Comparative Performance of Five Genotypes of Tomato to Salt Stress

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ABSTRACT

Proline content, chlorophyll pigment and potassium/sodium ratio (Na^+/K^+) of five different genotypes, Edkawy, Castle Rock and Budai Torpe and their hybrids EXC and EXB were significantly increased in proline content and Na^+/K^+, and significantly lowered in chlorophyll content by the rise of salinization levels 1.2, 2, 5, 10, 15 dS/m. The two hybrids gave a higher response to salinity; this is observed in the increase in Na and proline in the same time K concentration decreased. Edkawy showed mid values between the other parents and the hybrids.

Key words: *Lycopersicon esculentum* - salinity– proline -chlorophyll

INTRODUCTION

Salinity is one of the most abiotic stresses that reason for reduction in growth, development and productivity of plants of the world in arid and semi-arid regions, where salts in the soil is high. 45 million hectares of irrigated land are salt-affected throughout the world (Shrivastava and Kumar, 2015).

In developing countries, one of the solutions of the problem of over population densities is to increase productivity of cultivated land. In Egypt, soils suffer from extreme climatic factors such as high temperature and drought as well these conditions caused accumulation of dissolved salts in soils result of the insufficient leaching of ions. Salts accumulation in upper soil layers may also occur due to an unsuitable irrigation management. Plants subjected to excess salt suffer from osmotic regulation, ion imbalance, and oxidative stress, which affect plant metabolism and growth (Mohamed, 2016; Elkhatib *et al*., 2017).

Tomato, which is an important crop in the world and adapted to various climates, is also undergoing from salinised soils. The cultivated tomato (*Lycopersicon esculentum* Mill.) is one of the family *Solanaceae* and is distributed annual vegetable crop. Tomato is also an important crop for breeding programs, because the crosses between wild and cultivated tomato plants are simple and its wild relatives provide a rich germplasm pool. F1 hybrids are one of the targets to meet the demand. F1 hybrids in tomato offer several advantages such as earliness, higher productivity, improved quality and resistance to biotic and abiotic stresses. Like most crop plants tomato is sensitive to moderate levels of salinity. The yield of tomato is affect by salinity; all tomato developmental stages show sensitivity to salt stress (Jones *et al.*, 1986; Maas, 1986; Bolarin *et al.*, 1993; Saad *et al.*, 2018).

Proline is an amino acid present in plants normally. Under environmental stresses, proline is synthesized in large quantities (Ozturk and Demir, 2002; Hsu *et al*., 2003; Kavi Kishore *et al*., 2005).

Chlorophyll has the major role in photosynthesis process and chlorophyll content is positively correlated with the rate of photosynthesis (Anjum *et al.* 2011). Water deficiency and inability of water transport to leaves leads to photosynthesis declines (Loredana *et al.* 2011). Chlorophyll content decreases in salt susceptible plants such as tomato (Sudhir and Murthy, 2004), under salinity, chlorophyll pigments decreases subsequently photosynthesis rate reduced, as a result the yield negatively affected.

Na^+ has not an essential role for plants. Na^+ toxicity occurred because Na^+ replaced K^+ roles in tissues in plants under salinity conditions [Blumwald, 2000]. High Na^+ in the cytoplasmic matrix caused K+ deficiency; damage various enzymatic processes and imposing a vital burden on the cell because of the need to synthesize organic solute required to export of Na^+ for osmotic adjustment (Munns and Tester, 2008). K^+activate the work of the most enzymes in the cell which Na^+ cannot achieve it. (Tester and Davenport, 2003).

Keeping in view all these points, the present study was undertaken to examine the effects of salt stress on the physiological performance of three tomato cultivars and their two hybrids, mainly Na^+/K^+ ratio, proline content and chlorophyll content.

MATERIALS AND METHODS

This study carried out at Sabaheya Station of the Agricultural Research Center, Alexandria, Egypt**.**

Hybridization Experiment

Salt tolerant cultivar Edkawy was crossed with salt sensitive cultivar Castle rock and Budai torpe cultivar,

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their hybrids were Edkawy x Castle rock (E X C) and Edkawy x Budai torpe (E X B) F1 hybrids.

Salt application

The two hybrids and their three parents were used in this experiment. Seeds of the five genotypes were planted in peat moss trays. Four weeks old seedlings were transplanted into pots (25 cm) that contain peat and sand mixture (1:1) and one-half strength Hoagland was used for irrigation. Salinity treatments started seven days after transplanting by irrigated plants with half strength Hoagland solution supplemented by NaCl in four salinity levels 2, 5, 10, 15 dS/m beside control 1.2 dS/m. split plot design was used to achieve this experiment with three replicates. Plants salt tolerance was evaluated after 21 days of salt treatment.

K^+ and Na^+ determination

Leaves and roots of plants were dried and 0.1 g of each sample was digested with H_2SO_4 and H_2O_2 (Evenhuis and de Waard, 1980). Quantification of Na and K ions were done by flame photometer.

Proline content

For free proline determination, 0.5 g of each replicate was homogenized with 10ml sulfosalicylic acid 3%. The homogenate was filtered through Watman No. 1 filter paper. Two ml of the filtrate were left to react with 2 ml acid ninhydrine and 2 ml glacial acetic acid in a test tube for one hour at 100°C. The reaction was terminated in an ice bath. 4 ml toluene was used to extract the previous mixture, vigoursly mix for 15-20 5-20 sec.. Toluene containing chromophore aspirated from the aqueous phase, warmed to room temperature. At 520 nm, optical density of solution measure using toluene as blank. The determination of proline was done using the standard curve according to Bates *et al*. (1973). The data of proline was expressed as mg/g dry weight of leaf tissues.

Chlorophyll content

Extracts of plant material were obtained from green leaves 0.1 g by direct immersion in N,N-Dimethylformamide (DMF). Approximate ratio of 1:100 (w/v) for green material was used. Then samples solutions were measured for their absorbance by spectrophotometer, then chlorophyll a, chlorophyll b and total chlorophyll were measured according to Moran, 1982.

Statistical analysis

Data obtained were subjected to statistical analyses using Co-State Software (2004). Mean separation was done using the revised Least Significantly Difference (LSD) test at 0.05 probability level (Steel and Torrio, 1980).

RESULTS AND DISCUSSION

All salt-stressed plants showed a reduction on growth over the 3 weeks period of salt treatment. Compared to the control plants, the increase in salinity level of the nutrient solution resulted in a gradual reduction of the growth. Castle Rock plants were died at the two highest concentrations 10, 15 dS/m after three weeks of salt treatment.

Proline content

The content of free amino acid proline of the leaves of all genotypes of tomato showed significant rise with increased of salinity levels (Figure 1). The highest proline content was found at 15dS/m NaCl in the plants of the hybrid EXC followed by hybrid EXB.

It was noticed that the proline content in the sensitive cultivar, Castle Rock was higher than other genotypes at the first three salinity levels, that's agreed with storey and Wyn Jones (1977) reviewed that the increasing in proline content was not an evidence for tolerance but it is response to salt stress. Another study showed that Castle Rock had higher values of proline accumulation than in Edkawy cultivar (Fahmy *et al*., 1999).

Chlorophyll content

Chlorophyll content of plant tissue represented to efficiency of photosynthesis process, any factor effect on this vital process reduce the content of chlorophyll pigment. In this study, with increasing of salinity levels, chlorophyll content was reduced in all genotypes.

All tested genotypes showed that the presence of significant difference in the four salinity levels compared to the control group in chlorophyll a, chlorophyll b and total chlorophyll. The two hybrids had higher values of total chlorophyll than the three cultivars. Castle rock had smallest value of total chlorophyll at the highest salinity level 15dS/m, whereas Edkawy and Budai Torpe had moderate values between the previous (Figure 2).

Na^+ and K^+ measurements:

Na^+ content in the leaves and roots increase with increasing salinity levels in all genotypes. This increase was more in leaves than that in the roots (Sarg *et al.*, 1993).

The highest value of Na^+ was detected in EXB hybrid at salinity level 15 dS/m followed by EXC hybrid at 10 dS/m.

Potassium ions decreased with the increasing of salinity levels in all genotypes, this indicate that the potassium uptake was decreased in the presence of sodium chloride, which reflect the competition was occurred between K^+ and Na^+ ions in the transport system inside plants under salinity stress (Albino et al., 2007).

Na^+/ K^+ ratio was higher in shoots than that in roots. The highest value of Na^+/ K^+ ratio (5.70) was observed in EXB at 15 dS/m followed by EXC at 10 dS/m (3.98) (Table 1).

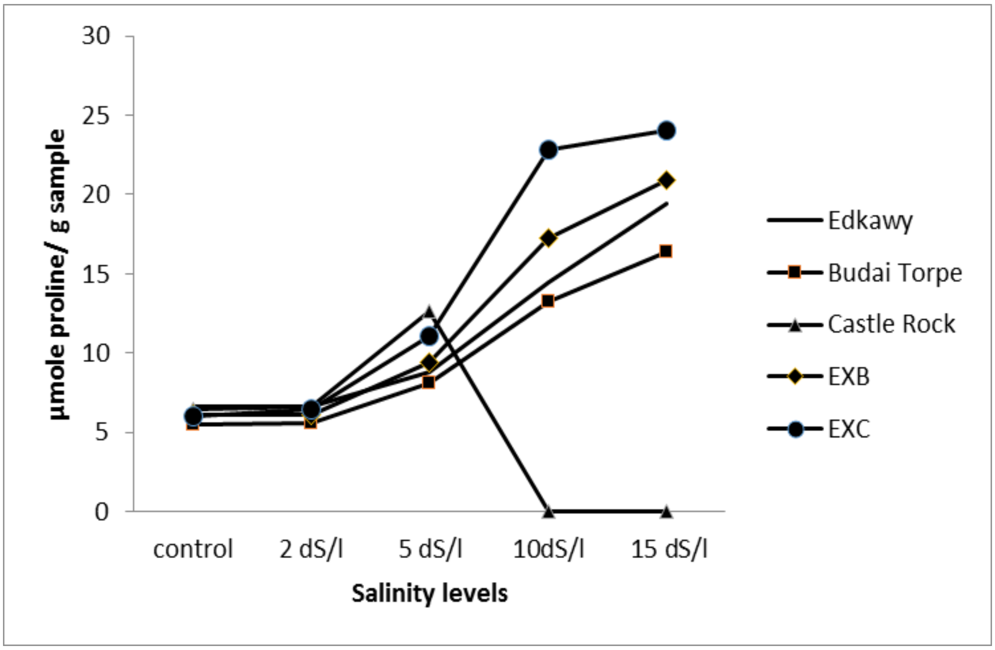

Figure 1. Effect of salinity levels on the average of proline content (µmole/g sample) in the leaves of the five tomato genotypes

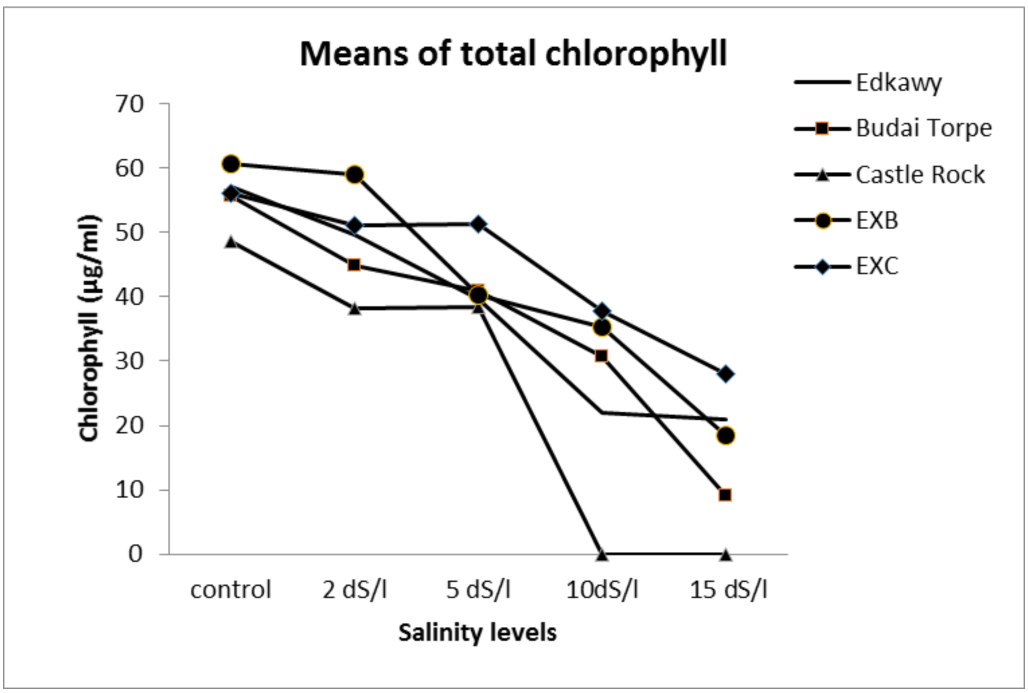

Figure 2. Effect of salinity levels on the average of total chlorophyll (µg/ml) in the leaves of the five tomato genotypes

Table 1. Na+ (ppm), K^+ (ppm) and Na^+/K^+ of the five tomato genotypes as affected by five salinity levels (T), control, 2, 5, 10, 15 dS/m

Genotypes	Treatments	Shoot			Root		
		Na^+	K^+	Na^+/K^+	Na^+	K^+	Na^+/K^+
Edkawy	T1	19ijk	41.67a	0.47gh	13ghij	31ab	0.42ij
	T2	10.67klm	15.33gh	1.35f	16fgh	28.67bcd	0.55hij
	T3	11.33klm	14gh	2.24de	17.67efgh	20.67def	0.85gh
	T4	42ef	11h	3.83bc	25.33cd	18.67efg	1.35ef
	T5	52.67cd	13gh	4.06bc	30bc	14.67fgh	2.04bc
Budai Torpe	T1	9.33lm	32.33b	0.29gh	10ij	23.67bcde	0.44ij
	T2	17jkl	28bc	0.61gh	18.33efg	31.33ab	0.59hij
	T3	31.33gh	17.33efgh	1.97def	18.33efg	12gh	1.56de
	T4	26.67hi	14.33gh	1.86ef	22.67de	12.33gh	1.84bcd
	T5	39fg	10.67h	3.76c	25.67cd	11.67gh	2.21b
Castle Rock	T1	8.67lm	33.33b	0.65g	9j	17.33efgh	0.53hij
	T2	32gh	23.33cdef	0.68g	20def	14fgh	1.43ef
	T3	22ij	16.33fgh	1.37f	21.33def	18.67efg	1.14fg
	T4	0n	0i	0h	0k	0i	0k
	T5	0n	0i	0h	0k	0i	0k
Edkawy x Budai Torpe	T1	9.67lm	28bc	0.34gh	10ij	37a	0.31jk
	T2	11.33klm	24.67cde	0.46gh	15.67fghi	21cdef	0.75ghi
	T3	48de	19.33defg	2.59d	34ab	21.33cdef	1.60de
	T4	73.33b	16.67fgh	4.39b	36.33a	21.67cdef	1.69cde
	T5	85.67a	15gh	5.70a	29.33bc	10.67gh	2.83a
Edkawy x Castle Rock	T1	6.67mn	29.33bc	0.26gh	12.33hij	29abc	0.45ij
	T2	13.33klm	25.33bcd	0.53gh	13.67ghij	16.33efgh	0.86gh
	T3	26.67hi	13.33gh	2.01de	22de	16.67efgh	1.32ef
	T4	59c	15gh	3.98bc	29.33bc	9.67h	3.03a
	T5	58c	15gh	3.90bc	36.67a	11.67gh	3.17a

* Means with the same character do not significantly different for each character.

CONCLUSION

The two hybrids were better than their parents in salinity tolerance demonstrated by the parameters studied under the experiment conditions. This is may be due to *hybrid vigour* which is the hybrid performed better than parents. It is recommended that these two hybrids Edkawy x Budai Torpe and Edkawy x Castle Rock need some studies for another yield characters.

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الملخص العربي

الاداء المقارن بين خمسة تراكيب وراثية من الطماطم تحت ظروف الملوحة

عفت عبد اللطيف بدر ، سناء احمد رياض، حورية محمد حسن، رمزى مرسى هدية، يحيى عبد السميع مصطفى ، منال احمد زكريا

تم قياس كل من محتوى البرولين والكلوروفيل ونسبة صوديوم/بوتاسيوم لكل من الاصناف ادكاوى وبوداى تورب و كاسل روك وكذلك الهجن الناتجة منها (ادكاوى x بوداى تورب) و (ادكاوى x كاسل روك) ؛ وقد وجد ارتفاع معنوى لكل من صفة محتوى البرولين ونسبة صوديوم/بوتاسيوم وانخفاض معنوى لصفة محتوى الكلوروفيل وذلك مع ارتفاع مستوى الملوحة وهى control, 2, 5, 10, 15 dS/m. الهجينان الناتجان اظهرا رد فعل مرتفع للملوحة حيث وجد فى الزيادة الملحوظة فى محتوى البرولين والكلورفيل والصوديوم عن باقى التراكيب الوراثية. اما الصنف الادكاوى فاعطى قيم متوسطة بين الهجن والابوين الاخريين.