8.60
Total $CaCO_3$ (%)	7.00

Table (2). Chemical properties of farm water well

Sample		pH	ECw		Milliequivalent/liter						
					Cations				Anions		
			ppm	dS/m	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Cl^{-}	CO_3^{--}	HCO_3^{-}
1		7.78	1664	2.60	4.00	3.60	18.01	0.32	17.20	*	5.20
Limits	Low	<7.3		<0.75			<1		<1		
	Normal	7.3-7.8		0.75-1.25			1-3		1-3		
	High	7.8<		>1.25			3<		3<		
	Sample			Ppm							
	1			Fe			Mn				Cu
	Max.Concentration			2.35			*				1.10
				5.00			0.20				0.20

This experiment was designed using a split plot design, with 20 treatment combinations (4 Arginine treatments × 5 salinity treatments, including the control). The salinity treatments were assigned to the main plots in a randomized complete blocks design with three replicates, while the arginine treatments were assigned to the sub-plots.

Anise plants were harvested in 5th April for the first season and 13th April for the second season.

Growth characteristics recorded were: Plant height (cm), number of shoots, dry plant weight (g), dry weight of roots (g) and root length (cm).

Crop yield characteristics were: Weight of 1000 fruit (g), fruits yield/plant (g) and fruits yield/feddan (kg).

Oil productivity: Essential oil content was carried out according to the method of **ASTA (1985).** Oil yield/plant (ml) and oil yield/fed. (l) were also determined.

GC/MS Analysis of Essential oil: The GC-MS system (Agilent Technologies) was equipped with gas chromatograph (7890B) and mass spectrometer detector (5977A) at Central Laboratories Network, according to **(Adams, 2007)**

Chemical composition of fruits at harvest: The Kjeldahl method of **(Pirie, 1955)** was used to determine the total nitrogen and protein levels. The method described by Chapman and **Pratt (1978)** was used to determine the amounts of the nutrients K, Na, Cl, and P in seeds.

RESULTS AND DISCUSS

Effect of saline irrigation levels and arginine rates on growth characters of anise plants

Results in Table (3) indicate proportional decrease in all growth characteristics *i.e.* (plant height, shoots number, dry weight of plant, root length and root weight) with the increase in saline water irrigation in both seasons. The minimum level of salinity 1664 ppm (farm water well) recorded the highest values of plant height (57.32 and 80.24 cm), shoots number (11.13 and 14.47), dry weight of root (7.12 and 8.54 g) and root length (9.27 and 12.13 cm) in the first and the second seasons, respectively. It was observed that irrigation with saline water had non-significant between S1 (farm water well, 1664 ppm) and S2 (2000 ppm). The highest reduction of plant growth parameters was recorded with S3, S4 and S5 compared to S1 and S2. The maximum salinity level (3500 ppm) distinguished significant decrease in all growth characteristics, as it gave the lowest values of plant height (32.69 and 35.63 cm), shoot number (6.58 and 7.17), plant dry weight (66.68 and 52.50 g), dry weight of roots (3.19 and 3.28 g) and root length (3.70 and 4.23 cm).

The reduction in vegetative growth caused by the maximum salinity level is in accordance with previous investigators **(Mohamedin *et al.*, 2006)** on sunflower, **(Mousa *et al.*, 2020)** and **(Safwat and Abdel Salam, 2022)** on basil plants, **(Said and Mohammed, 2023)** on Cumin plants

The efficacy of arginine in reducing the harmful effect of salinity on growth characteristics indicate in Table (3). spraying arginine at rate (100 ppm) have low efficacy on growth characteristics such as plant height (41.28 and 51.10 cm), shoots number (8.29 and 9.87), dry weight of plant (97.87 and 74.23 g), dry weight of roots (5.34 and 5.80 g) and root length (6.74 and 8.31 g) in the first and the second seasons, respectively. while, plants treated with A3 (300 ppm) produced highest values of plant height (59.20 and 74.48 cm), number of shoots (10.52 and 12.69 shoots/plant), dry weight g/plant (175.22 and 131.34 g/plant), dry weight of roots (6.89 and 7.48 g) and root length (8.47 and 10.81 cm) in two seasons, respectively), compared to in the control and the other two rates of arginine A2 and A1 in two seasons.

The results indicated in Table (3) that, promotion effect was recorded in growth parameters of anise plants sprayed by arginine under different saline irrigation water levels. Spray application of arginine at rate 100 ppm was less effective on growth characteristics under saline irrigation at level (3500 ppm) with values of plant height (29.52 and 32.18 cm), shoots number (6.35 and 6.93), dry weight of plant (58.29 and 45.90 g), dry weight of roots (2.69 and 2.77 g) and root length (3.95 and 3.79 cm) in the first and the second seasons, respectively. On the other hand, the highest values of growth characteristics, such as plant height (73.48 and 102.88 cm), shoots number (13.34 and 17.34), dry weight of plant (253.40 and 181.00 g), dry weight of roots (8.92 and 10.70 g) and root length (11.05 and 14.70 cm) were recorded in those plants irrigated with S1 (farm water well, 1664 ppm) and sprayed by A3 (300 ppm), followed by saline irrigation at level 2000 ppm with sprayed with A3 (300 ppm) followed by saline irrigation water at level 2500 ppm with the same rate of Arginine (A3). It was observed that, there was non-significant effect between S2 and S3 in most growth characteristics. The role of arginine in reducing salinity effect attributed to increases the level of some plant hormones such as auxins and cytokines which are necessary for cell division and elongation **(Shahin *et al.*, 2010).** Also, arginine is an important in regulating nutrient absorption, stomatal cloture and synthesis of creatine, polyamines, proline and nitric oxide (NO) **(Saklaabutdinova *et al.*, 2003).**

Effect of saline irrigation water levels and arginine rates on crop productivity of anise plants

Fruits yield g/plant, kg/fed and weight of 1000 fruit (g) of anise plants were significantly decreased as salinity of irrigation water increased in Table (4).

The reduction of seed yield may be due to the gradual decrease in the vegetative growth (plant length, leaf number and dry weight /plant) of anise plants. The lowest values of seed yield g/plant (13.16 and 13.41 g/plant) and (289.56 and 295.35 kg/fed.) were observed by the highest salinity level S5 compared to (22.83 and 26.95 g/plant) and (509.65 and 592.95 kg/fed.) when irrigated with S1 (farm water well 1664 ppm) as control or compared to (22.21 and 25.85 g/plant and 488.44 and 568.61 kg/fed.) when irrigated with S2 (2000 ppm) in both seasons. However, it was observed that, there is insignificant effect between S1 and S2. Weight of 1000 seed was significantly affected by salinity stress. The highest weights of 1000 seed 0.48 and 0.58 g were recorded from the control treatment S1 (farm water well), and the lowest weights of 1000 seed were 0.26 and 0.29 g with S5 (3500 ppm) in the two season, respectively. No significant differences were recorded between the control treatment S1 and treatment S2. Similar results were obtained by **(Saad-Allah, 2015 and Sadak *et. al*., 2020).** High salinity had effect on plants can be observed at the whole-plant level as the death of plants and decreases the productivity **(Parida and Das, 2005).** In fennel, cumin and *ammi majus* increasing salt concentrations caused a significant reduction in the number of umbels, fruit yield/plant and weight of 1000 seed **(Abd El Wahab, 2006; Nabizadeh, 2002 and Ashraf *et. al.*, 2004)**. Similar reductions in seed yield and yield components per plant were obtained on Milk thistle and *Trachyspermum ammi* **(Ghavami and Ramin, 2008 and Ashraf and Orooj, 2006).**

Table (3). Effect of saline irrigation water levels and arginine rates on vegetative growth of o anise plants during 2020/ 2021 and 2021/2022 seasons

Arginine ppm (A)	First season Plant height (cm) Salinity levels (ppm) (S)						Second season Plant height (cm) Salinity levels (ppm) (S)					
	S1	S2	S3	S4	S5	Mean	S1	S2	S3	S4	S5	Mean
A0 (0ppm)	42.46	43.45	38.31	34.46	25.16	36.77	59.44	56.49	45.97	37.91	27.43	45.45
A1 (100 ppm)	49.13	48.85	42.24	36.67	29.52	41.28	68.79	63.50	50.69	40.34	32.18	51.10
A2 (200 ppm)	64.18	60.71	49.83	40.34	34.75	49.96	89.86	78.93	59.80	44.37	37.87	62.17
A3 (300 ppm)	73.48	70.42	67.44	43.33	41.34	59.20	102.88	91.55	85.27	47.66	45.06	74.48
Mean	57.32	55.86	49.46	38.70	32.69		80.24	72.62	60.43	42.57	35.63	
LSD (0.05)	S = 4.44 A=6.45 S×A= 14.69						S= 5.54 A=4.13 S×A= 9.24					
	Number of shoots						Number of shoots					
	S1	S2	S3	S4	S5	Mean	S1	S2	S3	S4	S5	Mean
A0 (0ppm)	8.35	7.93	6.88	6.05	5.83	7.01	10.86	9.51	8.26	6.66	6.35	8.33
A1 (100 ppm)	10.36	10.41	7.28	7.03	6.35	8.29	13.46	12.49	8.74	7.73	6.93	9.87
A2 (200 ppm)	12.48	12.06	8.28	7.38	6.37	9.31	16.22	14.48	9.94	8.11	6.94	11.14
A3 (300 ppm)	13.34	12.69	10.66	8.16	7.75	10.52	17.34	15.23	13.44	8.98	8.45	12.69
Mean	11.13	10.77	8.28	7.15	6.58		14.47	12.93	10.10	7.87	7.17	
LSD (0.05)	S= 1.15 A=0.83 S×A= 2.49						S= 1.38 A=0.97 S×A=2.17					
	Dry weight (g/plant)						Dry weight (g/plant)					
	S1	S2	S3	S4	S5	Mean	S1	S2	S3	S4	S5	Mean
A0 (0ppm)	91.56	83.84	80.18	75.27	45.64	75.30	65.40	64.49	61.68	59.27	35.93	57.35
A1 (100 ppm)	142.19	111.63	94.23	82.99	58.29	97.87	101.56	85.87	72.48	65.35	45.90	74.23
A2 (200 ppm)	203.79	154.23	137.04	112.41	61.55	133.80	145.56	118.64	105.42	88.51	48.47	101.32
A3 (300 ppm)	253.40	210.66	187.82	123.00	101.22	175.22	181.00	162.05	137.10	96.85	79.70	131.34
Mean	172.73	140.09	124.82	98.42	66.68		123.38	107.76	94.17	77.49	52.50	
LSD (0.05)	S=18.11 A=11.57 S×A= 25.88						S= 11.35 A= 14.24 S×A= 32.41					
	Dry weight of root (g)						Dry weight of root (g)					
	S1	S2	S3	S4	S5	Mean	S1	S2	S3	S4	S5	Mean
A0 (0ppm)	5.43	4.55	4.51	3.53	2.26	4.05	6.52	5.00	4.65	3.56	2.33	4.41
A1 (100 ppm)	6.53	7.03	6.00	4.43	2.69	5.34	7.84	7.74	6.18	4.48	2.77	5.80
A2 (200 ppm)	7.58	7.07	6.21	5.26	3.52	5.93	9.10	7.78	6.40	5.32	3.63	6.44
A3 (300 ppm)	8.92	7.66	7.61	5.98	4.27	6.89	10.70	8.43	7.84	6.04	4.40	7.48
Mean	7.12	6.58	6.08	4.80	3.19		8.54	7.24	6.27	4.85	3.28	
LSD (0.05)	S= 0.89 A= 0.85 S×A=1.94						S= 0.94 A=0.73 S×A=1.65					
	Root length (cm)						Root length (cm)					
	S1	S2	S3	S4	S5	Mean	S1	S2	S3	S4	S5	Mean
A0 (0ppm)	7.23	6.22	5.68	5.33	4.16	5.73	9.40	8.08	6.82	5.87	4.54	6.94
A1 (100 ppm)	8.61	7.75	7.55	5.83	3.95	6.74	11.86	10.74	8.39	6.75	3.79	8.31
A2 (200 ppm)	10.17	8.85	8.10	7.68	3.40	7.64	12.55	12.51	10.38	8.79	3.98	9.64
A3 (300 ppm)	11.05	10.57	9.36	8.10	3.27	8.47	14.70	14.07	11.44	9.24	4.62	10.81
Mean	9.27	8.35	7.67	6.74	3.70		12.13	11.35	9.26	7.66	4.23	
LSD (0.05)	S= 0.27 A=0.15 S×A= 0.34						S=0.29 A=0.22 S×A= 0.44					

*S1(1600 ppm), S2 (2000 ppm), S3 (2500 ppm), S4 (3000 ppm) and S5 (3500 ppm), A0= without Arginine, A1= Arginine at rate 100 ppm, A2=Arginine at rate 200 ppm, A3=Arginine at rate 300 ppm

Table (4). Effect of saline irrigation water levels and arginine rates on crop productivity of anise plants during 2020/ 2021 and 2021/2022 season.

Arginine ppm (A)	First season Fruits yield/plant (g)						Second season Fruits yield/plant (g)					
	Saline irrigation water levels (ppm) (S)						Saline irrigation water levels (ppm) (S)					
	S1	S2	S3	S4	S5	Mean	S1	S2	S3	S4	S5	Mean
A0 (0ppm)	17.27	16.35	14.63	8.59	7.48	12.86	20.72	19.62	16.10	9.02	7.63	14.62
A1 (100 ppm)	21.89	21.37	19.01	14.67	13.62	18.11	26.27	25.64	20.91	15.40	13.89	20.42
A2 (200 ppm)	24.54	24.15	20.95	16.83	14.83	20.26	29.45	28.98	23.05	17.68	15.13	22.86
A3 (300 ppm)	27.60	26.95	25	18.46	16.72	22.95	31.37	29.14	27.89	19.39	17.05	25.32
Mean	22.83	22.21	19.90	14.64	13.16		26.95	25.85	21.99	15.37	13.42	
LSD (0.05)	S=1.53 A= 1.26 S×A= 2.46						S=1.57 A=1.39 S×A=2.41					
	Fruits yield/fed. (kg)						Fruits yield/fed. (kg)					
	S1	S2	S3	S4	S5	Mean	S1	S2	S3	S4	S5	Mean
A0 (0ppm)	409.87	359.70	321.93	188.98	164.56	289.01	455.84	431.64	354.13	198.43	167.85	321.58
A1 (100 ppm)	481.58	470.07	418.29	322.70	299.57	398.44	577.90	564.08	460.12	338.88	305.56	449.31
A2 (200 ppm)	539.95	531.07	460.90	370.33	326.26	445.70	647.94	637.65	506.99	388.85	332.79	502.84
A3 (300 ppm)	607.20	592.9	550	406.19	367.84	504.83	690.14	641.08	613.58	426.50	375.20	556.99
Mean	509.65	488.44	437.78	322.05	289.56		592.95	568.61	483.70	338.16	295.35	
LSD (0.05)	S=37.02 A=22.69 S×A=45.99						S=31.52 A=20.19 S×A=52.39					
	Weight of 1000 Fruit (g)						Weight of 1000 Fruit (g)					
	S1	S2	S3	S4	S5	Mean	S1	S2	S3	S4	S5	Mean
A0 (0ppm)	0.45	0.32	0.37	0.29	0.23	**0.33**	0.54	0.38	0.41	0.32	0.25	**0.38**
A1 (100 ppm)	0.48	0.33	0.38	0.29	0.24	**0.35**	0.58	0.40	0.42	0.32	0.28	**0.40**
A2 (200 ppm)	0.49	0.36	0.38	0.32	0.27	**0.36**	0.59	0.43	0.42	0.35	0.31	**0.42**
A3 (300 ppm)	0.50	0.45	0.40	0.36	0.29	**0.40**	0.60	0.54	0.44	0.39	0.32	**0.46**
Mean	**0.48**	**0.37**	**0.38**	**0.32**	**0.26**		**0.58**	**0.44**	**0.42**	**0.35**	**0.29**	
LSD (0.05)	S=0.08 A=0.06 S×A= 0.13						S=0.09 A=0.07 S×A=0.15					

***S1(1600 ppm), S2 (2000 ppm), S3 (2500 ppm), S4 (3000 ppm) and S5 (3500 ppm), Control= without Arginine, A1= Arginine at rate 100 ppm, A2= Arginine at rate 200 ppm, A3= Arginine at rate 300 ppm.**

Foliar spraying of arginine has a significant effect on fruits yield g/plant, fruits yield kg/ fed. and 1000 fruit weight at all rates of arginine (100, 200 and 300ppm) comparing with the control. The minimum rate of arginine (100 ppm) was less effective on crop productivity of anise plant such as fruits yield/plant (18.11 and 20.42 g), fruits yield/fed. (398.44 and 449.31 kg) and weight of 1000 fruit (0.35 and 0.40 g) in the first and the second season. While, the maximum concentration of arginine at 300 ppm gave the highest values of fruits yield/ plant (22.95 and 25.32g), fruits yield/fed. (504.83 and 556.99 kg) and weight of 1000 fruit (0.40 and 0.46 g).

These results may be due to the positive role of putrescine (the final product of arginine) in regulating growth, development and fruits yield. Also, arginine has a vital role in promoting early flowering and fruiting of plant **(Liu *et al*., 2007),** this result is in harmony with that concluded by **(Sadak *et al.*, 2015).** Also, these findings are in accordance of the results obtained previously by **(Abd El-Samad *et al.*, 2011**) who studied that, the role of arginine in stimulating cell division. (**Hendawy *et al.*, 2010)** showed that, an increase of the yield and its components in *Foeniculum vulgare* L. when sprayed with different concentrations of amino acids.

The interaction between salinity stress and foliar spray of arginine, demonstrated that arginine at rate 100 ppm had minimum effect on crop productivity of anise plant under saline water irrigation at level (3500 ppm) with values of fruits yield/plant (13.62 and 13.89 g), fruits yield/fed. (299.57 and 305.56 kg) and weight of 1000 fruit (0.24 and 0.28 g) in the first and the second seasons. On other hand, foliar application of arginine at rate 300 ppm under saline irrigation at level 1664 ppm (S1) gave significantly higher values of fruits yield/plant (27.60 and 31.37 g), fruits yield/fed. (607.20 and 690.14 kg) and weight 1000 fruit (0.50 and 0.60) in both seasons, followed by saline irrigation at level 2000 ppm with sprayed with A3 (300 ppm). It was noted, spraying with arginine at a rate of 300ppm led to an increase in yield with irrigation saline water at S3 (2500 ppm), compared to the control (A0) with irrigated with well water S1 (farm water well, 1664 ppm). Arginine as a source of poly amines increased plant protection from salinity damage via enhancing antioxidants enzymes production, growth promoters thus increasing vegetative growth and yield. These results were in harmony with that indicated by **(Velikova *et. al.*, 2000 and Sadak *et, al.*, 2015)** on Bean plant and **El-Bassiouny and Bekheta (2001)** on Wheat, **Ramadan *et al.*, (2019)** on Sunflower and **Ahmed *et al.*, (2020)** on Indian borage.

Effect of saline irrigation levels and arginine rates on essential oil productivity of anise

The obtained results in Table (5) showed that irrigation of anise plants with different salinity levels recorded significant effect on essential oil percentage and yield. Essential oil percentage was enhanced by increasing salinity levels, this increase was accompanied by decreasing the essential oil yield due to decreasing the seed yield. Essential oil content was 3.38% and 3.48% at the lowest salinity level S1 (water well 1664 ppm) and increased to 3.40% and 3.53% at S2 (2000ppm), 3.59% and 3.71% with S3 (2500 ppm) in the two seasons, respectively. However, high salinity levels S4 and S5 caused a maximum decrease, an oil content 2.94% and 3.12% at S4 (3000 ppm) and 2.88% and 2.98% at S5 (3500ppm) in the two seasons, respectively. The increase in oil content in salt stressed plants may be attributed to the decrease in primary metabolites, causing intermediary products to become available for secondary metabolites synthesis **(Morales *et al.*, 1993).** Salt stress may also affect the essential oil accumulation indirectly through its effects on either net assimilation or the partitioning of assimilates among growth and differentiation processes **(Charles *et al*., 1990).** The effect of salinity on essential oil and its constituents may be due to its effects on enzyme activity and metabolism **(Burbott and Loomis, 1969).** Similar result was obtained by **(Neffati and Marzouk, 2009)** on coriander. On the other hand, the oil yield ml/plant and l/fed. have decreased gradually with increased salty irrigation water. The highest values of oil yield were recorded in S1 (as control) 0.79 and 0.95 ml/plant and 17.41 and 20.86 l/fed., the lowest values were recorded 0.40 and 0.42 ml/plant and 8.77 and 9.18 l/fed. by the highest level of salty water irrigation S5 (3500 ppm), this reduction may be due to decrease the fruit yield under high salinity level. Similar results of negative effect of salt stress on essential oil yield were found by **(Tabatabaie and Nazari, 2007 and Aziz *et al.*, 2008)** on peppermint, (**Belaqziz *e. al.*, 2009)** on *Thymus maroccanus* and (**Said-Al Ahl and Mahmoud, 2010)** on basil, **(Abd El-Wahab, 2006)** on fennel. It was also shown that essential oil yield of coriander was stimulated only under low salinity level, while it decreased at the high salinity levels **(Neffati and Marzouk, 2008).**

As for the effect of spraying with Arginine, the results shown in Table (5) revealed that treatment with its all rates (100, 200 and 300 ppm) significantly mitigated the harmful effect of the saline irrigation water, an increase of essential oil percentage and yield compared to the control were recorded. A3 (300 ppm) recorded the highest percentage of essential oil (4.01 and 3.87%) compared to untreated plants (2.39 and 2.52%) in the two season, respectively. Also, the highest values of oil yield were 0.93 and 0.98 ml/ plant compared to 0.32 and 0.38 ml/plant in untreated plants and 20.38 and 21.61 l/fed. compared to 12.33 and 14.94 l/fed. on the first and the second seasons, respectively. Similar effect had reported by **(Ghoname *et al.*, 2010; Shekari and Javanmardi, 2017)** they found that, spraying arginine had a significant effect in increasing vegetative growth characteristics which reflected positively in stimulate of the percentage of volatile oil and its active compounds. The effect of arginine may be due to its role in building the requisite proteins and enzymes and building the vital compounds inside the plant or entering it in the installation of secondary metabolites such as shikimic acid" **(Reham *et al.*, 2016).**

The results of the interaction between the saline irrigation water and arginine treatment showed that, the superiority of S3 (2500 ppm) with A3 (300 ppm) treatment which giving the highest percentages of essential oil (4.22 and 4.24%) for both seasons, while the lowest percentages of essential oil were recorded in treatment S5 with A1 (2.49 and 2.89%) in both seasons. However, the highest essential oil yield ml/plant or L/fed. were 1.12 and 1.24 ml/plant and 24.59 and 27.19 l/fed., were obtained from A3 under S1 (water well, 1664 ppm) in two seasons, followed by S2 (2000 ppm) and S3 (2500 ppm) with same rate of arginine 300 ppm. On the other hand, the lowest values of oil yield were recorded 0.34 and 0.40 ml/plant and 7.46 and 8.83 l/fed. by A0 (without arginine) with S5 (3500 ppm) in the two seasons, respectively. In general, the increase in plant growth characteristics resulting from spraying Arginine due to its stimulating role for vegetation growth as it is classified within the group of stimulating plant hormones. It also works to reduce the effect of the abiotic stress, so it stimulates growth and increases the level of some plant hormones such as auxins and cytokines **(Shahin *et al.*, 2010).** Amino acid spraying has a role in stimulating phylogenetic and biochemical processes by sharing proteins and the carbohydrate industry by building chlorophyll, improving the properties of the components. Amino acid can protect the plant against environmental stress **(Baghalian *et al*., 2008 and Leithy *et al*., 2009).**

Table (5). Effect of saline irrigation water levels and arginine rates on oil productivity of anise plants during 2020/ 2021 and 2021/2022 season

Arginine (ppm) (A)	**First season Essential oil percentage**						**Second season Essential oil percentage**					
	Saline irrigation water levels (ppm) (S)						**Saline irrigation water levels (ppm) (S)**					
	S1	**S2**	**S3**	**S4**	**S5**	**Mean**	**S1**	**S2**	**S3**	**S4**	**S5**	**Mean**
A0 (0ppm)	2.55	2.50	2.67	2.15	2.08	2.39	2.61	2.65	2.76	2.39	2.19	2.52
A1 (100ppm)	3.27	3.31	3.49	2.56	2.49	3.02	3.39	3.41	3.63	3.05	2.89	3.27
A2 (200ppm)	3.63	3.66	3.98	3.19	3.11	3.51	3.82	3.84	4.20	3.49	3.47	3.76
A3 (300ppm)	4.05	4.11	4.22	3.86	3.82	4.01	3.94	4.21	4.24	3.56	3.38	3.87
Mean	3.38	3.40	3.59	2.94	2.88		3.44	3.53	3.71	3.12	2.98	
LSD (0.05)	**S=0.03 A=0.02 S×A=0.04**						**S=0.02 A=0.01 S×A=0.02**					
	Essential oil yield/plant (ml)						**Essential oil yield/plant (ml)**					
	S1	**S2**	**S3**	**S4**	**S5**	**Mean**	**S1**	**S2**	**S3**	**S4**	**S5**	**Mean**
A0 (0ppm)	0.44	0.41	0.39	0.18	0.16	0.32	0.54	0.52	0.44	0.22	0.17	0.38
A1 (100ppm)	0.72	0.71	0.66	0.38	0.34	0.56	0.89	0.87	0.76	0.47	0.40	0.68
A2 (200ppm)	0.89	0.88	0.83	0.54	0.46	0.72	1.13	1.11	0.97	0.62	0.53	0.87
A3 (300ppm)	1.12	1.11	1.06	0.71	0.64	0.93	1.24	1.23	1.18	0.69	0.58	0.98
Mean	0.79	0.78	0.74	0.45	0.40		0.95	0.93	0.84	0.50	0.42	
LSD (0.05)	**S=0.02 A=0.02 S×A=0.03**						**S=0.03 A=0.02 S×A=0.04**					
	Essential oil yield/fed. (L)						Essential oil yield/fed. (L)					
	S1	**S2**	**S3**	**S4**	**S5**	**Mean**	S1	S2	S3	S4	S5	Mean
A0 (0ppm)	9.69	8.99	8.59	4.06	3.42	6.95	11.90	11.44	9.78	4.74	3.68	8.31
A1 (100ppm)	15.75	15.56	14.60	8.26	7.46	12.33	19.59	19.24	16.70	10.33	8.83	14.94
A2 (200ppm)	19.60	19.45	18.34	11.81	10.15	15.87	24.77	24.48	21.30	13.57	11.55	19.13
A3 (300ppm)	24.59	24.37	23.21	15.68	14.05	20.38	27.19	26.99	26.02	15.19	12.68	21.61
Mean	17.41	17.09	16.19	9.95	8.77		20.86	20.54	18.45	10.96	9.18	
LSD (0.05)	**S=0.63 A=0.45 S×A=1.01**						**S=0.79 A=0.61 S×A=1.13**					

*S1(1600 ppm), S2 (2000 ppm), S3 (2500 ppm), S4 (3000 ppm) and S5 (3500 ppm), A0= without Arginine, A1= Arginine at rate 100 ppm, A2=Arginine at rate 200 ppm, A3=Arginine at rate 300 ppm

Essential oil constituents

Results in table (6) showed that, the GC-Mass analysis of anise oil, 14 components were identified. Anethole as which represent the main component and others such as Estragole, Carvone, Linalool, Methyl Eugenol, Comphor were identified. It was noticed that, anethole content was decreased with increasing salinity level. This could be attributed to secondary metabolites levels are reduced during stress, which is related to the general anabolism. Anabolism is prevented in salinity stress conditions **(Said-Al Ahl and Omer, 2011).** The value of anethole content (90.11%) was achieved by (S1A0) and decreased gradually with increasing saline water levels, the lowest value of anethole content (85.88%) by S5A0). On the other hand, using arginine treatment, led to raising the anethole content under saline water stress compared with control (A0) treatment. The highest value of anethole content was obtained with S3+A3 compared to the other treatments. On the other hand, the highest content of estragole (2.33%) was resulted from S5A0, while the lowest content (0.03%) was recorded by using S1+A3. It could be obtained that, arginine treatments led to an increase in the quality of the volatile oil content. The favorable effect of arginine on the main compound of essential oil is in agreement with those of **(Shehata *et al.*, 2011)** on celeriac plant and **(Omer *et al.*, 2013)** on chamomile plant and **(Saburi *et. al.*, 2014)** on the basil plant. Also, similar results of an effect of the maximum level of salinity were also found on lemon balm (**Ozturk *et al.*, 2004),** chamomile (**Razmjoo *et al.*, 2008),** *Salvia officinalis* **(Shalan *et al*., 2006),** and basil **(Said-Al Ahl *et al.*, 2010).** Also, **(Said-Al Ahl and Hussein, 2010)** on *Origanum vulgare* found that (carvacrol) content as the main essential oil constituent decreased under salt stress, while p-cymene and γ-terpinene contents increased under non-salt stress treatments**.**

Table (6). Effect of saline irrigation water levels and arginine rates on the essential oil constituents (%) of anise throughout first season

Tratments	A0S1	A0S2	A0S3	A0S4	A0S5	A3S1	A3S2	A3S3	A3S4	A3S5
Components	The essential oil constituents (%)									
α- Pinene	0.08	0.09	0.11	0.16	0.33	0.14	0.17	0.22	0.36	0.64
Camphene	0.01	0.03	0.15	0.25	0.72	0.04	0.09	0.13	0.28	0.25
Sabinene	1.21	0.85	0.79	0.59	0.56	0.29	0.17	0.04	0.27	0.16
β- Pinene	0.14	0.13	0.08	0.09	0.09	0.17	0.19	0.06	0.09	0.09
Linalool	0.50	0.59	0.66	0.56	0.50	0.64	0.66	0.63	0.62	0.83
Comphor	0.47	0.49	0.57	0.76	0.82	0.19	0.14	0.13	0.11	0.11
Estragole	0.14	1.11	1.39	1.46	2.33	0.03	0.19	0.2	0.4	0.65
Fenchyl acetate	1.08	1.15	1.24	1.49	1.92	1.47	1.27	1.22	1.20	1.18
Carvone	1.93	1.22	1.21	1.19	1.16	1.02	0.61	0.64	0.62	0.57
Anethole	90.11	90.35	89.03	88.16	85.88	93.09	94.11	94.21	92.84	91.62
Methyl Eugenol	0.18	0.22	0.42	0.73	1.31	0.19	0.16	0.17	0.23	0.45
Farnesene	0.72	0.61	0.79	0.52	0.44	0.03	0.05	0.06	0.18	0.39
Germacrene D	2.39	1.93	1.89	2.22	2.20	2.22	1.93	1.89	1.85	1.74
β- Farnsol	1.15	1.23	1.67	1.82	1.74	0.37	0.26	0.40	0.95	1.32

*S1(1600 ppm), S2 (2000 ppm), S3 (2500 ppm), S4 (3000 ppm) and S5 (3500 ppm), A0= without Arginine, A1= Arginine at rate 100 ppm, A2=Arginine at rate 200 ppm, A3=Arginine at rate 300 ppm

Effect of saline irrigation water levels and arginine rates on protein content

Results in Table (7) showed that, the percentage of protein in anise seeds sprayed with different rates of arginine and irrigated with different levels of salinity. It was observed that protein content in anise plant was decreased gradually with increasing the level of saline water.

The minimum level of salinity (farm water well, 1664 ppm) recorded the highest values of protein content (15.68 and 16.31%), Followed by S2 (2000 ppm) with values 14.47 and 14.78% in the first and the second seasons respectively. while the maximum level of salinity (3500 ppm) gave lowest values of protien (8.54 and 7.26%) in both seasons. Similar results had reported by **(Osman *et al* 2007)** on *Catharanthus roseus* protein significantly decreased with NaCl concentrations. Also, in *achillea fragratissima* it was indicated that salinity concentration of 4000 ppm decreased protein content **(Abd EL-Azim and Ahmed, 2009).** On the other hand, protein accumulation had significantly increased in plants sprayed with amino acid (arginine) at all rates 100, 200 and 300 ppm compared to the control. The highest protein content (14.10 and 13.93% in both seasons) was recoded in those plants sprayed with A3 (300 ppm). While, spraying arginine at rate (100 ppm) had low efficacy on protein content with values (12.98 and 12.83%) in the first and the second seasons, respectively.

As for the interaction between the effect of saline water and arginine treatment, it is observed that, the highest protein accumulation was recorded in those plants sprayed with A3 (300 ppm) under the low saline irrigation water (S1) with values (16.85 and 17.53%) in the first and the second seasons, respectively. In contrast, the minimum concentration of arginine (A1) under the highest saline irrigation water S5 (3500 ppm) gave lower protein content 8.33 and 7.08% in both seasons. These findings are in line with those of **El-Bassiouny and Bekheta (2001)** reported that, the plants treated with amino acid and irrigated with different salinity levels noticed that, the improving salt stress tolerance and increased the intensity of salt responsive proteins at molecular weights 91, 70, 36, 21, 17 and 15 KDa). Also**, Khalil *et al*., (2009)** who found that, arginine treatments induced the appearance of new protein bands at molecular weights 222.0, 214.6, 131.8, 93.1, 78.7, 50.7, 34.6 and 14.1 KDa in wheat plants.

Table (7). Effect of saline irrigation water levels and arginine rates on protein (%) of anise fruits during 2020/ 2021 and 2021/2022 season

Arginine ppm (A)	First season Protein %						Second season Protein %					
	Saline irrigation water levels (ppm) (S)						Saline irrigation water levels (ppm) (S)					
	S1	S2	S3	S4	S5	Mean	S1	S2	S3	S4	S5	Mean
A0 (0ppm)	14.58	13.90	13.50	12.90	8.00	**12.58**	15.17	14.17	13.64	12.38	6.80	**12.43**
A1 (100 ppm)	14.98	14.31	13.75	13.54	8.33	**12.98**	15.58	14.60	13.89	13.00	7.08	**12.83**
A2 (200 ppm)	16.31	14.44	14.33	14.04	8.50	**13.53**	16.97	14.73	14.48	13.48	7.23	**13.37**
A3 (300 ppm)	16.85	15.25	14.75	14.29	9.33	**14.10**	17.53	15.56	14.90	13.72	7.93	**13.93**
Mean	**15.68**	**14.47**	**14.08**	**13.69**	**8.54**		**16.31**	**14.76**	**14.22**	**13.15**	**7.26**	
LSD (0.05)	**S=0.28 A=0.19 S×A=0.52**						**S=0.23 A=0.17 S×A=0.62**					

*S1(1600 ppm), S2 (2000 ppm), S3 (2500 ppm), S4 (3000 ppm) and S5 (3500 ppm), A0= without Arginine, A1= Arginine at rate 100 ppm, A2=Arginine at rate 200 ppm, A3=Arginine at rate 300 ppm

Effect of saline irrigation water levels and arginine rates on macro and micro elements content in anise fruits

Data in (Table, 8) showed that N, P and K concentrations in anise plant were significantly decreased under different salinity levels of water irrigation compared with control plants (water well, 1664 ppm). The highest concentration of salinity S5 (3500 ppm) resulted in the minimum values for nitrogen (1.37 and 1.16%) phosphorus (0.23 and 0.21%) and potassium (1.13 and 1.15%) in the first and the second seasons, respectively.

While, Na and Cl concentrations increased significantly in response to irrigation with all salinity levels as compared to with well water irrigation (1664 ppm). The irrigation with saline water (3500 ppm) resulted in the highest concentration of sodium (0.57 and 0.73%) and chloride (0.30 and 0.32%) in the seeds. While, the lowest level of saline water (1664 ppm) gave the minimum values for the concentration of sodium (0.25 and 0.30 %) and chloride (0.14 and 0.16 %) in the seeds.

These results are similar to those obtained by **Pessarakli (1991)** and **Al-Rawahy *et al.* (1992)** who found that, salinity can reduce N accumulation in plants. This may be due to increase in Cl uptake which accompanied by a decrease in NO_3 concentration **(Bar *et al*., 1997)** and **(Lea-Cox and Syverten, 1993)**. Phosphate content in anise plants reduced in saline condition due to ionic strength effect that reduce the activity of phosphate, also because phosphate concentration in soil solution is tightly controlled by sorption processes and by the low solubility of P mineral. So it makes sense that phosphate content in plants reduced as salinity increased. **(Mohamedin *et al*., 2006). (Grattan and Grieve, 1999)** reported that, K content in plants decreased under saline conditions due to high level of external Na interfere with K^+ acquisition by roots also its effect of root membranes. The obtained results of Na and Cl concentrations are in good harmony with those obtained by **(Shi and Sheng, 2005)** on sunflower.

Arginine application reduced significantly Na and Cl concentrations, while increased N, P and K concentrations under all salinity levels compared to control well water irrigation. Foliar application of A3 (300 ppm) significantly decreased concentration of Na (0.34 and 0.42%) and Cl (0.18 and 0.20%) in two seasons. However, the same concentration (A3) significantly increased concentration of N (2.26 and 2.23%), P (0.47 and 0.49%) and K (1.43 and 1.47 %) in the first and the second season, respectively. Similar results were found by **(Sharma *et al*., 1997)** who studied that, foliar application of putrescine (as one product of arginine) enhance the uptake of N, P and K but decreased Na and Cl uptake in chick pea plant. **(Mansour and Al-Mutawa, 1999)** and **(El-Bassiouny and Bekheta, 2001)** reported that the main role of all arginine products (as putrescine, spermidine and spermine) in salt treated plants in the long term is to maintain a cation-anion balance in plant tissues by stabilizing membrane under high salinity levels.

As for the interaction between the effect of saline water and arginine treatment, it is observed that, the highest concentration N, P and K were recorded in those plants sprayed with A3 (300 ppm) under the low saline irrigation water (S1), followed by S2 (2000 ppm) and S3 (2500 ppm) combined with same rate of arginine (300 ppm). While the same treatment significantly decreased Na and Cl concentration. On the other hand, spraying with A0 (without arginine) under the high saline irrigation water (S5) gave the highest of concentration of Na and Cl, while decreased N, P, K in seeds in the first and the second seasons, respectively.

Table (8). Effect of saline irrigation water levels and arginine rates on macro and micro elements (%) of anise fruits during 2020/ 2021 and 2021/2022 seasons

Arginine ppm (A)	First season N						Second season N					
	Saline irrigation water levels (ppm) (S)						Saline irrigation water levels (ppm) (S)					
	S1	S2	S3	S4	S5	Mean	S1	S2	S3	S4	S5	Mean
A0 (0ppm)	2.33	2.22	2.16	2.06	1.28	**2.01**	2.43	2.27	2.18	1.98	1.09	**1.99**
A1 (100 ppm)	2.40	2.29	2.20	2.17	1.33	**2.08**	2.49	2.34	2.22	2.08	1.13	**2.05**
A2 (200 ppm)	2.61	2.31	2.29	2.25	1.36	**2.16**	2.71	2.36	2.32	2.16	1.16	**2.14**
A3 (300 ppm)	2.70	2.44	2.36	2.29	1.49	**2.26**	2.80	2.49	2.38	2.20	1.27	**2.23**
Mean	**2.51**	**2.32**	**2.25**	**2.19**	**1.37**		**2.61**	**2.36**	**2.28**	**2.10**	**1.16**	
LSD (0.05)	**S= 0.04**		**A=0.03**		**S×A= 0.07**		**S= 0.03**		**A=0.02**		**S×A= 0.06**	
	P						P					
	S1	S2	S3	S4	S5	Mean	S1	S2	S3	S4	S5	Mean
A0 (0ppm)	0.55	0.36	0.29	0.23	0.21	**0.33**	0.65	0.38	0.32	0.25	0.19	**0.36**
A1 (100 ppm)	0.62	0.46	0.31	0.26	0.22	**0.37**	0.72	0.49	0.34	0.28	0.21	**0.41**
A2 (200 ppm)	0.65	0.49	0.37	0.29	0.24	**0.41**	0.72	0.52	0.41	0.32	0.23	**0.44**
A3 (300 ppm)	0.78	0.54	0.45	0.31	0.25	**0.47**	0.80	0.57	0.50	0.34	0.23	**0.49**
Mean	**0.65**	**0.46**	**0.36**	**0.27**	**0.23**		**0.72**	**0.49**	**0.39**	**0.30**	**0.21**	
LSD (0.05)	**S= 0.03**		**A=0.02**		**S×A= 0.05**		**S= 0.03**		**A=0.03**		**S×A= 0.06**	
	K						K					
	S1	S2	S3	S4	S5	Mean	S1	S2	S3	S4	S5	Mean
A0 (0ppm)	1.42	1.37	1.26	1.17	1.04	**1.25**	1.45	1.41	1.31	1.21	1.06	**1.29**
A1 (100 ppm)	1.50	1.42	1.31	1.19	1.11	**1.31**	1.53	1.46	1.36	1.23	1.14	**1.34**
A2 (200 ppm)	1.58	1.49	1.36	1.24	1.14	**1.36**	1.62	1.53	1.41	1.27	1.18	**1.40**
A3 (300 ppm)	1.69	1.57	1.41	1.28	1.21	**1.43**	1.72	1.62	1.47	1.32	1.23	**1.47**
Mean	**1.55**	**1.46**	**1.34**	**1.22**	**1.13**		**1.58**	**1.51**	**1.39**	**1.26**	**1.15**	
LSD (0.05)	**S=0.06**		**A=0.03**		**S×A=0.08**		**S= 0.03**		**A=0.02**		**S×A=0.06**	
	Na						Na					
	S1	S2	S3	S4	S5	Mean	S1	S2	S3	S4	S5	Mean
A0 (0ppm)	0.26	0.33	0.42	0.50	0.60	0.42	0.32	0.42	0.54	0.64	0.76	0.54
A1 (100 ppm)	0.26	0.31	0.37	0.45	0.58	0.39	0.31	0.39	0.48	0.59	0.73	0.50
A2 (200 ppm)	0.24	0.29	0.33	0.42	0.56	0.37	0.29	0.37	0.42	0.54	0.71	0.47
A3 (300 ppm)	0.23	0.25	0.29	0.36	0.55	0.34	0.28	0.33	0.34	0.46	0.70	0.42
Mean	**0.25**	**0.29**	**0.35**	**0.43**	**0.57**		**0.30**	**0.38**	**0.44**	**0.56**	**0.73**	
LSD (0.05)	**S= 0.11**		**A=0.02**		**S×A= 0.14**		**S=0.09**		**A= 0.04**		**S×A=0.15**	
	Cl						Cl					
	S1	S2	S3	S4	S5	Mean	S1	S2	S3	S4	S5	Mean
A0 (0ppm)	0.17	0.23	0.26	0.28	0.31	**0.25**	0.19	0.25	0.28	0.31	0.34	**0.27**
A1 (100 ppm)	0.15	0.16	0.22	0.26	0.30	**0.22**	0.16	0.17	0.24	0.28	0.33	**0.24**
A2 (200 ppm)	0.14	0.13	0.21	0.25	0.29	**0.21**	0.16	0.14	0.23	0.28	0.31	**0.22**
A3 (300 ppm)	0.11	0.12	0.15	0.23	0.28	**0.18**	0.12	0.13	0.17	0.25	0.31	**0.20**
Mean	**0.14**	**0.16**	**0.21**	**0.26**	**0.30**		**0.16**	**0.17**	**0.23**	**0.28**	**0.32**	
LSD (0.05)	**S=0.02**		**A=0.01**		**S×A=0.03**		**S=0.02**		**A=0.01**		**S×A= 0.04**	

*S1(1600 ppm), S2 (2000 ppm), S3 (2500 ppm), S4 (3000 ppm) and S5 (3500 ppm), A0= without Arginine, A1= Arginine at rate 100 ppm, A2=Arginine at rate 200 ppm, A3=Arginine at rate 300 ppm

Conclusion

Based on the results in this study, it can conclude that anise plants were sensitive to saline irrigation water 3000 ppm which suppresses growth, fruits yield and essential oil accumulation. Foliar application of arginine at 300 ppm successfully enhanced growth, fruits and oil production.

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