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The phenotypic variation of eggplant (cv. Barcelona) under salt stress and the stimulating of the productivity by α-Tocopherol

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ABSTRACT: The presented study was carried out in private field, in Al Hashimiyah, Babylon province, during 2020 autumn season to study the effect of anatomical, chemical and phenotypic variation of eggplant (cv. Barcelona) under different levels of salty irrigation water and stimulate plant productivity by spraying α-Tocopherol and their interaction on studied indicators. Experiment was included two main factors, the first factor was three levels of salty irrigation water (1.5, 3 and 4.5 ds.m^{-1}) and the second factor was spraying eggplant with three concentrations of α-Tocopherol (0, 75 and 150 mg.L^{-1}). Three sprayings were applied during the season and time between each spraying was two weeks. Results showed that there were significant effect of the two studied factors on the phenotypic traits as the 1.5 ds.m^{-1} level of salty irrigation water was significantly increased (plant height, leaf area, the number of branches, dry weight of total vegetative, the number of fruits in each plant, the yield of each plant and total yield per unit area) compare to 4.5 ds.m^{-1} level which gave the lowest values of studied indicators. Spraying 150mg.L-1 of α-Tocopherol was also increased the studied indicators significantly, while, the interaction treatment between the two factors of the experiment was increased the above studied indicators significantly.

Key words: eggplant, α-Tocopherol, vegetative growth, yield, salty irrigation water.

1. INTRODUCTION

Eggplant (*Solanum melongana* L.) is considered a main vegetable crop that belongs to Solanaceae family and Solanum genus which including more than 2000 plant species. The plant is grown in the wild in central regions of India and south – east China then from there; it spread to most Asian countries, Egypt and other parts of the world (Cericola et al 2013). The crop is cultivated in most areas of Iraq either in open field or protected agriculture as its importance comes by consuming its fruits as it contains low calories, protein, carbohydrates, and different proportions of nutrients particularly potassium, iron and A, B1, B2, B5 vitamins as well as it has medical importance in treating many diseases such as diabetic, asthma, diarrhea, urinary system sores, gout and reduces cholesterol in blood (Mennell et al 2012; Plazas et al 2013). The area that grown by eggplant in the world estimated 1864556 hectare

with a total yield of 54077210 million ton, while in Iraq, the cultivated area estimated about 6307 hectare with total productivity of 113699 thousand ton (FAO 2018). Eggplant is moderately sensitive to salty water (Unlukara et al 1010), well water is an important natural resource for irrigation in many countries of the world, especially in arid and semi-arid regions as it is relied upon as one of the alternative sources of irrigation water during the summer months (Al-Taey 2011). Therefore, one of the methods that can be used to improve the tolerance of plants to salt or reduce its damage is the use of antioxidants such as **α**-Tocopherol which has a role in keeping photosynthesis as it belongs to non-enzyme group and protect cell membrane system, making it part of the plants defense mechanism (Rady et al 2015). **α**-Tocopherol is one of the most types of oxidative antagonism due to the presence of three methyl groups gathered to the phenol ring so it is the first line of defense against lipid oxidation (Dauqan et al 2011).
Thus, the aim of current study was to examine the effect of anatomical, chemical and phenotypic variation of eggplant (cv. Barcelona) under different levels of salty irrigation water and stimulate plant productivity by spraying **α**-Tocopherol and their interaction on eggplant tolerance to salty water and vegetative and yield traits.

2. MATERIALS AND METHODS

An experiment was carried out in a private farm in Al Hashimiyah, Babylon province, during 2020 autumn season under protective cultivation. Seeds of eggplant cultivar (cv. Barcelona) from Semillas (Spain) were obtained from local market. Eggplant seeds were planted in 25/7/2019 in cork plates after it was filled with sandy soil and peat moss (Germany) in 1:2 ratios then all services was applied. After the completion of seedlings growth (after 38 from planting) and became 12-16cm length and have 3-4 leaves, 9 lines with 20m length were done with 75cm distance between each line, it was transferred to the field in 2/9/2020 and cultivated in both sides of agricultural lines with 50cm distance between each plant then 10kg of organic (cow fertilizer) were put in each line. The total number of experimental units was 27 for the first factor represented by three levels of salty water (1.5, 3 and 4.5ds.m^{-1}) using irrigation drop system as the salty water levels were obtained after mixing river and well water and measure the EC daily. While, there were 24 experimental units for the second factor represented by (0, 75 and 150 mg.L^{-1}) of **α**-Tocopherol (Table 1). Plants were sprayed three times and the time between each spry was two weeks, while control plants were sprayed with water only (Al-Bayati et al 2020). A factorial experiment was arranged using randomize complete block design (RCBD) with three replicates. ANOVA analysis was done and the differences between means were tested using least significant difference test (L.S.D.) at 5% level of significance (P>0.05) (AL–Rawi and Khalf 2000). Data were analysed using GenStat International 12.1 VSN (2009).

Table 1. Experimental treatments.

No.		Treatments
1	T1	Interaction between salty water 1.5ds.m^{-1} + 0mg.L^{-1} of **α**-Tocopherol
2	T2	Interaction between salty water 1.5ds.m^{-1} + 75mg.L^{-1} of **α**-Tocopherol
3	T3	Interaction between salty water 1.5ds.m^{-1} + 150mg.L^{-1} of **α**-Tocopherol
4	T4	Interaction between salty water 3ds.m^{-1} + 0mg.L^{-1} of **α**-Tocopherol
5	T5	Interaction between salty water 3ds.m^{-1} + 75mg.L^{-1} of **α**-Tocopherol
6	T6	Interaction between salty water 3ds.m^{-1} + 150mg.L^{-1} of **α**-Tocopherol
7	T7	Interaction between salty water 4.5ds.m^{-1} + 0mg.L^{-1} of **α**-Tocopherol

8	T8	Interaction between salty water 4.5ds.m^{-1} + 75mg.L^{-1} of **α**-Tocopherol
9	T9	Interaction between salty water 4.5ds.m^{-1} + 150mg.L^{-1} of **α**-Tocopherol

Measured indicators

Plant height (cm): The main stem height of Bercelona cultivar of eggplant was measured using measuring tape from soil surface until the top of plant.

The main branches number (branch.plant-1): Mean of main branches of five plants (chosen randomly from each experimental unit) was calculated.

Leaf area (cm^2.leaf^{-1}): was measured according to the method described in Sadik et al (2011) using scanner device and Digimizer application on computer for the five randomize plants in each experimental unit then leaf area was calculated by multiplying the average of area of each leaf with the number of leaves in each plant.

Dry weight of total vegetative (gm.plant^{-1}): estimated in the end of season by taken 5 plants randomly from each experimental unit and removing its roots then weighted before drying after that 100 g of fresh weight was dried in electric oven at 75^{0}C for 48h until its weight was stable then scaled to get dry weight.

The average of fruits yield of each plant (kg.plant^{-1}) the number of accumulates fruits was calculated for plants in each experimental unit divided on the number of plants as follows:

$$\text{The number of fruit in each plant} = \frac{\text{The number of fruits in each experimental unit}}{\text{The number of plants in the experimental unit}}$$

Total yield (ton.h^{-1}) was calculated from first pickup until the end of the season then means were taken as follows:

$$\text{The total yield (ton.h}^{-1}\text{)} = \frac{\text{Yield of experimental unit (kg) x Area of hectare (10000m}^2\text{)}}{\text{The area of experimental unit (m}^2\text{)}}$$

3. RESULTS AND DISCUSSION

Results of Table 2 showed that there were significant differences between salty irrigation water levels as the 1.5ds.m^{-1} level was exceeded and gave high values of studied indicators (plant height, leaf area, the number of branches, dry weight of total vegetative) which recorded 83.29cm, 156.40cm^2.leaf^{-1} 5.40branch.plant^{-1} and 176.37g.plant^{-1} respectively compare to 4.5ds.m^{-1} level which gave the lowest values 65.91cm, 135.45cm^2.leaf^{-1} 4.32branch.plant^{-1} and 155.95g.plant^{-1}. Table 2 results also showed that there was significant exceeding of spraying 150mg.L^{-1} of **α**-Tocopherol which gave the highest values of studied indicators and recorded 80.39cm, 158.97cm^2.leaf^{-1} 5.70branch.plant^{-1} and 176.86g.plant^{-1} respectively compare to spraying with 0mg.L^{-1} level which gave the lowest values 71.21cm, 133.05cm^2.leaf^{-1} 4.10branch.plant^{-1} and 159.03g.plant^{-1}.

The interaction between the two factors of the experiment indicated that the 1.5ds.m^{-1} level of salty irrigation water and spraying with 150mg.L^{-1} of **α**-Tocopherol was significantly increased studied traits and gave 88.20cm, 168.99cm^2.leaf^{-1} and 188.85g.plant^{-1} respectively compare to non-spread plants with **α**-Tocopherol at 4.5ds.m^{-1} level which decreased the values of the above indicators to 61.80cm, 119.64cm^2.leaf^{-1} and 147.89g.plant^{-1}, while, there was no significant difference was noticed on branches number.

Table 2. The effect of salt stress and spraying α-Tocopherol and their interaction on vegetative growth indicators of eggplant.

Dry weight of total vegetative ($g.plant^{-1}$)	Main branches number ($branch.plant^{-1}$)	Leaf area ($cm2.plant^{-1}$)	Plant height (cm)	Treatments
167.65	4.55	144.69	88.77	**T1**
172.61	5.22	155.52	83.80	**T2**
188.85	6.44	168.99	88.20	**T3**
161.55	3.99	134.82	73.98	**T4**
167.06	5.21	145.78	79.29	**T5**
179.19	5.99	159.37	80.83	**T6**
147.89	3.77	119.64	61.80	**T7**
157.41	4.55	138.14	63.78	**T8**
162.55	4.66	148.56	72.14	**T9**
4.74	NS	3.85	1.44	**LSD Interaction**
176.37	5.40	047.51	83.29	**Effect of salty irrigation water levels**
169.27	5.07	146.65	78.03	
155.95	4.32	135.45	65.91	
2.08	1.57	1.38	2.10	**LSD salty irrigation water**
159.03	4.10	133.05	71.21	**Effect of spraying α-Tocopherol**
165.70	4.99	057.57	84.62	
176.86	5.70	047.58	80.39	
2.74	0.37	2.22	0.83	LSD **α**-Tocopherol

Table 3 results showed that there were significant differences between salty irrigation water levels as the $1.5ds.m^{-1}$ was exceeded in yield indicators (the average of fruit number in each plant, total yield per unit area) as it reached $16.92fruit.plant^{-1}$, $2.63kg.plant^{-1}$ and $35.15ton.hectare^{-1}$ compared to $4.5ds.m^{-1}$ level which decreased the studied indicators to $13.28fruit.plant^{-1}$, $2.01kg.plant^{-1}$ and $26.95ton.hectare^{-1}$. Results also showed significant exceeding when it spraying with $150mg.L^{-1}$ of **α**-Tocopherol as it achieved the highest average $17.19fruit.plant^{-1}$, $2.72kg.plant^{-1}$ and $36.42ton.hectare^{-1}$ compared to spraying with $0mg.L^{-1}$ of **α**-Tocopherol which decreased the studied indicators to $13.50fruit.plant^{-1}$, $2.01kg.plant^{-1}$ and $26.93ton.hectare^{-1}$. The interaction between the $1.5ds.m^{-1}$ level of salty irrigation water and spraying with $150mg.L^{-1}$ of **α**-Tocopherol was significantly increased studied traits and gave $19.95fruit.plant^{-1}$, $3.19kg.plant^{-1}$ and $42.60ton.hectare^{-1}$ respectively

compare to non-spread plants with **α**-Tocopherol at 4.5ds.m^{-1} level which decreased the values of the above indicators to 12.18fruit.plant^{-1}, 1.79kg.plant^{-1} and 23.87ton.hectare^{-1}.

Table 3. The effect of salt stress and spraying α-Tocopherol and their interaction on yield indicators of eggplant.

Total yield (ton.hectare^{-1})	The average of yield for each plant (kg.plant^{-1})	The average of fruits number (fruit.plant^{-1})	Treatments
29.55	2.21	14.37	**T1**
33.30	2.49	16.43	**T2**
42.60	3.19	19.95	**T3**
27.38	2.15	13.96	**T4**
31.89	2.38	04.52	**T5**
35.13	2.63	16.72	**T6**
23.87	1.79	12.18	**T7**
25.44	1.90	12.76	**T8**
31.54	2.36	14.90	**T9**
5.07	1.25	0.58	**LSD Interaction**
54.04	2.63	16.92	**Effect of salty irrigation water levels**
50.57	2.35	04.55	
27.54	2.01	13.28	
2.51	0.17	1.01	**LSD Salty irrigation water**
26.93	2.01	13.50	**Effect of spraying α-Tocopherol**
30.21	2.26	05.75	
36.42	2.72	17.19	
0.72	1.05	1.85	**LSD α-Tocopherol**

It can be noticed that there was significant decreasing in the vegetative growth indicators at 4.5ds.m-1 level of salty irrigation water and this may be attributed to the effect of increasing salts in soil which leads to absorb less water by plants and low amount of nutrients which negatively reflected on biological activities and affected photosynthesis and respiratory (Al-Taey and Golezani et al 2011). The most important negative effect is the increasing free radicals that cause cellular nutrition construction disorder and execution of some internal structures for cell components such as cell wall when the osmotic pressure increases with

saline which leads to decrease water voltage and transferring water through root and then reflected on vegetative growth or this increasing occurs due to the accumulation of sodium ions and increases the toxicity in plant tissues and prevent cell division and elongation (Azevedo and Ashraf 2009). This result is in agreement with Brenes et al (2020) who found that using levels of sodium chloride on eggplant was decreased plant height, leaves number and dry weight of plant. Issa et al (2020) also reported the effect of salt stress on the decreasing vegetative indicators of eggplant. Table 2 results showed that the spraying 150mg.L^{-1} of **α**-Tocopherol was improved studied vegetative traits due to the role of it in increasing cell division and activating some enzymes such as Glocosidase, Phosphatase, B-amylase, Amylopactin and helping to build other enzymes for instant, Protase. The increasing of macro nutrients absorption and the accumulation of it inside plant leads to increase cell division and protecting the chloroplast and its effect on carbon representation (Dowdle et al 2007) and this in agreement with Orabi et al (2017) on cucumber plants and with Mady (2009) on tomato as the spraying with **α**-Tocopherol was increased the vegetative growth clearly.

Table 3 indicated a decreasing in yield indicators at 4.5ds.m-1 level of salty irrigation water and this may be attributed to the effect of salinity which included osmotic effects, ionic toxicity and non-balanced nutrition of plant due to the increasing of growth inhibitors which leads to reduce photosynthesis, produced carbohydrates, decrease the size and the weight of fruits and reducing the yield (Al-Hamdany and Mohammed 2014). Salinity is affected plants size as the plants that grown in salty conditions are small in size in comparison with in non-salty environment (Christen and Ahmed 2012). The decreasing in yield indicators when using salty irrigation water may be attributed to the effect of increasing salts in surrounding aria of root which leads to decrease the density of roots and reduce its ability to absorb water and eventually decreasing the average of plant growth (Al-Taey et al 2015). These results are in agreement with Mahjoor et al (2016) findings on eggplant and with El-Mogy et al (2018) on tomato plants. The spraying with 150mg.L^{-1} of **α**-Tocopherol was increased leaves content of K, P and N elements, chlorophyll and increasing vegetative growth, therefore, increasing the total yield (Orabi et al 2017). This may be attributed to the fact that E vitamin is inhibited free radicals and prevent the increasing in lipids peroxide by cleaning these radicals in membrane which affect the activity of many enzymes and reduce the oxidation damages as it works as a antioxidants and increase auxins, cytokines and flowers (Orabi et al 2015; Semida et al 2016; Taha et al 2018).

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