J. Agric. Sci. Mansoura Univ., 33 (2): 1227 - 1240, 2008

GENETIC AND PHYSIOLOGICAL STUDIES ON SALT STRESS IN TOMATO, *Lycopersicon esculentum* MILL.

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ABSTRACT

Physiological relationships between salt tolerance and expression of various physiological traits during vegetative growth, yield and yield components in tomato *Lycopersicon esculentum* Mill, were studied. Parental, varieties F_1, F_2 and back cross progenies of a cross between a salt sensitive cultivar (Castlerock) and a salt tolerant tomato cultivar (Edkawy) were evaluated in pot experiment under effects of irrigation with the Mediterranean Sea water. The concentrations 3000, 6000, 9000 ppm in addition to the control 700 ppm. were used.

Under salt stress, plant height, total fresh weight, total dry weight, chlorophyll content, yield and yield components were decreased. The reduction was significantly less in the edkawy than the castlerock, suggesting greater salt tolerance of the Edkawy.

A linear comparison of plant height, total fresh weight, total dry weight, chlorophyll content, total fruit weight, total fruit number and average fruit weight of F_1 hybrid with the parental varieties mid point indicated insignificant differences, suggesting, the absent of dominance effects on these traits under interaction salt stress and various genotypes.

Also, the back cross means of these traits tended toward the respective recurrent parent, preferred the role of additive and epistatic gene action effects.

The results also showed that K%, K/Na and Ca/Na significantly decreased with increasing water salinity meanwhile, Na and Ca increased with increasing water salinity, under salt stress. Edkawy accumulated significantly less Na and more K^+, Ca^{++} than castlerock, consequently the Ca/Na and K/Na ratio were significantly larger in Edkawy than castlerock. It appeared that the Edkawy was able to exclude more Na^+ and maintain more K^+ and Ca in Biomass than castlerock. Ion accumulation controlled by the additive and epistasis gene effects. Ion accumulation was, therefore, considered as a superior mechanism of salt tolerance in tomato and was suggested as a criterion for evaluating germplasm in breeding programs.

Multiple linear regression show that total FW, K, Na, Ca contents, NF/P_1 AFW, K/Na and Ca/Na ratio had a significant effect in predicting the total dry weight (g plant^{-1}) of tomato plants.

INTRODUCTION

Tomato is one of the most important vegetable crops in the world. Salinity is one of several soil environmental factors, which can limit the successful, production or even survival of vegetable crops (Mass & Hoffman, 1977 and Saranga *et al.*, 1993). Furthermore, soil salinity caused great losses on crop production agriculture by lowering the yield of various crops, and hence excessive salt accumulation prevents or limits the production of economic crops on millions of hectares (Van Genuchten and Hoffman, 1984 and Szoboles, 1989).

Increasing salinity in Egyptian soils and raising ground water table levels represent a serious problem, which could face crop production (Hassan and Galal, 1989). Moreover, tomato plantations in *Damietta and* north Dakahlia governorates (55000 fedans) may be grown on soils where salinity problems already exist or that may develop due to inadequate drainage combined with irrigation mis management, consequently, the ever increasing demand for agricultural products is now requiring reassessment of the production potential of low- quality land and water resources. Specifically, increased plant tolerance of saline and other poor water quality will be of great importance (Epstein *et al.*, 1980; Rush & Epstein, 1981 and Hassan *et al.*, 1999).

When salt sensitive crops such as tomatoes are exposed to high salinity, they cannot adequately controlled salt uptake in the sensitive shoots Hassan *et al.* (1999) reported that tomato place in the moderately sensitive category of economic crop species. El-Masry and Hassan (2001) reported that plants of edkawy cultivar were salt tolerant more than those of castlerock cultivar. The relative vegetative growth was unaffected up to Ec of 2.2 ds/m and 1.5 ds/m for edkawy and castlerock, respectively. Each unit increase in Ec above these values reduced vegetative yield by 3.2% and 4.3% for edkawy and castlerock, respectively. Also, (Malash *et al.*, 2002, Amor *et al.*, 2001 and Heuvelink *et al.*,2003), found that, salinity at 4 and 6 dsm^{-1} decreased total yield, marketable yield, number of fruits and average fruit weight in all genotypes studied and the least reductions in yield under salinity treatments cultivars floradade and edkawy this implies that such genotypes were relatively salt tolerant.

Several investigators have drawn attention to genotypic differences in salt-tolerance and salt-sensitive plants in respect to a number of pertinent physiological and biochemical parameters (Rush and Epstein, 1976 and 1981 Hassan and Galal, 1989). Also (Cuartero *et al.*, 2002 and Parra *et al.*, 2007) studied the variability for some physiological characters affecting salt tolerance in tomato. They found that, the variability for leaf tissue tolerance was less and was varied widely for root Na^{+} selectivity. Amor *et al.* (2001), reported that, fruit calcium and potassium concentrations were decreased significantly by increasing salinity levels this was compensated for the accumulation of sodium.

Dessalegne and Caligari (2001) revealed that the mode of inheritance of salt tolerance appeared to be different to that of plant characters and salinity levels as measured by plant height and fruit yield components. However, the fruit count was consistently controlled by additive gene effects. While, Foolad (1997) studied the genetic control of ion accumulation and reported that, absence of dominance effects on Na and Ca accumulation under salt stress. and that were genetically controlled with additively being the major genetic component.

Juan *et al.* (2005) revealed that the most salt resistant tomato cultivars are characterized by reduced uptake and foliar accumulation of Na^{+} and Cl^{-}, increased K^{+} uptake, in addition, the validity and effectiveness of certain nutritional and biochemical indicators of salt stress, such as the K^{+}/Na^{+} ratio and sucrose, also Kaya *et al.* (2007).

MATERIALS AND METHODS

Crosses were made between a salt sensitive (Castlerok) and a salt tolerant (edkawy) cultivar of tomato, *Lycopersicon esculentum* Mill, and F_1, F_2 and first back cross progenies were generated. The former accession (here after referred to as P_1) is salt sensitive (Hushim *et al.* 1990) and the latter (edkawy) is salt tolerant (Tolba, 1997). Six generations, including the two parents, the F_1, F_2 and back crosses to both parents were used in this study.

Experimental Procedures:

On October 15^{th} 2005 the seeds of cultivars edkawy and castlerock were sown in seedling trays under green house at El-Baramon Experimental Farm of Horticultural Research Institute, Mansoura.

Transplanting took place 45 days after sowing, these cultivars were crossed to obtain F_1 hybrid. In the second season, the seeds of F_1 hybrid and their parents were sown on 5^{th} October 2005 and transplanted under greenhouse at Baramon Experimental Farm. Some flowers from each parent and F_1 plants were selected to obtain more seeds of parental genotypes as well as to produce F_2 generations seeds. Some F_1 plants were also backcrossed to their parents in order to obtain BC_1 and BC_2 seeds. In addition, the crosses between these parents were done in the same manner to increase F_1 hybrid seeds. Parental cultivars, F_1, F_2, BC_1 and BC_2 generations were evaluated in pot experiment under green house in 2006 at especial farm in Sherbein – Dakhelia. These pots filled with soil which is clay loam in texture. Table 1 illustrated some physical and chemical properties of the studied soil.

Table 1: Some physical and chemical properties of the studied soil.

Sand %	Clay %	Silt %	Texture	PH 1:5 Ext.	EC dSm^{-1} (1:2.5)	Soluble cations (mg kg $soil^{-1}$)				Soluble anions (mg kg $soil^{-1}$)			
						Ca^{+2}	Mg^{+2}	K^+	Na^+	$CO_3^=$	HCO_3^-	Cl^-	$SO_4^=$
27.0	40.8	32.2	C Loam	8.0	1.30	5.2	4.0	0.70	13.8	--	9.8	11.9	3.4

Available Nutrients (mg kg $soil^{-1}$)		
N	P	K
33	12	420

The pot experiment was arranged in a split blot design with three replications. Each replicate consisted of four main plots which included the three salt levels as well as control, each main plot divided into six sub plots, which included the six generations (P_1, P_2, F_1, F_2 and BC_1 and BC_2) plants were transplanted in pots of 35 cm. diameter. The pot contained three plants. The saline treatments were applied after two weeks from transplanting, the basic nutrient solution was salinized with the Mediterranean sea water. The concentration of the Mediterranean sea water was 40000 ppm salts. Three different Ec_1 levels of saline water measuring 3000, 6000, 9000 ppm in addition to the control 700 ppm, were used as salt treatments, plants were irrigated with the saline water for three times and the one time irrigated with tap water to distribution solts in roots region (Hassan & Desouki, 1986). Table 2 reveals the chemical analysis of irrigation water.

Table 2 : Chemical analysis of irrigation water.

pH	EC dS m^{-1}	Cations (meq L^{-1})				Sum of anions	Anions (meq L^{-1})				Sum of anions
		Ca^{+2}	Mg^{+2}	K^{+}	Na^{+}		$CO_3^{=}$	HCO_3^{-}	Cl^{-}	$SO^{=}_4$	
8.3	35.5	10.30	4.35	9.74	281.0	305.05	--	8.95	168.0	28.10	305.05

Samples of plants represented different treatments were collected for growth measurements and chemical analysis. Data were recorded on individual plants, which were recorded. Plant height (cm.), biomass (shoots and leaves) were sampled after 50 days from transplanting, weighted-the vegetative growth. Mature Fully expanded leaves and shoots were sampled and weighted immediately and then dried at 70°C for 72 hr to determine the dry weight and analysis of mineral elements, sodium, potassium and calcium were determined by Mansoura Center of soil improvement, Mansoura, Egypt, total weight of fruits per plant (Ty) (g), average fruit weight (AFW) (g) and total number of fruits per plant (TNF).

Chlorophyll readings were determined by a Minolata SPAD chlorophyll meter (Yadavo, 1986) chlorophyll meter readings were taken on 2nd leaf from the plant top, reading were done on the tip of leaf (Leaf midline 0.3 – 0.5 cm from leaf tip). A Minolata SPAD chlorophyll meter uses light sources and detector to measure the light transmitted by a plant leaf at two different wave lengths (one in the red and one in the infrared region of the spectrum) the ratio of the light transmittance at those wave lengths, in addition to the ratio determined with no sample, is processed by the instrument to produce a reading shown on a digital display. This reading is in SPAD units, which are values defined by Minolta to indicate the relative amount of chlorophyll contained in plant leaves.

The statistical analyses of the obtained data was done according to the methods described by (Gomez and Gomez, 1984) using LSD to compare the means of treatments values. Also, the obtained data of the total dry weight (y) and total FW, K, Na, Ca contents (mg $plant^{-1}$), NF/P, AFW, K/Na and Ca/Na ratio were subjected to multiple linear regression and path coefficient analysis. In addition, partial coefficient of determination (R^2) was estimated for each component to evaluate the relative contribution and to construct the prediction model of the total dry weight (y) according to the following formula:-

$Y = a + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4$......(Snedecor and Cochran, 1982).

RESULTS AND DISCUSSION

As clearly shown in Table 3, the six population means of cross (Castlerock x Edkawy) showed that. P_2 (Edkawy) was higher than P_1 (Castlerock) parent for plant height, total fresh weight, total dry weight chlorophyll reading (SPAD), total weight of fruits/plant (Ty), total number of fruits/plant and average fruit weight, with the mean values of 69.07, 37.53 g, 4.93 g, 48.1, 0.53 Kg, 12.51 and 41.27 g., respectively. Similar findings were renorted by Hajer *et al.* (2006), Maggio *et al.* (2004) and Kaya *et al.* (2007). While, A linear comparison of plant height, total fresh weight ,total dry weight, chlorophyll, total fruit number/plant, total fruit weight and average fruit weight in the F1 hybrid (65.25 cm, 33.26 g, 4.59 g, 41.31 SPA, 11.9, 051 kg and

41.56 g) with the parental midpoint (66.22 cm. 34.83 g, 4.39 g, 43.99, 11.73, 0.48 kg, and 39.54 g) indicated in significantly difference. This finding suggest the absence of dominance effects on these traits under interactive salt stress and various genotypes.

Table 3: Effect of different salinity concentrations on vegetative growth and yield of tomato.

Parameters	Plant H. (cm)	Total FW (g)	Total DW (g)	Chlor*	Total yield	NF/P	AFW (g)
Genotypes							
P1	63.39	32.12	3.85	39.88	428.0	10.93	37.81
P2	69.08	37.54	4.93	48.1	527.53	12.52	41.27
F1	65.25	33.26	4.59	41.31	511.38	11.9	41.56
F2	62.82	32.24	4.58	42.11	499.22	12.05	41.23
Bc1	61.75	32.25	3.85	39.74	341.86	9.808	34.96
Bc2	66.76	35.71	3.64	47.91	423.8	11.34	37.46
L.S.D	1.016	0.75	0.15	1.85	66.10	0.96	6.65
Salinity levels (ppm)							
C	71.03	38.20	5.72	46.88	644.6	12.666	50.43
3000	67.94	36.49	4.80	46.08	514.8	11.566	44.24
6000	63.76	32.63	3.93	40.53	343.3	11.244	30.32
9000	56.61	28.10	2.97	39.22	318.5	10.216	31.20
L.S.D	0.820	0.82	0.14	1.56	42.87	0.44	4.48

*Chlor. = Chlorophyll reading (SPAD).

The results also revealed that the back crosse means of most studied traits tended toward the respective recurrent parent, preferred the role of additive and epistatic gene action effects. These results agreement with the mode of inheritance of salt solerance controlled by additive gene effects (Saranga *et al.*, 1992 and Dessalegne and Caligari 2001).

Also, data presented in Table 3 showed that plant height, total fresh weight, total dry weight, chlorophyll content, total weight of fruits/plant, number fruits/plant, and average fruit weight was reduced as water salinity concentration increased, the level of 9000 ppm salinity gave the most reduction in all studied traits with means 56.1, 28.1, 2.97, 39.22, 318.5, 10.22 and 31.2 g, respectively. These results are in accordance with the results obtained by Malash *et al.* (2002) and Amor *et al.* (2001).

The six population means of cross (Castlerock x Edkawy) were calculated for means of various ions percentage and content in dry weight of biomass, and the obtained results are shown in Table 4. The means showed that under salt stress the P_2 Edkawy (salt tolerant cultivar) accumulated significantly less Na^+% and more K^+ % and Ca^{++} % than Castlerock (Salt sensitive cultivar). Consequently, the Ca/Na and K/Na ratio were significantly larger in P_2 than P_1.

It also appeared that the P_2 (Edkawy) was able to exclude more Na^+ and maintain more K and Ca in leaf than was P_1. Similar findings were reported for tomato (Foolad, 1997, Juan *et al.*, Maggio *et al.*, 2007 and Kaya *et al.*, 2007). The reported that leaves of salt tolerant cultivor under salt stress accumulated significantly less Na^+ and Cl^- and more Ca^{+2} than leaves of sensitive cultivar. Also, A linear comparison of Ca%, Ca/Na and K/Na ratio in the F1 hybrid (1.28,2.6 and 4.17) with the parental midpoint (1.37, 2.69, and 4.27) indicated in significant differences suggesting the absence of dominance effects on these traits under interactive salt stress and various genotypes.

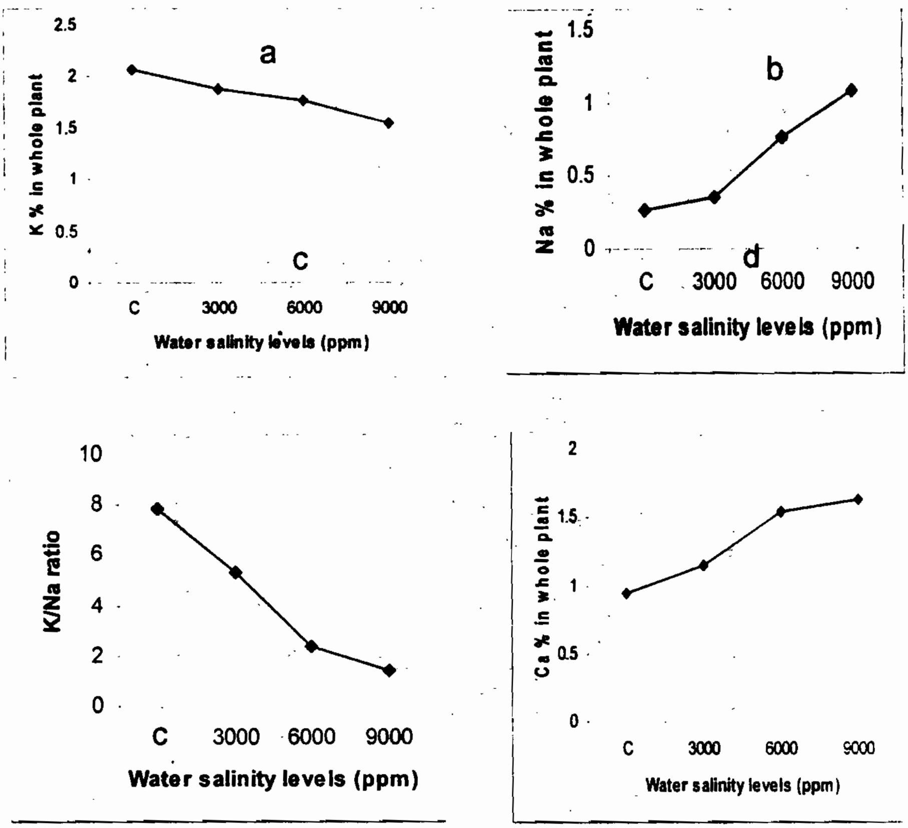
Table 4: Means of various ions content (mg plant^{-1}) and percentage in dry weight of biomass tomato plants as affected by salinity levels (ppm).

Parameters / Treatments	K %	K cont. (mg plant-1)	Na %	Na cont. (mg plant^{-1})	Ca %	Ca cont. (mg plant^{-1})	k/Na ratio	Ca/Na ratio
Genotypes								
P1	1.74	70.06	1.74	22.84	1.31	47.23	4.19	2.49
P2	1.86	93.69	1.86	24.83	1.44	67.83	4.36	2.89
F1	1.72	81.14	1.72	23.71	1.28	56.37	4.17	2.65
F2	1.82	85.73	1.82	26.8	1.18	52.08	4.10	2.24
Bc1	1.80	66.75	1.80	19.8d	1.24	42.07	4.18	2.42
Bc2	1.72	89.39	1.72	23.21c	1.42	61.82	4.45	2.87
L.S.D	0.067	3.54	0.067	1.002	0.056	2.29	0.19	0.103
Salinity levels (ppm)								
C	2.07	118.66	2.07	15.36	094	53.76	7.88	3.58
3000	1.88	90.44	1.88	17.08	1.15	55.30	5.31	3.23
6000	1.77	69.61	1.77	29.78	1.54	60.6	2.35	2.05
9000	1.54	45.78	1.54	31.92	1.63	48.61	1.44	1.52
L.S.D	0.034	2.53	0.034	1.07	0.067	3.53	0.22	0.134

While the F_2 generations means was superior over their F_1 hybrid means for K (% and its content) and Na (% and content). These findings reflect the transgressive segregation and indicating the role of additive and epistasis gene effects in the inheritance of these traits. Data also, showed that the back cross means of most studied traits tended toward the respective recurrent parent, reflecting the role of additive and epistasis gene effects These results, were in agreement to the results found by foolad 1997.

Also, data and (Fig. 1-a and c) show that, K% K/Na ratio and Ca/Na ratio means were significantly decreased with increasing water salinity. The differences between the control and levels of 3000, 6000 and 9000 ppm were significant at these traits. This finding indicated that tomato was characterized by high selectivity for K^+/Na^+ ratio. Similar results were found for tomato by Hashim *et al.* (1988 and 1990) and Saranga *et al.* (1993). On the other hand, Na% and Ca% means were significantly increased with increased water salinity (Fig. 1-b and d). Na accumulation under increasing salinity were reported by Rush and Epstein (1976 and 1981).

As shown in Table 5, data reveal that, plant height, total fresh weight, total dry weight, chlorophyll readings (SPAD), total fruit weight/plant, total number of fruits/plant and average fruit weight were significantly decreased as affected by the interactive of salinity water and various genotypes.



Figs. 1 (a, b, c and d): Means of various ions percentage in dry weight of biomass tomato plants as affected by salinity levels (ppm).

The results also showed that, P_2 (edkawy) under the control achieved the highest means of the plant height, total dry weight and chlorophyll readings with means 73.13 cm, 6.09 g and 51.5 (SPAD), respectively. The BC_1 under control achieved the highest means of total fresh weight with means 40.29 g, while, the F_1 hybrid under the control achieved the highest means of yield and yield components (total fruit weight/plant, total number of fruits/plant and average fruit weight), with means 828.33 g, 14.66 and 56.57 g, respectively. On the other hand, the BC_1 under level of 9000 ppm. achieved the lowest means of plant height, total fresh weight, total dry weight, chlorophyll readings and total fruit number with the means of 51.26 cm., 23.28 g, 2.14 g, 34.66 (SPAD) and 8.66, respectively. Also, the P_1 (Castlerock) under level of 9000 ppm achieved the lowest means of total fruit weight/plant and average fruit weight with means 213.69 g and 23.55 g, respectively.

This reduction in growth and consequently in yield may be attributed to the fact that exposure to salinity during growth induces stunted growth and structural changes at various levels of organization. Additionally, it could be noticed that the large variations in response of different plants and crops to salinity can be related to the following causes which have been reported by Poljakoff – Mayber and Gale (1975); (a) their ability to exclude salt from sensitive tissues cells and organelles, (b) the ability to achieve complete osmotic adjustment, (c) the ability to generate stabilizing macromolecules and enzyme systems (d) the ability to carry out other adaptive modifications, at the lowest possible cost to overall plant growth.

Table 5: The means of vegetative growth, yield and yield components of tomato plants as affected by interactive of genotypes and salinity levels (ppm).

Treatments \ Parameters		Plant height (cm)	Total FW (g)	Total DW (g)	Chlorophyll	Total Yield (g)	(NF/P)	AFW (g)
C	1	70.93	37.59	5.59	43.766	680.9	12.33	55.21
	2	73.13	40.22	6.09	51.5	733.33	13.66	53.69
	3	72.53	35.66	5.92	43.63	828.33	14.66	56.57
	4	69.07	36.72	5.78	46.06	673.33	13	52.1
	5	69.40	38.68	5.23	45.1	451.66	10.66	42.30
	6	71.10	40.29	5.71	51.2	500	11.66	42.75
3000	1	68.00	36.06	4.11	43.43	541.93	11.6	46.71
	2	70.53	39.18	5.42	51.16	646.18	13.66	47.28
	3	69.13	35.94	5.09	43.23	560.75	11.6	48.30
	4	67.53	34.71	4.94	46.06	388.68	11.46	43.38
	5	64.90	35.66	4.12	43.43	498.12	9.96	38.98
	6	67.56	37.38	5.12	49.16	453.17	11.1	40.82
6000	1	60.36	29.13	3.2	36.8	275.52	10.7	٢٥,٧٦
	2	69.06	36.73	4.72	43.1	397.99	11.93	33.33
	3	62.76	33.87	4.11	40.3	362.18	11.43	31.69
	4	61.87	30.69	4.37	40.56	411.42	11.4	35.91
	5	61.43	31.37	3.03	35.76	245.86	9.93	24.81
	6	67.06	33.98	4.12	46.63	366.77	12.06	30.39
9000	1	54.26	25.72	2.47	35.53	213.69	9.06	23.55
	2	63.56	34.00	3.48	46.63	332.63	10.8	30.78
	3	56.46	27.58	3.24	38.07	294.27	9.9	29.68
	4	52.80	26.85	3.21	35.76	414.04	12.33	33.54
	5	51.26	23.28	2.14	34.66	281.24	8.66	33.75
	6	61.30	31.15	3.23	44.63	375.43	10.53	35.88
L.S.D		1.71	1.93	0.35	1.76	108.66	1.27	NS

Data presented in Table 6 show that K content, K/Na and Ca/Na ratio means decreased significantly as affected by the interactive of water salinity and various genotypes, whereas, the highest means were 131.39, achieved by P_2 (Edkawy) under the control 9.54 and 4.43 achieved by P_1 (Castlerock) under the control salinity level, respectively. While, the lowest means were 34.25, 1.08 and 1.27 achieved by P_1 (Castlerock) under the 9000 ppm level. Potassium and potassium/sodium ratio decreased as soil salinity increased, this may be indicated that tomato is characterized as high selectivity for K/Na ratio similar results were found for tomato by Hashim *et al.* (1988 and 1990), Saranga *et al.* (1993), Hassan *et al.* (1999) and El-Masry and Hassan (2001), Junn *et al.* (2005), Parra *et al.* (2007) and Kaya *et al.* (2007).

On the other hand, Na content and Ca contents were increased as affected by interactive water salinity and genotypes, whereas, the highest means were 37.68 and 81.92 achieved by F_2 under the level of 9000 ppm and P_2 under the level of 6000 ppm, respectively. The lowest means were 12.32 and 32.85 achieved by P_1 (Castlerock) under the control salinity level and BC_1 under the level of 9000 ppm, respectively. Sodium accumulation under increasing salinity was reported by Rush and Epstein (1976 and 1981), Hassan *et al.* (1999) and El-Masry and Hassan (2001). They found that increasing soil salinity leads to increase Cl and Na, in the leaf tissue of tomato. The back cross populations accumulated ratio of Na, Ca and K that were generally similar to their recurrent parent.

From these data, it appeared that the inability of Castlerock to stand salinity was linked to its limited efficiency in keeping Na in leaf tissue below toxic levels and compensating for lower water potentials associated with salinity by increasing tissue levels of organic solutes (Rush and Epstein, 1976 and El-Masry and Hassan, 2001). The Edkawy cultivar was not similarly affected by Na and accumulated large concentrations in leaf tissue as has been shown for other tomato genotypes (Rush & Epstein, 1976, Hassan *et al.*, 1999 and El-Masry and Hassan, 2001).

Table 6: The means of various ions percentage and its content (mg plant^{-1}) in dry weight of tomato plants biomass as affected by interactive of parents and salinity levels (ppm).

Treatments \ Parameters		K%	K cont mg plant^{-1}	Na%	Na cont. mg plant^{-1}	Ca%	Ca cont. mg plant^{-1}	K/Na	Ca/Na
C	1	2.10	117.32	0.22	12.32	0.97	54.41	9.54	4.43
	2	2.16	131.39	0.3	18.26	0.93	57.05	7.19	3.12
	3	1.95	115.50	0.26	15.40	0.96	56.86	7.51	3.70
	4	2.18	126.24	0.32	18.51	0.92	53.76	6.85	2.91
	5	1.92	100.54	0.22	11.69	0.86	45.04	8.6	3.85
	6	2.12	121.01	0.28	16.00	0.97	55.45	7.57	3.47
3000	1	1.85	75.95	0.42	17.27	1.1	45.26	4.4	2.62
	2	1.93	105.05	0.33	18.07	1.26	68.15	5.81	3.77
	3	1.84	93.76	0.34	17.50	1.11	56.76	5.36	3.24
	4	1.86	92.05	0.3	15.03	0.94	46.72	6.15	3.11
	5	1.84	76.01	0.4	16.50	1.12	46.46	4.61	2.82
	6	1.95	99.84	0.35	18.09	1.33	68.44	5.52	3.79
6000	1	1.65	52.71	0.94	30.08	1.52	48.87	1.76	1.63
	2	1.75	82.87	0.64	30.24	1.73	81.92	2.74	2.71
	3	1.67	68.65	0.69	28.5	1.50	61.79	2.41	2.17
	4	1.76	76.91	0.82	35.98	1.36	59.44	2.14	1.66
	5	1.84	55.97	0.86	26.12	1.45	43.94	2.14	1.68
	6	1.95	80.56	0.67	27.77	1.64	67.63	2.90	2.43
9000	1	1.35	34.25	1.28	31.70	1.63	40.37	1.08	1.27
	2	1.59	55.47	0.94	32.77	1.84	64.20	1.69	1.96
	3	1.44	46.64	1.03	33.44	1.54	50.09	1.39	1.5
	4	1.48	47.72	1.17	37.68	1.5	48.39	1.27	1.29
	5	1.60	34.47	1.16	24.91	1.53	32.85	1.38	1.32
	6	1.74	56.16	0.96	31.00	1.73	55.78	1.81	1.80
L.S.D		8.09	8.09	8.09	0.02	0.09	0.09	0.29	0.19

The multiple linear regressions as shown in the following equation exert that, all obtained parameters i.e. total FW, K, Na, Ca contents, NF/P, AFW, K/Na and Ca/Na ratio had a significant effect and vital role in predicting the total dry weight (g plant^{-1}) of tomato plants. The expected equation to predict the total dry weight of tomato plants was computed as:

Regression coefficient between the total dry weight of tomato plant and Total FW, K, Na, Ca uptake, NF/P, AFW, K/Na and Ca/Na.

Variables	Regression coefficient	Standard Error SE
Total FW	0.00941	0.01229
K content	0.033109	0.004745
Na content	0.03000	0.01477
Ca content	-0.00397	0.01137
NF/P	0.03962	0.02165
AFW	0.002404	0.003158
K/Na	-0.02522	0.09293
Ca/Na	0.3820	0.2448

Constant (a) = -0.5685 R-Sq = 97.6% R-Sq (adj) = 97.3%

Meanwhile, the technique stepwise regression analysis showed that, the most important variables which contribute total dry weight of tomato plants (Y) were; K contents (r^2 = 97.3**), Ca contents (r^2 = 33.9^{NS}) and K/Na ratio (r^2 = 82.9**). So, there are polynomial predicting equations for the total dry weight of tomato plants (Y) as following:

Y = 0.501575 + 5.84E-02X – 1.19 E-04X**2 for K contents (with r^2 = 97.0%, Fig 2).

Y =-5.90496 + 0.328541X – 2.48E-03X**2 for Ca contents (with r^2 = 97.0%, Fig 3).

Y = 1.92015 + 0.870543X – 5.07E-02X**2 for K/Na ratio (with r^2 = 97.0%, Fig 4).

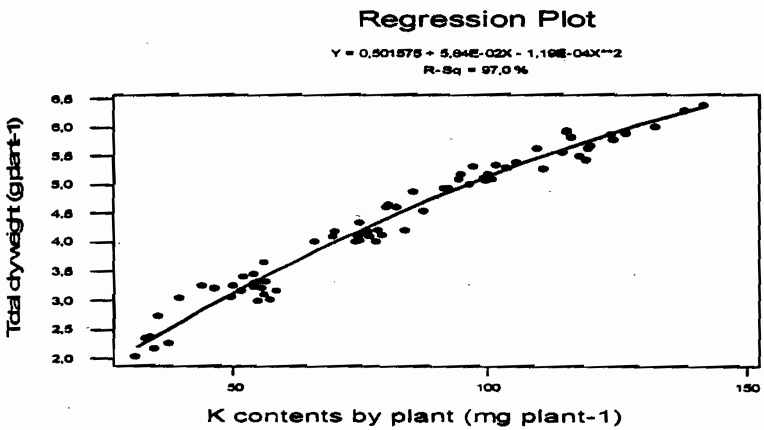


Fig. 2: Simple regression coefficient between total dry weight(mg plant^{-1}) and K contents (mg plant^{-1}) in tomato plants.

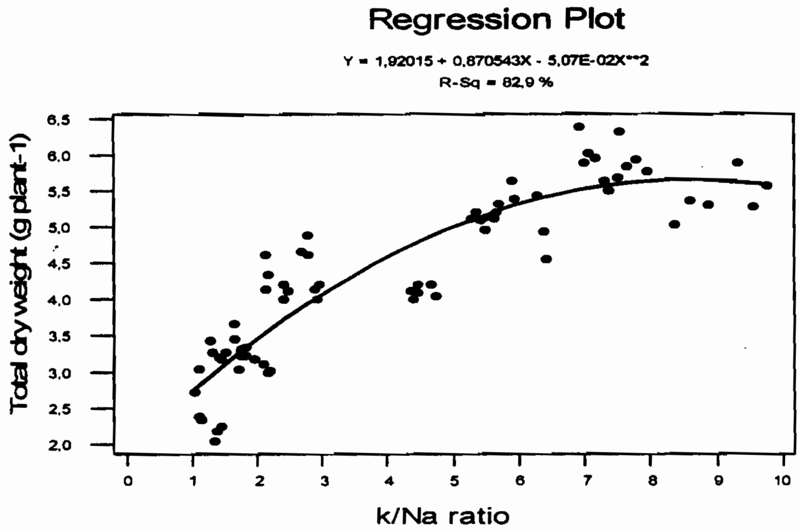


Fig. 3: Simple regression coefficient between total dry weight (mg plant^{-1}) and Ca contents (mg plant^{-1}) in tomato plants.

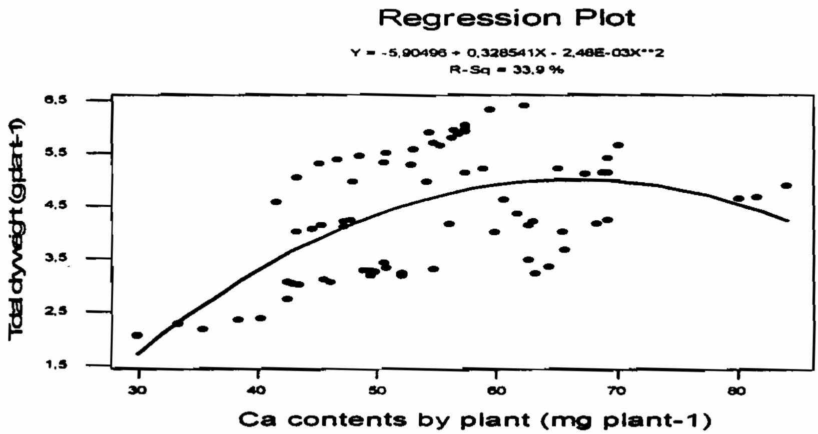


Fig. 4: Simple regression coefficient between total dry weight (mg plant^{-1}) and K/Na ratio.

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دراسات وراثية وفسيولوجية على الإجهاد الملحي فى الطماطم

وهبة على السيد رمضان[1]، الشبراوى عبد الحميد أمين[1] والمتولى مصطفى سليم
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فى هذا البحث تم دراسة العلاقات الفسيولوجية بين المقاومة للملوحة وتعبير الصفات الفسيولوجية المختلفة خلال مرحلة النمو الخضرى والمحصول فى الأباء والجيل الأول والجيل الثانى والهجن الرجعية للهجين الناتج من تهجين صنف حساس للملوحة (كاسل روك) وصنف لتحمل الملوحة (إدكاوى).

تم تقييم هذه التراكيب الوراثية بواسطة الرى بماء ملحى من البحر الأبيض المتوسط الذى تم تخفيفه للحصول على بتركيزات ٣٠٠٠، ٦٠٠٠، ٩٠٠٠ جزء فى المليون علاوة على مستوى الكنترول ٧٠٠ جزء فى المليون.

وتشير النتائج إلى أن طول النبات والوزن الطازج والوزن الجاف والكلوروفيل والمحصول ومكوناته انخفضت تحت تأثير الملوحة، ولكن هذا الانخفاض كان أقل معنوية فى الصنف الأبكاوى عما فى كاسل روك وهذا يوضح صفة المقاومة للملوحة فى الأدكاوى بالمقارنة بين متوسط الـ F_1 لصفات طول النبات والوزن الطازج للنبات والوزن الجاف والكلوروفيل والوزن الكلى للثمار على النبات والعدد الكلى للثمار على النبات ومتوسط وزن الثمرة بمتوسط الأبوين، لهذه الصفات يتبين أن الفروق غير معنوية وهذا يدل على غياب تأثير جينات السيادة فى وراثة هذه الصفات تحت التأثير المشترك للملوحة والتراكيب الوراثية المختلفة وكذلك تميل الهجن الرجعية إلى الأب الرجعى فى الصفات الخضرية و فى المحصول مما يشير إلى وجود التأثير الفعال لجينات الإضافة والتفوق فى وراثة تلك الصفات.

كما تشير النتائج إلى انخفاض كل من البوتاسيوم ونسبة البوتاسيوم إلى الصوديوم، وكذلك نسبة الكالسيوم إلى الصوديوم كلما زادت ملوحة مياه الرى، بينما تزداد نسبة الصوديوم فى الأنسجة لزيادة ملوحة مياه الرى.

كما يتبين أن الصنف الأدكاوى تراكم به نسبة من الصوديوم أقل ونسبة أعلى من البوتاسيوم والكالسيوم عما فى الصنف الكاسل روك وينتج عن ذلك أن نسبة كل من الكالسيوم والبوتاسيوم إلى الصوديوم كانت أعلى فى الأدكاوى عنها فى صنف كاسل روك. ويرجع ذلك إلى الصنف الأوكاوى كانت لديه القدرة على استقصاء نسبة كبيرة من الصوديوم خارج الخلايا النباتية والاحتفاظ بنسبة عالية من البوتاسيوم والكالسيوم عما هو الحال فى الكاسل روك.

كما يتضح أن تراكم الأيونات فى أنسجة نباتات الطماطم تحت التأثير المشترك للملوحة والتراكيب الوراثية المختلفة يتحكم فى وراثتها العوامل الوراثية المضيفة والمتفوقة بدرجة أكبر.

يعتبر تراكم الأيونات آلية للمقاومة للملوحة فى الطماطم لذلك يمكن أن تكون مقياس لتقيم التراكيب الوراثية فى برامج التربية للمقاومة للملوحة.