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TOLERANCE RESPONSE OF MUSKMELON GENOTYPES AGAINST SALINITY

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Muskmelon is the most important fruit crop of arid and semi-arid regions and salinity as the most prevailing substance in such areas. Therefore, the present study was conducted to evaluate salt tolerance of muskmelon (*Cucumis melo* L.) genotypes based on some morphological, physiological and biochemical attributes in hydroponic system in the growth chamber of Plant Physiology Program, Crop sciences Institute, National Agricultural Research Centre, Islamabad, Pakistan during 2011-12. Seven muskmelon genotypes (T-96, Ravi, Mankera, White Candy, Bukhara, Surkh Kharboza and Adventa-1701) were sown in plastic trays for germination and then shifted to 3L nutrient solution in hydroponics containers. Fourteen days old plants were subjected to 0, 100, and 200 mM NaCl for sixteen days. Increasing levels of salt stress substantially declined the shoot and root biomass, plant height, root length and leaf area in all the tested muskmelon genotypes; however, genotypes differed in their response. Increasing level of salt also decreased the tested physiological and biochemical attributes; although genotypes T-96 and Mankera had higher photosynthesis (4.9 and 4.3 µmol m^{-2} s^{-1}), stomatal conductance (142 and 132 mmol m^{-2} s^{-1}), and higher K^+/Na^+ ratio (1.22 and 1.11 %) respectively at maximum salt level. Genotypes T-96 and Mankera were found salt tolerant, Ravi and White Candy as moderate and remaining genotypes as salt sensitive.
Keywords: Muskmelon, salt tolerance, salinity, K^+ concentration, Na^+ concentration

INTRODUCTION

Salinity is one of the main factors in the reduction of growth and crop productivity in arid and semi-arid regions of the world in spite of latest techniques developed in few decades (Edelstein *et al*., 2011). Salt stress altered almost all the physiological and biochemical development within the plants, higher transport of Na^+ declined the water potential and reduced the uptake of essential nutrients like K^+ in the plant tissues (Cicek and Cakirlar, 2002; Gurmani *et al*., 2013). A number of plant species showed decline in growth and production under saline conditions due to decrease in photosynthesis by the action of stomatal and non-stomatal restrictions (Stepien and Klobus, 2006; Dadkhah, 2011). The potential salt tolerance depends on the capability of a plant to exclude Na^+ transport or tolerance of Na^+ within the leaf tissues (James *et al*., 2006). Similarly, James *et al*. (2011) also reported that salinity stress is a kind of hyper ionic stress and high accumulation of Na^+ and Cl^- ions in plant tissues inhibits the uptake of K^+ and other beneficial ions. Sodium (Na^+) is most toxic ion of the salt, which adversely effects the plants growth by inhibiting their enzymatic activities and the metabolic processes. An optimum K^+/Na^+ ratio is important to run the enzymatic reactions in cytoplasm which is necessary for maintenance of plant growth (Wakeel, 2013). A reduction in various gas exchanges attributes, for example photosynthesis, transpiration, stomatal conductance and water use efficiency under saline conditions has been reported in different crops (Stepien and Klobus, 2006; Ashraf and Harris, 2013). Salinity induced decline in net photosynthetic rate is mainly dependent on plant genotype. Generally salt tolerant genotypes showed least reduction in net photosynthetic rate and stomatal conductance than salt sensitive genotypes (Kanwal *et al*., 2011; Gurmani *et al*., 2014).

Because of the heterogeneity in saline soil field conditions, greenhouse based screening of genotypes are generally preferred as compared to field evaluation (Munns and James, 2003). Although all the plant growth stages are sensitive to salinity, however seedling stage is found to be critical in most plant species (Munns, 2002). Selection of salt tolerant cultivars on the basis of physiological and biochemical traits have been investigated in various crop species like muskmelon (Botia *et al*., 2005), watermelon (Colla *et al*., 2006), Tomato (Shibli *et al*., 2007) and cucumber (Zhu *et al*., 2008). Vegetable crops are mostly sensitive to salinity (Botia *et al*., 2005) and the improvement in salt tolerance by the traditional breeding has very limited success in the past (Flowers, 2004).

Muskmelon (*Cucumis melo* L.) is an important potential crop of dry and semidry areas, which is threatened with medium to high salinity (Botia *et al*., 2005). Although muskmelon is

recognized to be semi tolerant to salinity (Franco *et al*., 1997), but how much it can withstand against salinity, depends on the genetic diversity, environment and genotype (Gurmani *et al*., 2014). The depression in growth and yield losses due to salinity in various melon cultivars have been reported in a number of studies (Franco *et al*., 1997; Botia *et al*., 2005). Many attempts have been accomplished to increase the salt tolerance of melon by the physiological responses of salt stress. Salinity hampered the muskmelon growth, reduces its yield as it adversely affect its photosynthetic rate, stomatal conductance, transpiration and increase the toxic ions (Na^+, Cl^-) level (Franco *et al*., 1997; Mavrogianopoulos *et al*., 1999). The main objective of the present study was to evaluate the performance of seven commercial muskmelon genotypes under salt stress on the basis of various morphological, physiological and biochemical attributes. Assessments were further made as to whether there is any correlation between physiological and biochemical parameters with plant biomass.

MATERIALS AND METHODS

Seed of seven genotypes of muskmelon viz., T-96, Ravi, Mankera, White Candy, Bukhara, Surkh Kharboza and Adventa-1701 were obtained from Ayub Agricultural Research Institute (AARI), Faisalabad, Pakistan. The experiment was carried out in hydroponic system in the growth chamber of Plant Physiology Program, Crop sciences Institute, National Agricultural Research Centre, Islamabad, Pakistan during 2011-12. Growth Chamber was maintained at 14hr photo period with a light intensity of 400-500µmol $m^{-2}s^{-1}$ photosynthetically active radiation with a temperature between 25±5°C. Seeds were treated with 5% sodium hypochlorite solution for 2 minutes and then washed several times with distilled water. Fifty seeds of each genotype were sown in plastic trays containing silica washed sand and were grown for ten days. Forty seedlings of each genotype were selected and shifted into 5 black boxes, each containing 8 seedlings and 3L half strength Hoagland's solution (Hoagland and Arnon, 1950). These plants were allowed to grow for four days in Hoagland's solution in the same black boxes. Seedlings (14-days old) were then subjected to 0, 100 and 200mM NaCl levels and were allowed to grow for 16 days. Plants (30 days old) were harvested and data (leaf area, shoot and roots length and dry weight) were collected immediately. Leaf area was determined by leaf area meter (Li-Cor, model LI-3000A) UK. Shoot and root biomass were dried in oven at 70°C for 72 hours and weighed.

***Physiological parameters*:** Data on gas exchange parameters like photosynthetic rate (*A*) and stomatal conductance (g_s) were recorded through Infrared Gas Analyzer (IRGA, LCA-4, ADC, Hoddesdon UK). The readings were taken from the fully expanded 4th leaf from the base of the muskmelon plants at mid-day (10:30am to 12:30pm). During gas exchange measurements, humidity ranged from 60-65%, temperature 28-32°C, photon flux density 1000µmole (photon) $m^{-2}s^{-1}$ and CO_2 concentration ranged from 350-355 µmol mol^{-1}.

***Biochemical parameters*:**

***Chlorophyll contents*:** Fresh leaf sample was chopped in mortar and pestle using 20mL of 80% acetone. The sample was centrifuged at 2500rpm for 10 minutes. The supernatants of samples were used for chlorophyll estimation. Readings were taken at A_{654} nm and A_{663} nm of wavelength for chlorophyll 'a' and 'b' and total chlorophyll was calculated by summation of chlorophyll 'a' and 'b', using spectrophotometer (Unico-UV 210 Japan). Leaf total chlorophyll contents were calculated according to Arnon (1949).

***Na^+, K^+ determination*:** Na^+ and K^+ were analyzed by dry ash method in muffle furnace at 550 °C for 5 hours. Subsequently, 2N HCl was added to the ash samples for 1h. Samples were diluted to 50mL with distilled water and then filtered through Whatman42. Sodium and potassium concentrations were determined by spectrophotometer (Sherwood model 410, Japan).

***Statistical analysis*:** The experiment was laid out as Completely Randomized Design. Data collected on variables were analyzed by M-STAT software. Analysis of Variance (ANOVA) was applied and LSD (Least Significant difference) test was used to test the difference among treatments as suggested by Steel and Torrie (1980). The regression analysis was also performed as prescribed by Gomez and Gomez (1984). Association between shoot dry weight and all the tested parameters were analyzed by simple linear regression at 200mM NaCl stress using MS-Excel-2010. In order to calculate salt indices, each observation was divided by the average of control at a given salt level. On the basis of mean performance, ranking numbers were allocated and applied to score each genotype. This was based on Ward's minimum variance analysis. By totaling these ranked numbers, a summation was acquired, and on the basis of summation genotypes ranking as tolerant, moderate and sensitive to salinity was determined as outlined by Zeng *et al*. (2002).

RESULTS AND DISCUSSION

***Morphological parameters*:** The data showed that shoot-root dry weight and shoot-root length of all the tested genotypes were significantly decreased at both salinity levels (Table 1, 2). The mean values showed that maximum shoot (1.33 g) and root (0.118 g) dry weight was recorded in genotype T-96, while minimum shoot (1.16 g) and root (0.104 g) dry weight was observed for genotype Bukhara. The reduction percentages in shoot and root dry weight were (33%) and (24%) in T-96, whereas in Bukhara it were (56%) and (54%) respectively when evaluated at 200mM NaCl. The mean data also showed that shoot dry weight for Mankera was (1.31 g),

Table 1. Effect of different levels of NaCl on shoot and root dry weight of muskmelon genotypes.

Genotypes	Shoot dry weight (g)				Root dry weight (g)			
	0mM	100mM	200mM	Mean	0mM	100mM	200mM	Mean
T-96	1.61±0.05	1.29±0.08	1.09±0.06	1.33 a	0.133±0.012	0.122±0.012	0.100±0.006	0.118 a
Ravi	1.64±0.14	1.26±0.07	0.96±0.05	1.29 ab	0.135±0.004	0.110±0.006	0.088±0.006	0.111 ab
Mankera	1.59±0.07	1.31±0.08	1.03±0.05	1.31ab	0.137±0.003	0.117±0.003	0.098±0.005	0.117a
White candy	1.62±0.07	1.25±0.06	0.90±0.06	1.26 bc	0.141±0.008	0.115±0.006	0.093±0.005	0.116 a
Bukhara	1.61±0.07	1.13±0.05	0.73±0.04	1.16 e	0.135±0.006	0.102±0.007	0.075±0.007	0.104 b
Surkh Kharbuza	1.57±0.05	1.19±0.08	0.81±0.04	1.19 de	0.133±0.005	0.109±0.006	0.080±0.007	0.107 b
Adventa-1701	1.61±0.06	1.27±0.08	0.77±0.03	1.22 cd	0.131±0.007	0.106±0.009	0.076±0.005	0.104 b
Mean	1.61 a	1.24 b	0.90 c		0.135 a	0.112 b	0.087c	

Means not sharing common letters are significantly different at 5% level of probability.

Table 2. Effect of different levels of NaCl on shoot and root length of muskmelon genotypes.

Genotypes	Shoot length (cm)				Root length (cm)			
	0mM	100mM	200mM	Mean	0mM	100mM	200mM	Mean
T-96	30.13±0.67	26.93±0.64	21.73±0.20	26.27 a	13.03±0.93	12.03±0.52	10.86±0.28	11.97 ab
Ravi	29.96±0.72	24.56±0.49	17.50±0.40	24.01 b	12.66±0.91	11.23±0.79	9.33±0.26	11.07 c
Mankera	30.39±0.44	26.26±0.41	20.23±0.81	25.63 a	13.26±0.54	12.10±0.55	10.56±0.52	11.97 ab
White candy	29.86±0.86	23.90±0.32	17.80±0.49	23.85 b	13.66±0.49	11.76±0.84	10.00±0.82	11.81 abc
Bukhara	30.96±0.85	23.60±0.64	16.56±0.50	23.71 b	13.63±0.32	11.46±0.65	9.53±0.52	11.54 bc
Surkh Kharbuza	31.50±0.67	26.50±0.72	18.63±0.42	25.54 a	14.60±0.74	12.43±0.50	10.43±0.28	12.48 a
Adventa-1701	30.90±0.74	24.46±0.78	17.43±0.66	24.26 b	13.23±0.96	11.23±0.66	9.33±0.47	11. 26 bc
Mean	30.53 a	25.18 b	18.56 c		13.44 a	11.75 b	10.01 c	

Means not sharing common letters are significantly different at 5% level of probability.

Table 3. Effect of different levels of NaCl on leaf area and chlorophyll contents of muskmelon genotypes.

Genotypes	Leaf area (cm^2)				Chlorophyll (mg g^{-1} FW)			
	0mM	100mM	200mM	Mean	0mM	100mM	200mM	Mean
T-96	27.07±0.70	23.71±0.40	20.55±0.27	23.78 a	1.40±0.043	1.22±0.054	0.97±0.059	1.20 a
Ravi	26.86±0.61	22.78±0.61	16.26±0.35	21.97 bc	1.43±0.034	0.98±0.056	0.68±0.051	1.03 c
Mankera	27.71±0.73	24.19±0.64	18.69±0.59	23.53 a	1.42±0.037	1.12±0.070	0.89±0.064	1.14 b
White candy	27.82±0.60	23.60±0.63	16.40±0.54	22.60 b	1.38±0.027	1.05±0.051	0.76±0.050	1.06 c
Bukhara	27.27±0.67	21.72±0.53	14.27±0.39	21.08 c	1.46±0.042	0.81±0.033	0.37±0.046	0.88 e
Surkh Kharbuza	27.10±0.85	22.37±0.30	15.67±0.57	21.71 bc	1.36±0.061	0.85±0.070	0.43±0.055	0.88 e
Adventa-1701	27.29±0.75	22.11±0.35	14.86±0.33	21.42 c	1.39±0.065	0.90±0.023	0.51±0.061	0.93 d
Mean	27.30 a	22.92 b	16.67 c		1.40 a	0.99 b	0.66 c	

Means not sharing common letters are significantly different at 5% level of probability.

Ravi (1.29 g), White candy (1.26 g), Surkh Kharbuza (1.19 g) and Adventa- 1701 (1.22 g) and the reduction percentages were 35, 41, 44, 49, and 52% respectively at 200 mM NaCl when compared to control plants. Similarly, the reduction percentages in root dry weight of Mankera, Ravi, White candy, Surkh kharbuza and Adventa-1701 were 29, 34, 34, 40, and 41% respectively at 200mM NaCl when compared to control. Shoot and root length of all the tested genotypes were also significantly decreased with the increasing level of salt.

The mean data showed that maximum shoot length (26.27cm) was obtained in T-96 and the minimum shoot length (23.71cm) was observed in Bukhara. The reduction percentages in shoot and root length were 28 and 16% in T-96, 42 and 26% in Ravi, 33 and 23% in Mankera, 40 and 27% in White Candy, 47 and 33% in Bukhara, 41 and 29% in Surkh Kharbuza and 44 and 26% in Adventa-1701, respectively when evaluated at 200mM NaCl. Leaf area of all the tested genotypes was significantly decreased with the increment of salt levels; however maximum leaf area (23.78 cm^2) was recorded for T-96 and minimum leaf area (21.08 cm^2) was observed in Bukhara (Table 3). T-96 showed the least leaf area decrease which was 24% only, while Bukhara showed maximum decrease of 48% at 200mM NaCl. Present results showed that vegetative growth of all the tested genotypes was generally declined with the increasing level of salt; however tolerant genotypes behaved differently in this regard. Genotypes T-96 and Mankera achieved greater biomass and leaf area while genotype Bukhara produced lowest under both

Table 4. Effect of different levels of NaCl on Na^+ and K^+ concentration of muskmelon genotypes.

Genotypes	Na^+ (%)				K^+ (%)			
	0mM	100mM	200mM	Mean	0mM	100mM	200mM	Mean
T-96	0.28±0.006	0.65±0.035	1.39±0.088	0.77 e	2.59±0.081	2.19±0.116	1.70±0.155	2.16 a
Ravi	0.33±0.015	0.95±0.108	1.72±0.091	1.00 bc	2.70±0.091	1.97±0.159	1.29±0.116	1.99 bc
Mankera	0.27±0.012	0.76±0.047	1.47±0.064	0.83 de	2.54±0.116	2.14±0.110	1.58±0.105	2.09 ab
White candy	0.30±0.012	0.84±0.050	1.64±0.118	0.93 cd	2.42±0.059	2.07±0.090	1.45±0.089	1.98 bcd
Bukhara	0.26±0.006	1.17±0.089	1.99±0.138	1.14 a	2.35±0.051	1.76±0.121	1.03±0.113	1.71 e
Surkh Kharbuza	0.25±0.006	0.97±0.075	1.71±0.108	0.97 bc	2.47±0.052	1.91±0.137	1.09±0.116	1.82 de
Adventa-1701	0.28±0.009	1.09±0.072	1.88±0.078	1.08 ab	2.62±0.083	1.84±0.098	1.04±0.044	1.83 cde
Mean	0.28 c	0.91 b	1.68 a		2.53 a	1.99 b	1.31 c	

Means not sharing common letters are significantly different at 5% level of probability.

Table 5. Salt tolerance indices of different parameters in muskmelon genotypes under different salinity levels.

Genotypes	Salinity	SDW	RDW	SL	RL	LA	Na^+	K^+	K^+/Na^+	TC	A	gs
T-96	100	0.80	0.92	0.89	0.93	0.88	132.8	0.85	0.37	0.87	0.75	0.74
	200	0.67	0.76	0.72	0.84	0.76	398.0	0.66	0.13	0.69	0.26	0.47
Ravi	100	0.77	0.81	0.82	0.89	0.85	189.1	0.73	0.25	0.69	0.54	0.62
	200	0.59	0.66	0.58	0.74	0.61	425.0	0.47	0.09	0.47	0.16	0.39
Mankera	100	0.82	0.85	0.86	0.91	0.87	180.0	0.85	0.30	0.79	0.61	0.70
	200	0.65	0.71	0.67	0.77	0.67	439.4	0.62	0.12	0.63	0.23	0.44
White candy	100	0.77	0.81	0.80	0.86	0.85	182.7	0.85	0.31	0.76	0.56	0.65
	200	0.56	0.66	0.60	0.73	0.59	452.6	0.62	0.11	0.56	0.19	0.41
Bukhara	100	0.70	0.76	0.76	0.84	0.80	349.4	0.75	0.17	0.55	0.53	0.60
	200	0.46	0.56	0.53	0.67	0.52	668.5	0.44	0.06	0.25	0.13	0.30
Surkh Kharbuza	100	0.76	0.82	0.84	0.89	0.83	288.8	0.77	0.20	0.63	0.54	0.61
	200	0.51	0.60	0.59	0.71	0.58	586.7	0.54	0.07	0.32	0.16	0.37
Adventa-1701	100	0.79	0.81	0.79	0.85	0.81	279.5	0.70	0.18	0.65	0.56	0.63
	200	0.48	0.59	0.56	0.74	0.54	555.9	0.50	0.06	0.37	0.17	0.30

SDW, shoot dry weight; RDW, root dry weight; SL, shoot length, RL, root length; LA , leaf area; TC, total chlorophyll; A, Photosynthetic rate; gs, stomatal conductance.

salt stress levels. A significantly positive correlation was observed between shoot dry weight and root dry weight (0.92^{**}), shoot length (0.68^{*}) and leaf area (0.89^{**}). However, correlation between shoot dry weight and root length (0.41^{ns}) was not significant (Table 6). Earlier studies also confirm that genotypic differences exist for salinity tolerance within the plant species (Islam *et al*., 2008; Hussain *et al*., 2013; Gurmani *et al*., 2014).

Genotypes sustaining greater biomass under salt stress are considered salt tolerant while those produced less biomass are salt sensitive (Hussain *et al*., 2013; Gurmani *et al*., 2014). The decrease in shoot and root length of plant was attributed due to the uptake and accumulation of toxic ions like Na^+ and Cl^- in cell wall, which reduce cell turgidity and decrease cell enlargement and cell division (Islam *et al*., 2008; Hussain *et al*., 2013). In muskmelon, genotypes having the ability to maintain balance ions uptake especially K^+, Na^+ and Cl^- under salt stress are can be recognized as salt tolerant. Keeping high K^+/Na^+ ratio in cytosol is the main characteristic of salt tolerant plants (Wang *et al*., 2016). Our results also showed that the genotypes with higher Na^+ concentrations showed less plant biomass; while the plants with less Na^+ had higher plant biomass. Genotypes with greater K^+/Na^+ ratios showed greater tolerance to salinity and gave high biomass production.

Table 6. Linear regression equation between values of shoot dry weight and physiological/ionic attributes in muskmelon at 200 mM NaCl.

Physiological/ionic attributes	Regression equation	R^2
Root dry weight	Y=0.074X+0.0206	0.92**
Shoot length	Y=11.184X+8.486	0.68*
Root length	Y=3.0568X+7.123	0.41^{NS}
Leaf area	Y=15.538X+2.682	0.89**
Total chlorophyll	Y=1.641X-0.818	0.91**
Photosynthetic rate	Y=5.786X-1.782	0.77**
Stomatal conductance	Y=134.35X-3.737	0.84**
Na^+	Y=-1.457X+2.999	0.87**
K^+	Y=1.922X-0.419	0.90**
Na^+/K^+	Y=1.933X-0.931	0.90**

**, $P < 0.01$; *, $P < 0.05$ and NS, Non-Significant

Leaf is the important food preparatory component of plant. Higher buildup of Na^+ ions in cytoplasm is the possible reason for leaf area reduction in plants as high salinity creates osmotic stress and reduces the uptake of essential mineral elements (Gurmani *et al*., 2014). Similar results have been observed on muskmelon (Franco *et al*., 1997), maize (Cicek and Cakirlar, 2002), squash (Yildirim *et al*., 2006), wheat (Gurmani *et al*., 2007), sugarcane (Ashraf *et al*., 2007) and sunflower (Islam *et al*., 2008).

***Physiological parameters*:** Photosynthetic rate (*A*) was significantly decreased with increasing level of NaCl; however, genotype T-96 and Mankera showed significantly higher photosynthetic rate at both 100 and 200mM NaCl (Fig. 1).

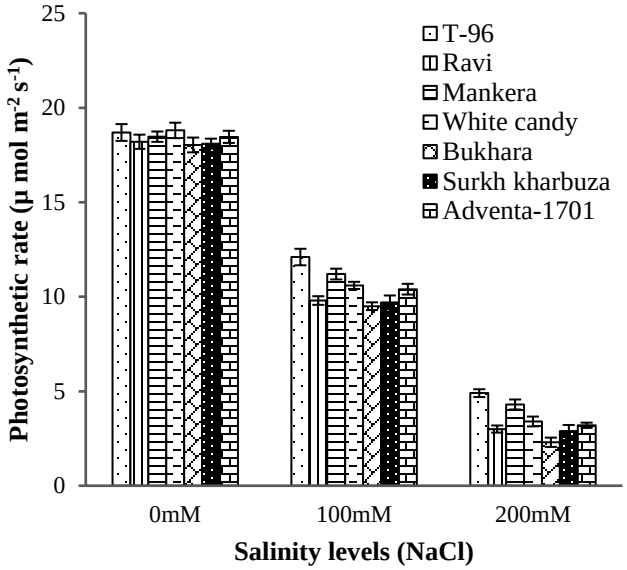

Figure 1. Effect of different levels of NaCl on photosynthetic rate of muskmelon genotypes.

The data showed that maximum photosynthetic rate (4.90 µmol m^{-2} s^{-1}) was recorded for T-96; whereas minimum photosynthetic rate (2.30 µmol m^{-2} s^{-1}) was observed for Bukhara when evaluated at 200mM NaCl. Stomatal conductance (g_s) was significantly reduced due to salt application (Fig. 2). Stomatal conductance was significantly diminished with increasing level of NaCl in all the tested genotypes; however T-96, Mankera and White Candy exhibited significantly higher stomatal conductance at both 100 and 200 mM NaCl. Maximum stomatal conductance (222.4mmol $m^{-2}s^{-1}$) was recorded in T-96 while minimum was achieved in Bukhara (194.4mmol $m^{-2}s^{-1}$). The present findings are in accordance with Ashraf and Harris (2013) and Gurmani *et al*. (2014) who reported that salinity adversely affect the photosynthetic rate and stomatal conductance. The decrease in plant growth is mainly attributed due to low photosynthesis in plant (Chaves *et al*., 2009; Ashraf and Harris, 2013). The reduced photosynthetic rate can be linked to stomatal and non-stomatal attributes or the combination of both as different arguments are involved (James *et al*., 2006; Dadkhah, 2011). In the present study, salt stress significantly decreased photosynthetic rate and stomatal conductance in all the muskmelon genotypes; however, percent reduction due to salt was dependent on genotype. Genotype T-96, Mankera and White Candy maintained higher gas exchange attributes and had higher plant biomass. Such results are in accordance of Wang *et al.* (2016) who reported that in muskmelon the genotypes with better photosynthetic rate and stomatal conductance proved as salt tolerant as produces greater biomass production. Also, similar results have been reported by Kanwal *et al.* (2011) and Gurmani *et al.* (2014) who observed positive correlation between gas exchange attributes and plant biomass under salt stress.

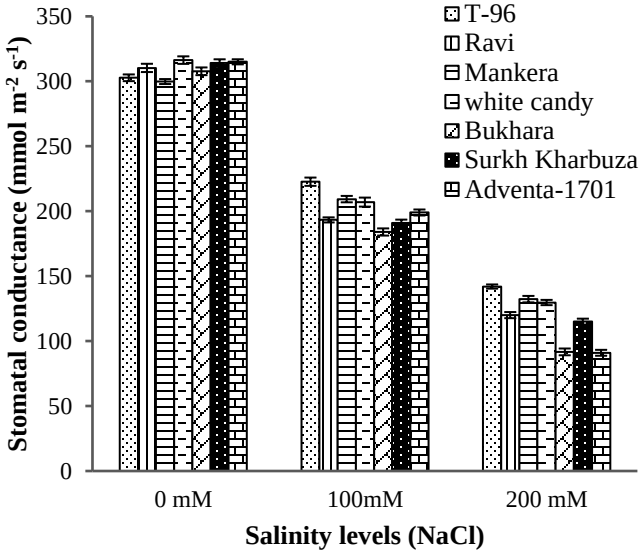

Figure 2. Effect of different levels of NaCl on stomatal conductance of muskmelon genotypes.

***Biochemical attributes*:** The results showed that Na^+, K^+ and K^+/Na^+ concentrations in leaf were significantly affected at both 100 and 200mM NaCl (Table 4, Fig. 3). In all the tested genotypes, Na^+ concentration was increased with the increment of salt levels. However, genotype T-96 and Mankera accumulated low Na^+ concentrations as compared to other tested genotypes. Relatively higher Na^+ concentrations were recorded in Bukhara and Adventa-1701. In contrast K^+ was decreased in all the tested genotypes with the increase of salt level. Present results showed that maximum K^+ concentration (2.16%) was recorded in T-96 while minimum K^+ (1.71%) was observed in Bukhara. The reduction percentages in K^+ concentration was 34, 53, 38, 38, 56, 46 and 50% for T-96, Ravi, Mankera, White Candy, Bukhara, Surkh Kharbuza and Adventa-1701 respectively at 200mM NaCl as compared to control plants. In all the tested genotypes, K^+/Na^+

ratio was significantly decreased with the raise of salinity levels (Fig. 3).

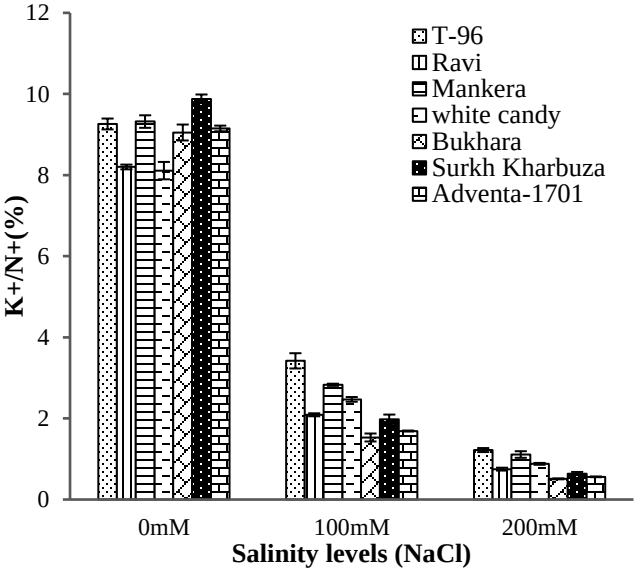

Figure 3. Effect of different levels of NaCl on K^+/Na^+ ratio of muskmelon genotypes.

Data showed that maximum K^+/Na^+ ratio (1.22%) was observed in T-96, while minimum K^+/Na^+ ratio (0.51%) was recorded in Bukhara when evaluated at 200 mM NaCl. Total chlorophyll contents were significantly decreased in all the tested genotypes at both 100 and 200mM NaCl levels; however, genotypes T-96 and Mankera showed higher chlorophyll contents (Table 3). T-96 showed maximum (1.20 mg g^{-1} FW) chlorophyll contents while Bukhara exhibited minimum (0.88 mg g^{-1} FW) chlorophyll contents. Study of Ionic homeostasis in plant during salt stress is important to determine the tolerance capacity of plant (Serrano and Navarro, 2001). Plants having low Na^+ in their leaf and higher K^+/Na^+ ratio were considered salt tolerant (Saqib *et al*., 2012; Hussain *et al*., 2013). The K^+/Na^+ ratio was used as a key tool to discriminate between salt tolerant and salt sensitive genotypes (Cicek and Cakirlar, 2002; Khan *et al*., 2009; Saqib *et al*., 2012). The present results showed that ions regulation in muskmelon genotypes altered when exposed to saline environment. Applied salinity caused an increase in Na^+ concentration in all muskmelon genotypes leading to decreased K^+/Na^+ ratio. However, different muskmelon genotypes behaved differently in this regard due to their differing genetic character. Genotypes T-96 and Mankera showed high K^+/Na^+ ratio as compared with other tested genotypes. Further, it can be explained that selective transport of K^+ from root to shoot and then finally to leaf was more efficient in T-96 and Mankera as indicated from higher K^+/Na^+ in their leaf. The present results of our study are in complete accordance of Wang *et al*. (2016) who reported that under salt stress the ions composition of muskmelon plants changed. The genotypes that made high K^+/Na^+ ratio produced greater biomass and proved as salt tolerant. Based on this phenomenon, genotypes T-96 and Mankera were considered tolerant and Bukhara was the most sensitive genotype among tested genotypes. Chlorophyll is the other important biochemical of plant and its degradation under salt stress is mainly concerned to chloroplast structure disruption and the pigment-protein instability (Sivasankaramoorthy, 2013). The present results showed that chlorophyll contents in leaf decreased with the increase of salt level but genotype T-96 and Mankera maintained higher chlorophyll contents. Chlorophyll degradation under saline conditions has been reported in a number of studies as given by Kaya *et al*. (2007) and Gurmani *et al*. (2014).

Linear regression analyses of shoot dry biomass with various physiological and biochemical attributes were performed at 200mM NaCl (Table 6). A significantly strong correlation between shoot dry weight with Photosynthetic rate, stomatal conductance, total chlorophyll and K^+/Na^+ ratio (r^2: 0.77, 0.84, 0.91 and 0.90**). Thus photosynthetic rate, stomatal conductance, total chlorophyll and K^+/Na^+ ratio could be used as effective selection criteria for salt tolerance in muskmelon genotypes. Salt tolerance ranking on the basis of physiological and biochemical attributes showed that genotypes T-96 and Mankera were ranked as tolerant, Ravi and White Candy as moderately tolerant whereas genotypes Bukhara, Adventa-1701, and Surkh Kharbuza as salt sensitive (Table 7).

Table 7. Ranking of relative salt tolerance of seven muskmelon genotypes at 200mM NaCl.

Genotypes	SDW	RDW	SL	RL	LA	T.C	Na	K	K/Na	*A*	gs	SUM	Rank
T-96	1	1	1	1	1	1	1	1	1	1	1	11	T
Ravi	1	1	2	3	2	3	4	2	3	3	3	27	M
Mankera	1	1	1	1	1	2	2	1	1	1	2	14	T
White candy	2	1	2	1	2	3	3	2	3	2	1	22	M
Bukhara	5	2	2	2	3	5	5	5	3	4	5	41	S
Surkh kharbuza	4	2	1	1	2	5	4	4	2	3	4	32	S
Adventa-1701	3	2	2	2	3	4	5	3	3	2	4	33	S

SDW, shoot dry weight; RDW, root dry weight; SL, shoot length, RL, root length; LA , leaf area; TC, total chlorophyll; A, Photosynthetic rate; gs, stomatal conductance; T, tolerant; M moderate; S, sensitive.

***Conclusion*:** Based on morphological, physiological and biochemical attributes, it is inferred that photosynthetic capacity, stomatal conductance, chlorophyll content, K^+/Na^+ ratio and plant growth were higher in salt tolerant genotypes than other tested genotypes. On the basis of these selected parameters, genotypes T-96 and Mankera were ranked as salt tolerant while, genotype Ravi and White Candy as moderately tolerant and rest of the genotypes were found sensitive towards salinity. Present promising results further argue for the field evaluation of selected muskmelon genotypes under salt prone areas.

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