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ADAPTATION AND SELECTION FOR NEW SALINITY TOLERATING TOMATO LINE (*Lycopersicon esculentum*)

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ABSTRACT

This study aimed to investigate the adaptation and selection of Castle Rock (fresh market tomato cv) for salinity tolerance. Also, to study the initial assessment of epigenetic variation under the salinity stress and taking advantage of these variations to adapt and select new tolerant line of Castle Rock. The study took about 6 years from 2005 to 2010. Adaptation and selection was conducted for the characteristics, plant height, main stem diameter, number of branches per plant, number of leaves per plant, leaf area, dry matters weight per plant, fruit setting, number of days to 50% flowering, number of days to fruit ripening, number of fruits per plant, average fruit weight, total yield per plant, total chlorophyll content, total soluble solids, titrated acidity, vitamin C content, seed germination, proline content, Ca^{++}, K^{+} and Na^{+} content. As well as, anatomy was done for the main stem examining the percentage in measure between the stem diameter and pith, cortex and xylem. Three tomato genotypes were under the trial, Castle Rock (salinity sensitive cv), Edkawy (salinity tolerance cv) and C_9 (Castle Rock adapted selected new line). C_9 proved tolerant to salinity through adaptation in 9 selecting cycles and it can be reproduced as a new Castle Rock improved line for salinity tolerance.

***Key words**: adaptation and selection, salinity tolerance, tomato.*

1. INTRODUCTION

Stalinity plays a major role in soil degradation. It affects 19.5% of irrigated land and 2.1% of dry land agriculture existing on the globe. In many crop production areas., using of low quality water for irrigation and application of excess amounts of mineral fertilizers are the major reasons for increasing salinity problem in cultivated soils. Due to very rapid accumulation of salts in soil, salinity problem is also a critical constraint to vegetable production (Shannon and Grieve, 1999). Salinity effects are more conspicuous in arid and semiarid regions, where limited rainfall, high evaporation and high temperature associated with poor water soil management contribute to the salinity problem and become of great importance for agriculture production in these regions.

Environment cues are perceived and transmitted by a myriad of plant signal transduction pathways that, by turning on specific transcription factors in the nucleus, lead to the activation of genes encoding effectors productions that enable adaptation to environmental challenges. In recent years, it is become clear that dynamic changes in chromatin properties and the biogenesis of small RNAs also contribute to transcriptional and post-transcriptional regulation of gene expression important for stress responses (Angers *et al.*, 2010; Madlung and Comai, 2004; Borsani *et al.*, 2005; and Kumar & Wigge, 2010). Salt tolerance is a complex, quantitative, genetic character controlled by many genes. A few of these genes have been identified and provide information that can be useful in screening and selection programs (Shannon and Noble, 1990). Information is lacking on how most genes function in concert with other genes that may have influenced the mechanisms of salt tolerance. There is some capacity for selection under a particular stress environment, *i.e.*, genetic variance is high compared to that under non-stress, tolerance might be improved without a concomitant yield decrease in a non-stress environment. These principles were demonstrated by Johnson *et al.* (1992) who found that selection for increased yield in alfalfa was effective under low and moderate salinities but not under non-saline conditions. Selection for salt tolerance under the wrong conditions or using the

wrong genetic material can result in low yielding selections that are not competitive with higher yielding, non-tolerant varieties (Richard, 1983). Environmentally induced epigenetic status (studying of heritable changes that occur without a change in the DNA sequence) thus could be passed to the progeny. Plant epigenetic has recently gained unprecedented interest, not only as a subject of basic research but also as possible new source of beneficial traits for plant breeding. These mechanisms are responsible for the formation of heritable epigenetic gene variants (epialleles) and also regulate transposons (a segment of DNA that is capable of independintally replicating itself and inserting the copy into a new position within the same or another chromosome or plasmid) mobility, both aspects could be exploited to broaden plant phenotypic and genetic variation, which could improve long-term plant adaptation to environmental challenges and, thus, increase productivity (Mirouze and Paszkowski, 2011). The main target of this investigation aimed to study the initial assessment of the degree of hidden epigenetic variation under stress conditions among genetically broad-based variety (Castle Rock), and then take advantage of these variations to obtain that breed salinity-tolerant.

2. MATERIALS AND METHODS

The current study was conducted during the years of 2005 to 2010. Two tomato cultivars, Castle Rock (salinity sensitive) and Edkawy (salinitiy tolerant), were used in an adaptation trial for Castle Rock cv to adapt and select new tolerant genotype. Nine selected adapted generations were achieved in plastic pots in two growing times, mid of February and August, during 2005 to 2009 for the adaptation trial in glasshouse at Vegetable Research Departments, Dokki-Giza and the evaluation trial for the ninth generation was carried out in plastic bags on Summer (mid of February) 2010 in the open field at Kaha Vegetable Research Station, Kalubia Governorate. The adaptation treatment was applied by diluting the sea water at the ratio 1 (sea water): 5 (fresh water) which measured 7.86 EC. Table (1) shows the chemical analysis for water samples used in the trial. The plants during the adaptation trial were irrigated two times by saline water without fertilizers and followed by one time by fresh water with compound fertilizer (Kristalon: 19 -19 -19, 1 gm/Liter). The evaluating trial was achieved for Castle Rock cv (mother population) and Edkawy (tolerated cv) that were irrigated with fresh water and saline water, while Castle Rock (adapted selected population, C_9) was irrigated with saline water. The used saline water for the evaluating trial was a diluted sea water for 4 EC (4 deciSemiens per meter = 4 dsm^{-1} = 4 milliohms per centimeter = 4* 640 ppm) that was applied during the whole trial period as alternately with irrigation contained compound fertilizer (Kristalon, 1 g/Liter). The used plastic pots and bags in both adaptation and evaluation trials were 20 liters volume and contained washed sandy soil with chicken manure.

Plant evaluation

Data were recorded for the characteristics, plant height (cm), main stem diameter (cm), number of branches per plant, number of leaves per plant, leaf area (cm^2), dry matter content per plant (g), fruit setting (%), number of days to 50% flowering, number of days to fruit ripening, number of fruit per plant, average fruit weight (g), total yield per plant (g), total chlorophyll content (SPAD units), total soluble solids per plant (%), titrated acidity (TA), vitamin C content (mg/100g), seed germination (%), proline content (mmol kg^{-1} FW), Ca^{++} content (mg/plant) - samples of leaves were taken three weeks later.

The determination of nutrient concentrations were according to Chapman and Pratt (1978). K^+ content (mg/plant), Na^+ content (mg/plant) and the anatomy of main stem was done to examine the differences between the diameter of cortex and pith comparing to the diameter of main stem, determination of the differences between the diameter of pith to the diameter of cortex. In addition, comparing the diameter of xylem vessels to the diameter of parenchyma cells of xylem. The three genotypes namely Castle Rock (sensitive genotype - mother population), Edkawy (tolerated genotype) and Castle Rock (adapted selected population - C_9) were used to an anatomy of main stem.

The Randomized Complete Block design (RCB) statistical analysis according to Snedecor and Cochran (1980) with three replications was used while the differences among the treatment means were compared using Duncan's (1955) multiple range test at 5% level.

Estimation of proline content in leaves was determined as described by Bates *et al.* (1973). Leaf tissues (250 mg) were rinsed three times with distilled water and the stoppered tubes with 10 ml water placed in a boiling water for 10 min to extract the hot water - soluble compounds. An aliquot of water extract was treated with ninhydrin reagent. Toluene phase was decanted and the absorbance was recorded at 250 nm. The

Table (1): Chemical characterization of water used for irrigation.

EC (ds m^{-1})	pH	Soluble ions (meq l^{-1})						SAR
		$Ca^{++}+Mg^{++}$	Na^{+}	K^{+}	$HCO3^{-}$	Cl^{-}	$SO4^{--}$	
Fresh water: 0.43	7.05	3.85	0.73	0.16	1.53	1.92	1.29	0.53
Diluted sea water: 4	7.27	17.49	25.3	0.42	1.21	39.47	2.53	8.55
Diluted sea water (1:5): 7.86	7.63	39.35	61.2	0.60	1.73	78.65	20.77	13.78

concentration of proline was calculated from a standard curve plotted with known concentration of L-proline as standard.

Estimation of vitamin C, total soluble solids (TSS) and titrated acidity: Three tomato fruits were juiced to be used in analysis of total soluble solids, vitamin C and titratable acidity. Total soluble solids content was measured with an optical refractometer. Titratable acidity was determined by titration with 0.1 M NaOH, also vitamin C content was determined according to A.O.A.C (1980). Chlorophyll content was measured with a SPAD.

3. RESULTS AND DISCUSSION

Data in Table (2) show the mean values of mother population of sensitive tomato plants (Castle Rock cv) and the selected individual plants that were derived from mother population for the yield character. The obtained results clearly showed that there were increasing in selection response to salinity adaptation in yield. The mother population (43.97 g) and the selected individual derived from mother population 102.90 (C_0) were lower in yield than the selected ninth cycle plants through adaptation to salinity and the individual selected plants (C_9), 99.51 g and 260.82 g, respectively. The increasing in the mean values was gradually through the selecting cycles from the first to the ninth cycle and that was in agreement with the breeder target during the study.

While, the coefficient of variation (CV%) showed reduction in respect to the yield of mother population, 72.30% (C_0) than the single selected plant, 41.30% (C_9). That reduction was gradually through the nine selecting cycles from the first to the ninth cycle and that was in agreement with the breeder target. Our finding generally agreed with those of Dai *et al.* (2007), Deal and Henikoff (2010) and Mirouze and Paszkowski (2011), who reported that there are many examples of acquired traits related to the activities of transposons, and especially retroelements, which are an abundant component of plant genomes. Thus, we propose that the most attractive way by which epigenetic regulation could contribute to enrichment of novel traits related to plant stress adaptation is, directly or indirectly, the controlled generation and exploitation of retrotransposon (transposon copied from RNA with the use of reverse transcriptase) induced genetic diversity. We could even envisage that plant populations with a variety of new retroelement insertions, to recruit activated retrotransposons as fast drivers of evolution. Next-generation sequencing technologies, the availability of methylomes from plants responding to stress, and access to tissue-specific or single cell-specific genome and epigenome information may provide us with sufficient resolution power and, thereby, more dynamic and thus more complete appreciation of the mobile part of the genome, mobilome. This will shed new light on its role in adaptive plant responses and their evolution.

Table (3a) shows the mean square for analysis of variance of genotypes (Castle Rock mother population-sensitive genotype, Edkawy tolerant genotype and Castle Rock adapted selected population) of tomato grown under saline irrigation. The results show significant differences for the characteristics: plant height, main stem diameter, number of branches per plant, number of leaves per plant, leaf area, dry matter per plant and fruit setting. Data in Table (3b) show the mean values of plant performance and the reduction and increasing percentage compared to the Castle Rock (mother population) for the characteristics plant height, main stem diameter, number of branches per plant, number of leaves per plant, leaf area, dry matter weight per plant and fruit setting difference percentage. The results showed that there was a significant for all previously mentioned characteristics. Regarding the mean values, there was significant differences for all the treatments between the adapted selected population compared to the mother population and Edkawy for all the characteristics except for number of branches per plant and fruit setting of the adapted selected population compared to Edkawy in saline water treatment that showed no significant differences. Also, the adapted selected population compared to the mother population under saline water irrigation showed no significant differences for the characteristic number of leaves per plant. The adapted selected population compared to the mother population showed reduction under fresh water treatment characteristics, plant height (-

Table (2): Selecting cycles for tomato plants (Castle Rock variety) under saline water irrigation during the years 2005 to 2009.

Selecting cycles	Number of population plants (n)	Average yield (g plant^{-1})	Number of survival plants	Coefficient variance (CV%)	Selected plants	
					Individual plant yield (g)	Entry code
C_0 (mother population) (Summer 2005)	120	43.97	71	72.30	104.21	CR-C0-1
					103.15	CR-C0-2
					101.35	CR-C0-3
					102.90	Mean
C_1 (Fall 2005)	120	42.34	69	70.90	122.53	CR-C1-1
					120.31	CR-C1-2
					119.25	CR-C1-3
					120.70	Mean
C_2 (Summer 2006)	120	50.67	75	64.50	155.73	CR-C2-1
					150.65	CR-C2-2
					145.93	CR-C2-3
					150.77	Mean
C_3 (Fall 2006)	120	59.23	77	55.30	173.56	CR-C3-1
					169.59	CR-C3-2
					162.62	CR-C3-3
					168.59	Mean
C_4 (Summer 2007)	120	59.23	74	55.90	189.53	CR-C4-1
					189.97	CR-C4-2
					186.31	CR-C4-3
					187.60	Mean
C_5 (Fall 2007)	120	73.55	71	49.70	203.51	CR-C5-1
					201.73	CR-C5-2
					188.59	CR-C5-3
					197.94	Mean
C_6 (Summer 2008)	120	73.92	76	49.30	223.51	CR-C6-1
					220.15	CR-C6-2
					211.63	CR-C6-3
					218.43	Mean
C_7 (Fall 2008)	120	89.23	75	44.40	230.51	CR-C7-1
					226.43	CR-C7-2
					221.13	CR-C7-3
					226.02	Mean
C_8 (Summer 2009)	120	95.52	79	40.20	264.63	CR-C8-1
					261.52	CR-C8-2
					254.13	CR-C8-3
					260.09	Mean
C_9 (Fall 2009) adapted selected population	120	99.51	77	41.30	271.13	CR-C9-1
					262.21	CR-C9-2
					249.13	CR-C9-3
					260.82	Mean

15.40) , main stem diameter (-9.69), leaf area (-3.80), dry matter weight per plant (-10.35) and fruit setting (-5.19), while it showed increasing under the same treatment in two characteristics namely number of branches per plant (45.68) and number of leaves per plant (0.73). In addition, it

showed increasing for the characteristics: plant height (83.41), main stem diameter (17.46), number of branches per plant (77.59), number of leaves per plant (51.67), leaf area (31.64), dry matter weight (32.92) and fruit setting (39.87) under saline water irrigation.

Table (4a) shows the mean square for analysis of variance of genotypes (Castle Rock mother population-sensitive genotype, Edkawy tolerant genotype and Castle Rock adapted selected population) of tomato grown under saline irrigation. The results show significant differences for the characteristics number of days to 50% flowering, number of days to fruit ripening, number of fruits per plant, average fruit weight, total yield per plant, total chlorophyll content and total soluble solids. Data in Table (4b) show the mean values of Castle Rock (mother population), Edkawy and the Castle Rock (adapted selected population), beside the reduction and increasing in the adapted selected population compared to Castle Rock (mother population) for the characteristics, number of days to 50% flowering, number of days to fruit ripening, number of days to fruit ripening, number of fruits per plant, average fruit weight, total yield per plant, total chlorophyll content and total soluble solids. The results showed significant differences for all characteristics. In respect to the differences among the mean performances there was a significant difference under both fresh and saline water irrigation comparing the adapted selected population to the mother population and Edkawy for the characteristics, number of days to fruit ripening, average fruit weight, total yield per plant, total chlorophyll content and total soluble solids. While, under the saline water irrigation there was no significant differences among the mean values of the Castle Rock (adopted selected population) comparing to both Castle Rock (mother population) and Edkawy for the characteristics number of days to 50% flowering and number of fruits per plant.

Comparing the Castle Rock (adapted selected population) to the Castle Rock (mother population) under fresh water irrigation, it showed reduction in mean performance for the characteristics number of days to ripening (-8.95), number of fruits per plant (-11.10), average fruit weight (-8.18), total yield per plant (-17.80), total chlorophyll content (-14,20) and under saline water irrigation for number of days to 50% flowering (-21.27), total soluble solids (-30.18). On the other hand, the adapted selected population showed increasing compared to the mother population (fresh water) for the characteristics number of days to 50% flowering (10.22) and total soluble solids (9.88), and the mother population (saline water) for number of days to fruit ripening (31.51), number of fruits per plant (1.34), average fruit weight (81.89), total yield per plant (68.95) and total chlorophyll content (24.16).

Table (5a) shows the mean square for analysis of variance of genotypes (Castle Rock mother population-sensitive genotype, Edkawy tolerant genotype and Castle Rock adapted selected population) of tomato grown under saline irrigation. The results show significant differences for the characteristics titrated acidity, vitamin C content, seed germination, proline content, Ca, K and Na content. Data in Table (5b) show the mean plant performance of Castle Rock (mother population) and Edkawy under both fresh and saline water besides the Castle Rock (adapted selected population) under saline water, also it shows the reduction and increasing in the adapted selected population (C_9) compared to the mother population (Castle Rock cv). The results obviously showed significant differences for the characteristics, titrated acidity, vitamin C content, seed germination, seed germination percentage, proline content, Ca^{++} content, K^+ content and Na^+ content. The compared means between Castle Rock (adapted selected population C_9), Castle Rock (mother population) and Edkawy showed significant differences for the characteristic shown in Table (5b) except for the vitamin C content and Na^+ content in comparing the adapted selected population (C_9 - saline water) to the mother population (fresh water). In respect to the reduction and increasing in mean plant performances, the Castle Rock (adapted selected population C_9) compared to the Castle Rock (mother population - fresh water irrigation) showed reduction for seed germination (-18.38), Ca^+ content (-8.17) and K^+ content (-11.25), while it showed increasing for titrated acidity (3.57), vitamin C content (0.42), proline content (147.93) and Na^+ content (2.88). On the other hand, Castle Rock (adapted selected population - C_9) compared to the mother population (saline water irrigation) showed reduction in the mean performance of the characteristics titrated acidity (-13.66), vitamin C content (-1.05), proline content (-9.57) and Na^+ content (-82.40), while it showed increasing for seed germination (44.83), Ca^{++} content (104.36) and K^+ content (95.96). Our findings generally agreed with that of Hsiao (1973) who reported that the higher salinity affects the osmotic pressure and the water absorption in plant which affects

consequentially the cell division and the meristemic cells growth in apical myristime and prevent them of getting the adequate size that allow to divide, and in the meantime affects plant growth especially plant height. Also, RajaseKaran and Shanmugavelu (1981) reported reduction in plant height by increasing the salinity in water irrigation of tomato (0.9 - 4.5 deciSemiens per meter (ds m^{-1}), (2.8 ds m^{-1}) and (6.5 ds m^{-1}).

Many researchers mentioned the reduction in dry matter weight of tomato plants under higher salinity (1.5, 3, 4.5, 6, 8 and 10 ds m^{-1}), Skogley and Haider (1969) and Nanawati and Maliwal (1974). Francois and Bernstein (1964) stated that salinity in growth area causes the plants to flower fast and fruit ripening as well. While, Kazim (1978) reported the contrary that the higher salinity resulted in preventing and delaying the flowering in tomato plants. In addition, Mizrahi (1982) reported that salinity caused the tomato plants to decrease the period between fruit setting and fruit ripening as well as the fruits were smaller in size and better in taste.

Salinity affects plant yield where it reduces the fruit weight, number and seeds through affecting the plant vegetative growth and nutritional balance in plant (Lapina and Popov, 1970 and Hsiao, 1973). Also, Shalhevet and Yaron (1973) found that the reduction of yield was 10% for each 1.5 ds m^{-1} higher salinity than in the root zone. In addition, Bernstein *et al.* (1974) reported that yield reduced by 50% under saline soil (8 ds m^{-1}). Similar results were obtained by Nukaya *et al.* (1979) who reported that tomato was irrigated with saline water (50 - 3000 ppm) the yield reduced by 47%. Rajasekaran and Shanmugavelu (1981) and Mondal (1983) reported reduction in tomato yield that was grown under irrigation with saline water ranged from 2.8 to 10.2 ds m^{-1}, the reduction ranged from 5 to 40%.

Many other researchers emphasized that salinity affects the photosynthesis process through affecting the chlorophyll content where the higher salinity leads to changes in chloroplasts construction and reduction in chlorophyll content and consequentially reduction in photosynthesis process (Nieman, 1962). In addition, Sivtser *et al.* (1973) reported that the higher salinity causes suppression of enzyme constructing like chlorophyllase that responsible of chlorophyll in plants. Also, salinity leads to reduction in chlorophyll of the tomato leaves that could be due to the negatively affection on chloroplast constructing and suppressing the nutritional elements absorption and transporting. Also, Tsenov *et al.* (1973) mentioned that the higher salinity leads to suppress the DNA and RNA production in tomato plant. In addition, it affects in constructing of some enzymes and their function especially ATPase that plays important role in the active transporting of ions through blasmic membrane (Knight *et al.*, 1997).

The amount of free proline is dependent on the degree of osmotic stress (Flowers *et al.*, 1977). Under non-saline conditions proline levels are low and increase as the salinity is raised and the capacity of proline accumulations is correlated with tolerance (Stewart and Lee, 1974). Amino acid proline concentration is positively correlated with the amount of $Na^{++}Cl^{-}$ in the plant. After a certain period, depending on plant age, the molar ratio of proline to ($Na^{++}Cl^{-}$) becomes constant. It is possible that proline may function as a compatible solute in the important role of balancing cytoplasmic and vacuolar water potentials (Flowers *et al.*, 1977)

The maximum soil salinity level that is tolerated by tomatoes without yield reduction is EC_e = 2.5 ds m^{-1} (Maas and Hoffman, 1977). However, as salinity increases, fruit development time is shortened by 4 - 15% and fruit size and juice pH is reduced (Mizrahi, 1982). The later author also reported an increase in total soluble solids (TSS), titratable acidity (TA), reducing sugars, and electrical conductivity (EC) of the tomato juice subjected to 3 and 6 grams of NaCl per liter (EC_w = 4.7 and 9.4 ds m^{-1}) of irrigation water.

Calcium ions play a crucial role in the regulation of the salt economy of plants and specially in the selective transport or exclusion of Na^{+} and specifically in the selective transport or exclusion of Na^{+} and other mineral ions by plant cell membrane (Lahaye and Epstein, 1969). Salinity reduces leaf K^{+}, Ca^{++}, Mg^{++} and NO^{-}_3 concentrations. Those plants which take up more K^{+}, Ca^{++}, Mg^{++} and NO^{-}_3 from the medium will have lower Na^{+}/K^{+}, Na^{+}/Ca^{++} and Na^{+}/Mg^{++} ratios and an equilibrium of nutrients more similar to the non-Salinised plants (Cuartero *et al.*, 1992; Perez-Alfocea *et al.*, 1996).

Table (6a) shows the mean square for analysis of variance of genotypes (Castle Rock mother population-sensitive genotype, Edkawy tolerant genotype and Castle Rock adapted selected population) of tomato grown under saline irrigation. The results show significant differences for the characteristics cortex, pith, pith/cortex and xylem vessels diameter. Data in Table (6b) show the anatomy measurements of main stem of

Table (3a): Mean square for analysis of variance of genotypes (Castle Rock mother population-sensitive genotype, Edkawy tolerant genotype and Castle Rock adapted selected population) of tomato grown under saline irrigation during the year 2010.

Source of Variance	DF	Characteristics						
		Plant height (cm)	Main stem diameter (cm)	Number of branches per plant	Number of leaves per plant	Leaf area (cm^2)	Dry matter per plant (g)	Fruit setting (%)
Blocks	2	3.10	0.02	0.02	0.32	0.15	0.03	0.01
Genotypes	4	8074.82*	3.23*	60.98*	2411.76*	1643.43*	3.06*	287.68*
Error	8	3.96	0.01	0.03	0.34	0.12	0.01	0.10

* Significant at 5% level

Table (3b): Mean performance, reduction and increasing of the three tomato genotypes (Castle Rock mother population-sensitive genotype, Edkawy tolerant genotype and Castle Rock adapted selected population) grown under saline irrigation during the year 2010.

Genotypes	Treatments		Characteristics						
			Plant height (cm)	Main stem diameter (cm)	Number of branches per plant	Number of leaves per plant	Leaf area (cm^2)	Dry matter per plant (g)	Fruit setting (%)
Castle Rock (mother population - sensitive genotype)	Fresh water	Mean	122.58 c	11.25 a	14.06 b	112.47 c	175.72 c	5.72 b	75.42 a
		Reduction and Increasing (%)	-15.40	-9.69	45.68	0.73	-3.80	-10.35	-5.19
	Saline water	Mean	56.54 e	8.65 e	11.53 c	74.69 d	128.41 e	3.86 d	51.12 d
		Reduction and Increasing (%)	83.41	17.46	77.59	51.67	31.64	32.92	39.87
Edkawy (tolerant genotype)	Fresh water	Mean	182.25 a	11.02 b	11.54 c	131.55 b	187.44 a	6.53 a	72.50 b
		Reduction and Increasing (%)	-43.09	-7.78	77.42	-13.88	-9.81	-21.36	-1.36
	Saline water	Mean	173.80 b	10.71 c	20.30 a	151.35 a	181.65 b	5.92 b	71.44 c
		Reduction and Increasing (%)	-40.33	-5.14	0.91	-25.14	-6.93	-13.37	0.09
Castle Rock (adapted selected population)	Selected for salinity tolerance		103.70 d	10.16 d	20.48 a	113.29 c	169.04 d	5.13 c	71.51 c
LSD			3.74	0.21	0.34	1.09	0.66	0.21	0.60

Significant at 5% level

Table (4a): Mean square for analysis of variance of genotypes (Castle Rock mother population-sensitive genotype, Edkawy tolerant genotype and Castle Rock adapted selected population) of tomato grown under saline irrigation during the year 2010.

Source of Variance	DF	Characteristics						
		Number of days to 50% flowering	Number of days to fruit ripening	Number of fruits per plant	Average fruit weight (g)	Total yield per plant (g)	Total chlorophyll content (SPAD unit)	TSS (%)
Blocks	2	0.04	0.06	0.07	0.03	6160.13	0.0001	0.005
Genotypes	4	158.37*	409.22*	149.09*	2964.38*	3193430.9*	0.01*	3.10*
Error	8	0.09	0.05	0.08	0.05	1277.99	0.0001	0.007

* Significant at 5% level

Table (4b): Mean performance, reduction and increasing of the three tomato genotypes (Castle Rock mother population-sensitive genotype, Edkawy tolerant genotype and Castle Rock adapted selected population) grown under saline irrigation during the year 2010.

Genotypes	Treatments		Characteristics						
			Number of days to 50% flowering	Number of days to fruit ripening	Number of fruits per plant	Average fruit weight (g)	Total yield per plant (g)	Total chlorophyll content (SPAD unit)	TSS (%)
Castle Rock (mother population - sensitive genotype)	Fresh water	Mean	46.74 d	100.33 a	18.50 b	86.36 c	1622.59 c	0.52 b	4.51 d
		Reduction and Increasing (%)	10.22	-8.95	-11.10	-8.18	-17.80	-14.20	9.88
	Saline water	Mean	65.44 a	69.45 e	16.22 c	43.59 e	789.35 e	0.36 e	7.09 a
		Reduction and Increasing (%)	-21.27	31.51	1.34	81.89	68.95	24.16	-30.18
Edkawy (tolerant genotype)	Fresh water	Mean	49.36 c	84.56 c	24.41 a	120.52 a	3082.70 a	0.56 a	5.07 c
		Reduction and Increasing (%)	4.36	8.01	-32.62	-34.20	-56.73	-20.74	-2.34
	Saline water	Mean	51.67 b	79.66 d	19.31 b	117.22 b	2252.04 b	0.47 c	5.86 b
		Reduction and Increasing (%)	-0.29	14.66	-14.82	-32.35	-40.77	-5.49	-15.45
Castle Rock (adapted selected population)	Selected for salinity tolerance		51.52 b	91.34 b	16.44 c	79.29 d	1333.69 d	0.44 d	4.95 c
LSD			0.57	0.43	0.85	0.44	67.97	0.01	0.15

Significant at 5% level

Table (5a): Mean square for analysis of variance of genotypes (Castle Rock mother population-sensitive genotype, Edkawy tolerant genotype and Castle Rock adapted selected population) of tomato grown under saline irrigation during the year 2010.

Source of Variance	DF	Characteristics						
		Titrated acidity	Vitamin C content (mg/100 g)	Seed germination (%)	Proline content (mmol kg-1 FW)	Ca (mg/plant)	K (mg/plant)	Na (mg/plant)
Blocks	2	3.46	0.006	0.02	0.002	0.0002	0.003	0.63
Genotypes	4	0.004*	0.42*	961.43*	7.92*	3.47*	5.69*	7.04*
Error	8	0.00001	0.004	0.35	0.001	0.0002	0.002	0.59

*Significant at 5% level

Table (5b): Mean performance, reduction and increasing of the three tomato genotypes (Castle Rock mother population-sensitive genotype, Edkawy tolerant genotype and Castle Rock adapted selected population) grown under saline irrigation during the year 2010.

Genotypes	Treatments		Characteristics						
			Titrated acidity	Vitamin C content (mg/100 g)	Seed germination (%)	Proline content (mmol kg^{-1} FW)	Ca (mg/plant)	K (mg/plant)	Na (mg/plant)
Castle Rock (mother population - sensitive genotype)	Fresh water	Mean	0.47 e	16.88 c	100.00 a	2.17 e	3.21 c	3.88 c	0.62 b
		Reduction and Increasing (%)	3.57	0.42	-18.38	147.93	-8.17	-11.25	2.88
	Saline water	Mean	0.57 a	17.13 b	56.35 d	5.96 a	1.44 e	1.75 e	3.64 a
		Reduction and Increasing (%)	-13.66	-1.05	44.83	-9.57	104.36	95.96	-82.40
Edkawy (tolerant genotype)	Fresh water	Mean	0.51 c	17.64 a	100.00 a	3.51 d	4.43 a	5.34 a	3.56 a
		Reduction and Increasing (%)	-4.45	-3.92	-18.38	53.51	-33.46	-35.55	-82.00
	Saline water	Mean	0.53 b	17.67 a	83.38 b	5.61 b	3.35 b	4.75 b	2.94 a
		Reduction and Increasing (%)	-8.02	-4.04	-2.11	-4.07	-11.90	-27.50	-78.17
Castle Rock (adapted selected population)	Selected for salinity tolerance		0.49 d	16.95 c	81.61 c	5.39 c	2.95 d	3.44 d	0.64 b
LSD			0.006	0.11	1.12	0.05	0.02	0.08	1.45

Significant at 5% level

Table (6a): Mean square for analysis of variance of genotypes (Castle Rock mother population-sensitive genotype, Edkawy tolerant genotype and Castle Rock adapted selected population) of tomato grown under saline irrigation during the year 2010.

Source of Variance	DF	Cortex (%)	Pith (%)	Pith/Cortex (%)	Xylem vessels diameter (%)
Blocks	2	0.0002	0.0001	0.0001	6.49
Genotypes	2	243.16*	253.33*	2004.01*	22.86 *
Error	4	0.0001	0.001	0.0002	0.06

* Significant at 5% level

Table (6b): Mean performance, reduction and increasing of the three tomato genotypes (Castle Rock mother population-sensitive genotype, Edkawy tolerant genotype and Castle Rock adapted selected population) grown under saline irrigation during the year 2010.

Genotypes	Cortex (%)	Pith (%)	Pith/Cortex (%)	Xylem vessels diameter (%)
Castle rock (mother population – sensitive genotype)	52.03 c	47.94 a	92.18 a	9.91 a
Edkawy (tolerant genotype)	68.24 a	31.14 c	45.64 c	7.36 a
Castle rock (adopted selected population)	66.93 b	33.08 b	49.43 b	4.02 b
LSD	0.02	0.07	0.03	5.78

Significant at 5% level

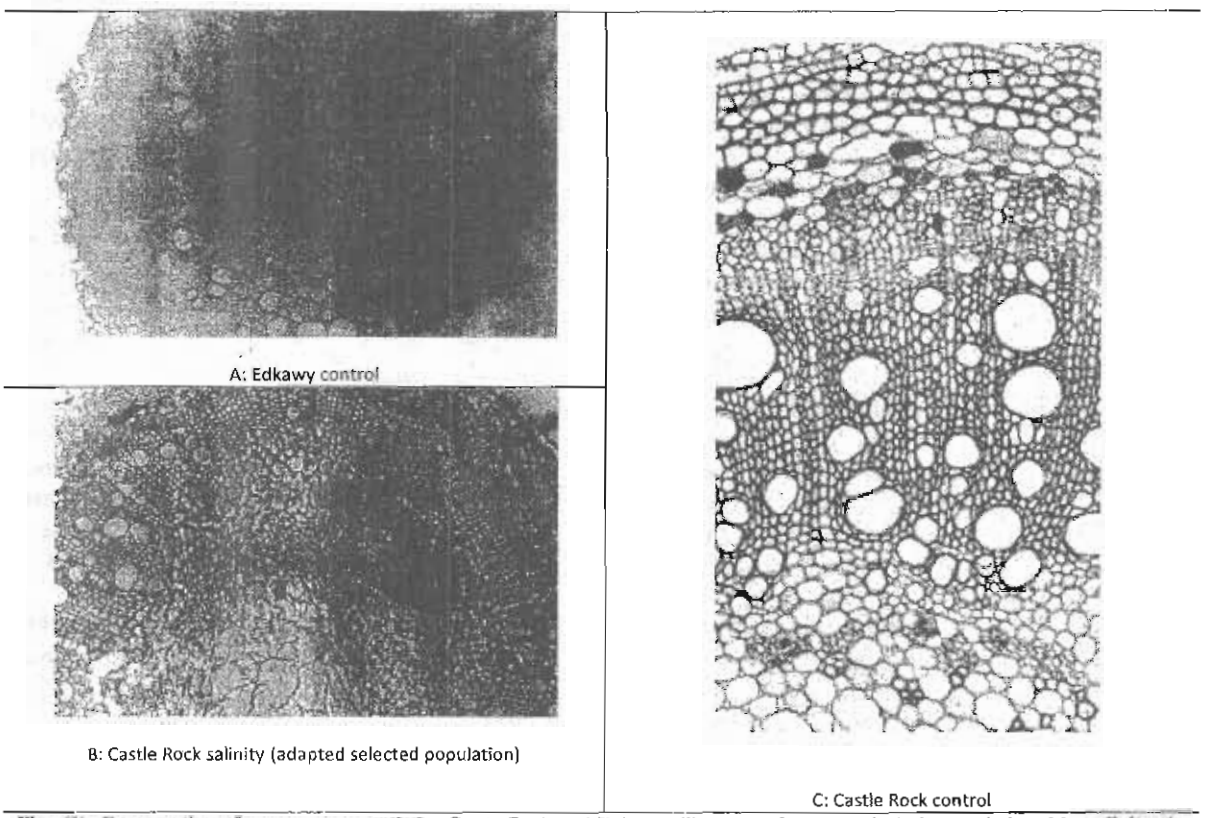

Fig. (1): Cross section of tomato stem, varieties Castle Rock and Edkawy, illustrates the anatomical changes induced by salinity. A: Edkawy tolerant genotype. B: Castle Rock (adapted selected population) with wide cortex, small pith and small xylem vessels diameter. C: Castle Rock (sensitive genotype) with small cortex, wide pith and wide xylem vessels diameter.

tomato plants grown under saline water stress.The percentage of comparison of cortex to the stem diameter showed significant differences and it was 52.03 for Castle Rock (sensitive genotype - mother population), 68.24 for Edkawy and 66.93 for Castle Rock (adapted selected population C_9). Comparing the pith to the stem diameter showed significant differences and it was 47.44 for Castle Rock (mother population), 31.14 for Edkawy and 33.08 for Castle Rock (C_9). In addition, the percentage of comparison of pith to cortex showed significant differences and it was 92.18 for Castle Rock (mother population), 45.64 for Edkawy and 49.43 for Castle Rock (adapted selected population C_9). While, the percentage of comparing the diameter of xylem vessels to the parenchyma cells showed significant differences and it was 9.91 for Castle Rock (mother population), 7.36 for Edkawy and 4.02 for Castle Rock (adapted selected population C_9). Similar results were generally reported by Ester *et al.* (1999) who stated that with increased salinity the cortex and pith of radical increased in width, while the xylem decreased. Also, salinity produced a reduction in the stele diameter of both genotypes because of the decrease in the number and diameter of the xylem vessels (Garzon and Marina, 2011). Figure (1) shows cross section of tomato stem (pith, cortex and xylem), varieties Castle Rock, Edkawy and C_9, illustrating the anatomical changes induced by salinity.

As a conclusion, C_9 proved tolerant to salinity through adaptation in 9 selecting cycles and it can be reproduced as a new Castle Rock improved line for salinity tolerance.

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التأقلم و الانتخاب لسلالة جديدة من الطماطم متحملة للملوحة

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ملخص

تهدف هذه الدراسة إلى التعرف على التأقلم والانتخاب فى صنف الطماطم كاسل روك (طماطم استهلاك طازج) لتحمل الملوحة. أيضاء لدراسة التقييم الأولي للتباين الجيني البيئى تحت اجهاد الملوحة والاستفادة من هذه الاختلافات فى التأقلم و انتخاب سلالة جديدة من الصنف كاسل روك متحملة للملوحة. أستغرقت الدراسة حوالي ٦ أعوام من ٢٠٠٥ إلى

٢٠١٠. وقد أجريت دراسة التأقلم والانتخاب على الصفات: طول النبات، قطر الساق الرئيسي، عدد افرع النبات، عدد أوراق النبات، مساحة الورقة، وزن المادة الجافة للنبات، عقد الثمار، عدد الأيام حتى ٥٠٪ ازهار، عدد الايام حتى نضج الثمار، عدد ثمار النبات، متوسط وزن الثمرة، المحصول الكلي للنبات، المحتوى الكلى من الكلوروفيل، المواد الصلبة الذائبة الكلية، حموضة الثمار، محتوى فيتامين ج، إنبات البذور، محتوى البرولين، محتوى الكالسيوم، محتوى البوتاسيـــوم و محتوى الصوديوم. وكذلك، تم تشريح الساق الرئيسي للنبات لدراسة النسبة المئوية لقياس قطر الساق إلى النخاع، القشرة و الخشب بساق النبات. تم تعريض ثلاثة طرز وراثية من الطماطم لاجهاد الملوحة هى كاسل روك (صنف حساس للملوحة)، الادكاوى (صنف متحمل للملوحة) و C_9 (سلالة جديدة متحملة للملوحة منتخبة من الصنف كاسل روك من خلال التكيف). أثبتت السلالة C_9 تحملها للملوحة من خلال التأقلم في ٩ دورات انتخاب و يمكن اكثارها كسلالة كاسل روك جديدة محسنة و متحملة للملوحة.

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