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Full Length Research Paper

Screening of tomato (*Solanum lycopersicum* L.) genotypes at different salinity levels

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The experiment was conducted at 10 and 15 dS/m along with control condition. The accessions namely; PB-BL-1076, BL-1079, LO-2576, 017902, LO-3686, 017859, 017860 and 017867 were used. Different morphological and physiological characters such as number of flowers, number of flowers shed, number of fruits, number of leaves/plant, number of days for fruit setting, Na^+ concentration, K^+ concentration and K^+/Na^+ ratio were recorded at flowering and maturity stages. Variability and heritability of the studied characters were determined. The overall performance of the genotype O17859O was better at both NaCl concentrations for the traits like number of fruits, number of flowers, K^+ concentration and K^+/Na^+ ratio. The genotype 017867 was the poorest in performance and was affected severely by salinity for the characters like number of flowers, number of fruits, K^+/Na^+ ratio while all other genotypes showed intermediate response.

Key words: Variability, heritability, Na^+/K^+ ratio.

INTRODUCTION

Soil salinity is one of the major abiotic stresses that reduces agricultural productivity. It has affected large terrestrial areas of the world and therefore the need to produce salt-tolerant crops is suggested (Yamaguchi and Blumwald, 2005). Salinity is a serious problem affecting irrigated agriculture. Salts exert general and specific affects on plants which directly influence crop growth and yield. Improper irrigation practices and lack of drainage have generally led to accumulation of salts in the soil to harmful concentrations. Each year, about 120 million tons of salts are added to the land through canal and brackish underground water and only about 1/5th of this salt finds its way to the sea and the remaining is accumulated in the soil. One-fifth of irrigated agriculture is adversely affected by soil salinity (Chinnusamy et al., 2005). Tomato plant show wider adaptability to soil and climatic conditions of the world but salinity adversely affects plant growth and decrease the overall yield. Salinity effects inflorescence, root growth slows down, reduce germination rate, reduce number of fruits and lengthen the period of germination etc. Plants vary in their tolerance to salts especially after seedling establishment, to produce well when irrigated with saline waters, especially typical drainage water, provided appropriate cultural management practices.

Installation of tube wells and drainage has been proposed to solve the problem of sailinity in Pakistan but due to increasing cost of energy and labor was not remained feasible. This engineering approach need many resources and thus chances of its adoption, in the developing countries like Pakistan, are remote (Shannon, 1984). Another alternative that is, biological/genetic approach seems to be feasible to utilize the saline areas of the country. The genetic approach, the development of salt tolerant crop varieties through selection and breeding has the potential to tackle the salinity problem (Epstein et al., 1980). For bringing genetic modification in crop plants like tomato, availability of two components is necessary. Firstly, there must be variation in the crop endemic to the area and secondly, the variation must be governed by genetic factors. For this purpose, a small sample of tomato germplasm was taken to observe the response to

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Table 1. Mean square of absolute values for various traits of 8 tomato accessions grown in control, 10 and 15 dS/m NaCl concentration.

SOV	d.f	NFLP	NFLS	NFRP	NDFR	Na^+ Conc.	K^+ Conc.	K+/Na+ratio
Genotypes (G)	7	83076**	16668**	29571**	45.587**	12025**	28986**	0.158**
Salt level (s)	2	115664**	31004**	28367**	17.389	170959**	9574**	2.224**
Interaction (G*S)	14	4163*	1395	1168**	49.706**	1940**	74.64**	0.032**
Error	48	2074	1709	404	10.889	147	13.686	0.010

NFLP = Number of flower/pant, NFLS = number of flowers shed, NFRP = number of fruit/plant, NDFR = number of days for fruit setting, Conc. = concentration, CV = coefficient of variability, Vg = genotypic variance, Vp = phenotypic variance, H^2b.s = heritability broad sense and GA = genetic advance.

salinity. Information derived from these investigations would help vegetable breeders to devise a breeding strategy for the improvement in tomato crop.

MATERIALS AND METHODS

The experiment was conducted in Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad. Study was carried out by using eight tomato accessions that is, PB-BL-1076, BL-1079, LO-2576, 017902, LO-3686, 017859, 017860 and 017867. The seeds of the accessions were sown in the iron trays under normal growing conditions during November 2008, and transplanted in the earthen pots during December 2008. The experiment was carried out in the greenhouse. Two seedlings of each accession were transplanted in one earthen pot and there were three pots of each accession including control. The response of each accession was examined under 10 and 15 dS/m salinity levels and also under non salinized condition. The experiment was carried out by using completely randomized design with three replications.

In order to develop the desired salinity of 10 and 15 dS/m EC, the EC of soil was checked, and then the required quantity of salt was calculated to develop 10 and 15 dS/m using the following formula:

Amount of salt required = Total soluble salts (TSS) × Molecular weight of NaCl ×saturation% /1000× 100

The desired salinity level in soil was developed by mixing 1.734 g NaCl salt in 1 kg of soil for 10 dS/m and 2.758 g in 1 kg of soil for 15 dS/m. For this purpose, 1.734 g of salt was mixed in water and this water was mixed in 1 kg of soil to develop 10 dS/m, and 2.758 g/1 kg of soil for 15 dS/m. This soil was filled in earthen pots in which the seedlings were transplanted. The two salinity levels in pots were monitored every 2 weeks after translating the tomato seedlings and the tomato plants were allowed to grow for a period of 3 months. In order to examine the response of genotypes to salinity, the data were recorded on the following, that is, number of flowers/plant, number of flowers shed, number of fruits/plant, number of leaves/plant, number of days for fruit setting, Na^+ concentration, K^+ concentration and K^+/Na^+ ratio at flowering and maturity stage. Plant protection measures were adopted to obtain healthy plants.

Statistical analysis

The data for all the traits was analyzed following analysis of variance technique (Steel et al., 1997) to determine the significance of genotypic responses to salinity. Broad sense heritability was calculated by using the formula given by Falcon and MacKay (1996):

H_{bs} = Vg/Vp,

Where, Vg = genotypic variance, Vp = phenotypic variance, H_{bs} = heritability broad sense.

Genetic advance was computed by the following formula given by Falcon and MacKay (1996):

$G.A = K.Sp.H^2$

Where, G.A = genetic advance, K = selection differential at 10% selection intensity, Sp = standard deviation of the phenotypic variance of the population under selection and H^2 = broad sense heritability.

RESULTS

Variability in tomato was evaluated under salinized and non salinized conditions. Data on various characters of eight tomato accessions were collected for making comparison. The accessions under study were compared on absolute as well as relative basis. Analysis of variance of absolute data regarding number of flowers per plant showed significant genotypic differences at P<0.01 (Table 1). Differences between the three NaCl concentration appeared significant at P<0.000 and genotypic × salinity interaction were also significant at P< 0.01 revealing that eight genotypes responded differently to increasing salinity levels. When genotypes were grown in salinized condition, the maximum decrease in flowers was up to 369 in O178590 at 10 dS/m as compared to the maximum number of flowers in non-salinized condition. While in 15 dS/m, it was 252 as shown in Figure 1, indicating the adverse effect of NaCl stress. From overall performance of genotypes, it is found that accession O17867 showed the poorest response with 63.3 and 33 numbers of flowers in 10 and 15 dS/m salt concentrations while others showed intermediate performance. On the basis of means of number of flowers production, the genotypes O17859O and O17902 may be the most salt tolerant, whilst PB-BL-1076 and 017867 were the most sensitive genotypes. On the basis of mean values of absolute salts, overall performance of O178590 was significantly better than the O17867 and the value of broad sense heritability was high (0.928) along with genetic advance 1582.4.

The value of broad sense heritability (0.745) showed

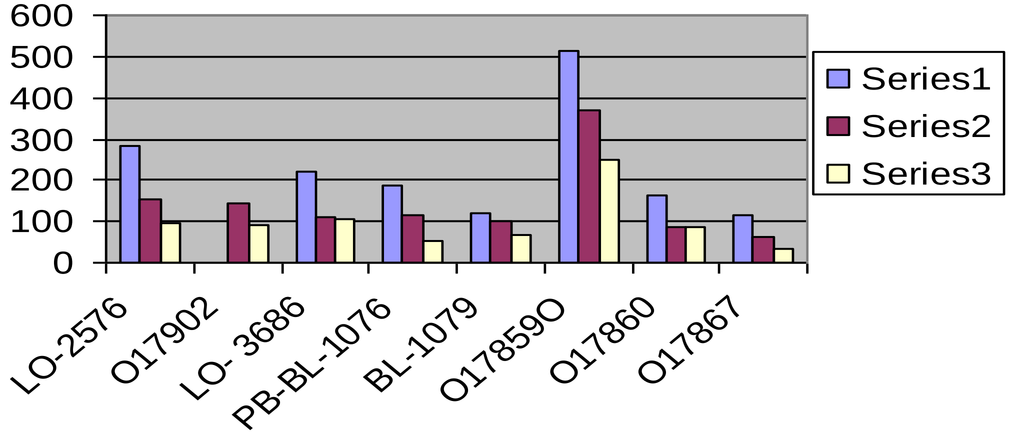

Figure 1. Mean number of flowers/plant of eight tomato accessions at two salt concentrations.

Table 2. Components of variance and broad sense heritability of NaCl tolerance.

Component	NFLP	NFLS	NFRP	NDFR	Na^+ conc.	K^+ conc.	K+/Na+ratio
CV (%)	28.78	53.31	24.90	15.92	8.09	1.20	19.52
Vg	27000.60	4986.17	9722.407	11.56	3959.59	9657.55	0.049
Vp	29074.85	6695.73	10126.4	22.46	4106.8	9671.23	0.059
H^2b.s	0.93	0.745	0.96	0.52	0.96	0.99	0.83
GA	1582.4	609.61	966.05	24.40	617.77	981.46	2.016

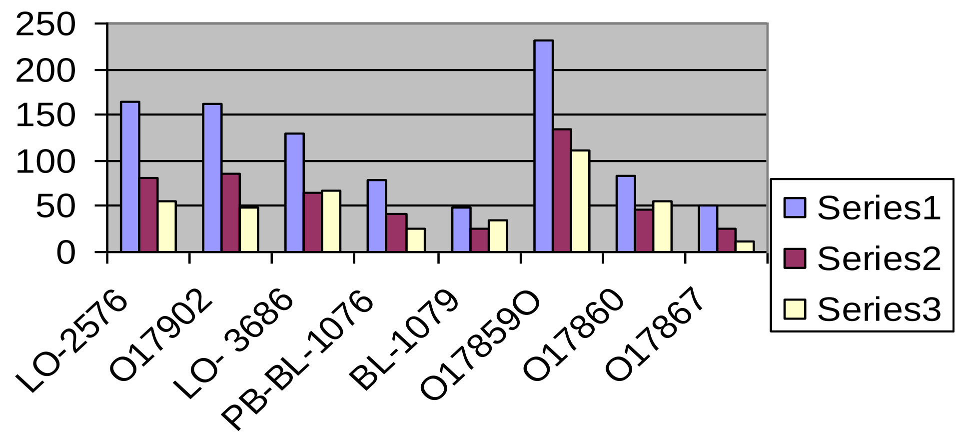

Figure 2. Mean number of flowers shed of 8 tomato accessions at two salt conditions.

that about 74% of the variation observed in the character was genetically determined while genetic advance was 609.61 for number of flowers shed and coefficient of variation was 53.31% as shown in Table 2. The comparison of response showed that mean number of flowers shed ranged form 231 in control condition to 50 in O178590 and O17867 as shown in Figure 2. On the basis of mean values of absolute salt overall performance of variety O178590 was poor because more flowers were shed from this genotype and variety O17867 was the best because less number of flowers was shed from this genotype. Study of tables showed that mean of number of days for fruit setting differed in control condition from 26 to 17 for O17860 and LO-3686 respectively. When genotypes were grown in salinized condition, the high number of days for fruit setting in O17860 was reduced to22 in 10 dS/m and 19 in 15 dS/m, thus showing that by increasing salt level, number of days were reduced and maturity can be obtained early. Similar reduction in number of days for fruit setting was noted in other genotypes

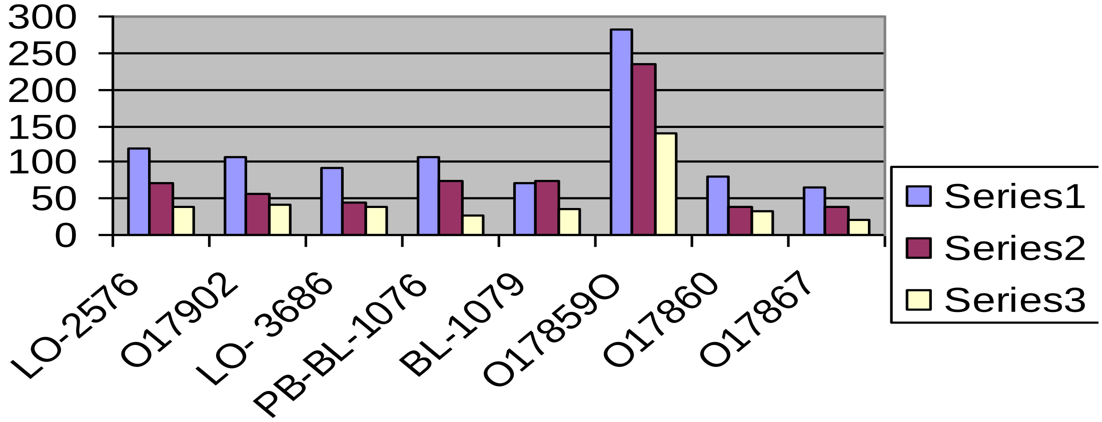

Figure 3. Mean number of fruits/plant of eight tomato accessions at salt concentration.

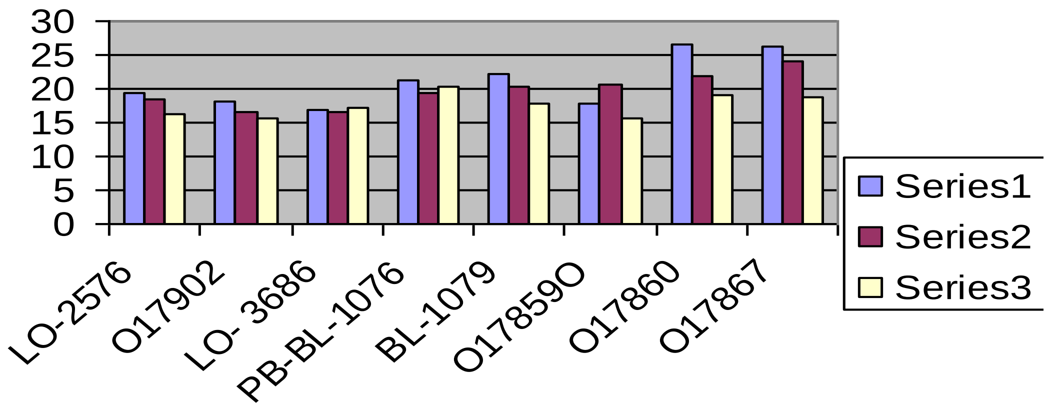

Figure 4. Mean number of days to fruit setting of 8 tomato accessions at two salt concentrations.

under low and high salinity levels. From overall genotypes performance, it is found that variety O17867 was the poorest because by increasing salt it requires more days than all other genotypes as shown in Figure 3.

On the basis of mean values of absolute salt variety O17902 was best because it require less number of days for fruit setting and variety O17867 was the poorest because it require more number of days for fruit setting. The low value of broad-sense heritability (0.52) and genetic advance shows that this character is more sensitive to stresses. On the basis of relative salt basis genotypes BL-1079 and O17859O had highest values in 10 and 15 dS/m then other genotypes and variety LO-3686 in 10 dS/m and variety PB-BL-1076 in 15 dS/m have the lowest values respectively while all other genotypes showed intermediate performance as shown in Figure 4. On the basis of mean values of relative salts the overall performance of genotypes BL-1079 and O17859O was best among the studied genotypes. The value of broad sense heritability (0.96) showed that variation observed in the character had strong genetic basis and genetic advance was 966.05 for this character.

Mean K^+ concentration differed in control condition from 382.1 to 189.3 as shown in Figure 5. On the basis of overall performance genotypes, PB-BL-1076 and O17859O accumulated more K+, so had more tolerance against salinity while genotypes LO-2576 and BL-10790 were found to be salt sensitive because they had less K+ accumulation by increased salt level. High broad sense heritability (0.99) showed that about 99% of the variation observed is genetically determined. While relative value of genotype O17902 was highest at 10 and 15 dS/m, then all other genotypes and genotypes LO-3686 and PB-BL-1076 had minimum relative value at 10 and 15 dS/m, respectively. Means of Na^+ concentration of eight genotypes grown in control, 10 and 15dS/m NaCl salinities are given in Table 3. Study of tables showed that mean Na^+ concentration differed in control condition from 90 to 46.3 for BL-1079 and O17860 respectively. In 10dS/m NaCl concentration variety PB-BL-1076 had the minimum Na^+ concentration while in 15dS/m variety O17860 had minimum Na^+ concentrations. The relative value of LO-3686 in 10 and 15 dS/m was higher in relative salt and mean value of genotype O17902 was

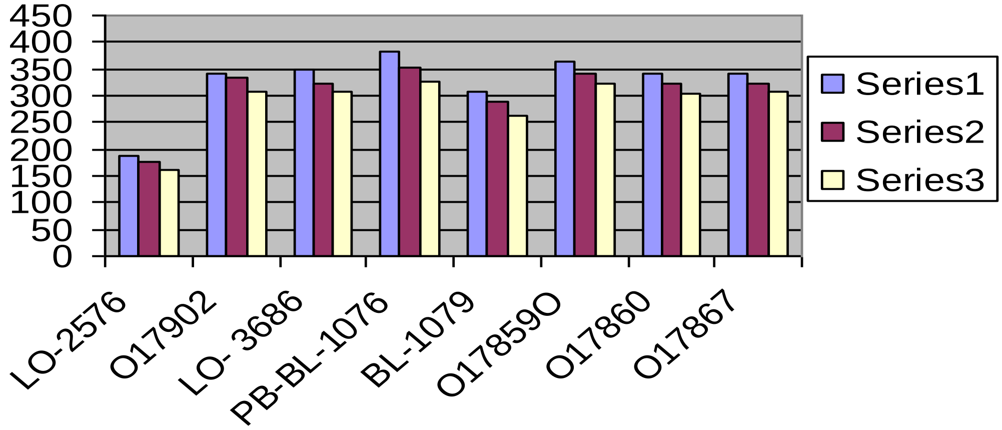

Figure 5. Mean of K+ contents of eight tomato accessions at two salt concentrations.

Table 3. DMR values of different parameters studied of each variety.

Genotype	NFLP	NFS	NFRP	NDF	Na+	K+	K+/Na ratio
LO-2576	177.1^{B}	100.6^{B}	776.56^{B}	22.33^{A}	110.6^{D}	175.7F	0.6472^{A}
O17902	168^{B}	99.33^{B}	68.67^{BC}	20.44^{AB}	150.4^{B}	327.3^{C}	0.4856^{B}
LO- 3686	145.2^{BC}	87^{BC}	58.22^{BCD}	17^{C}	130.3^{C}	326.2^{CD}	0.4107^{B}
PB-BL-1076	117.3^{CD}	48.33^{CD}	69^{BC}	22.3^{A}	129.9^{C}	354.4^{A}	0.4273^{B}
BL-1079	95.89^{D}	35.78^{D}	60.11^{BCD}	20.11^{ABC}	199.6^{A}	286E	0.719^{A}
O17859O	379^{A}	159^{A}	220^{A}	18^{BC}	211^{A}	342.6^{B}	0.6323^{A}
O17860	112.6^{CD}	61.78^{BCD}	50.78^{CD}	22.56^{A}	121.6^{CD}	323.2^{D}	0.3859^{B}
O17867	71^{D}	28.67^{D}	42.33^{D}	23^{A}	146^{B}	324.6^{CD}	0.3961^{B}

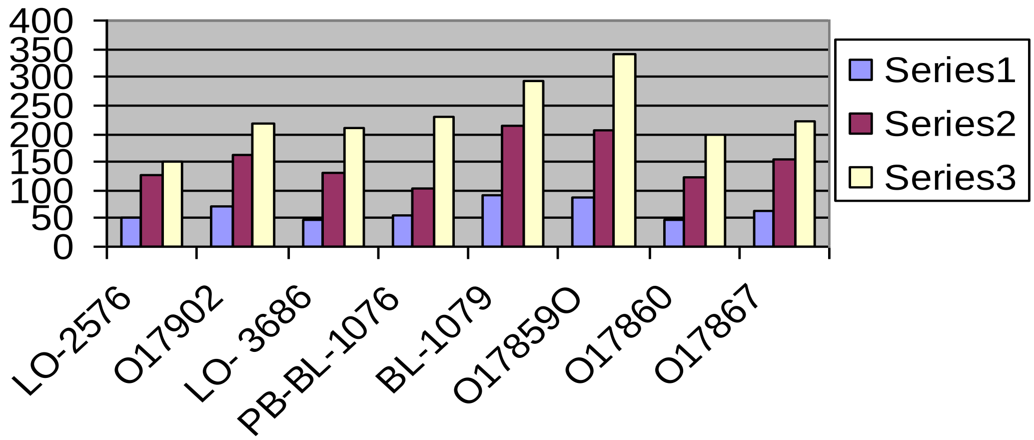

Figure 6. Mean of Na+ content of eight tomato accessions at two salt concentrations.

lowest while other genotypes showed intermediate performance as shown in Figure 6. The value of broad sense heritability was (0.96) while genetic advance was 617.77. Means K+/Na+ ratio showed that genotypes differed in control condition from 0.295 to 0.135. At 10 dS/m NaCl concentration, the genotype BL-1079 had the maximum K^+/Na^+ ratio while at 15 dS/m, O17859O had maximum K^+/Na^+ ratio as described in Figure 7 and the poorest performance was of the varieties of PB-BL-1076 and BL-1079 at 10 and 15 dS/m respectively. While relative salt values were maximum of genotype LO-3686 at 10 dS/m and of PB-BL-1076 at 15 dS/m, the calculated values of broad sense heritability and genetic advance were 0.83 and 2.016 respectively.

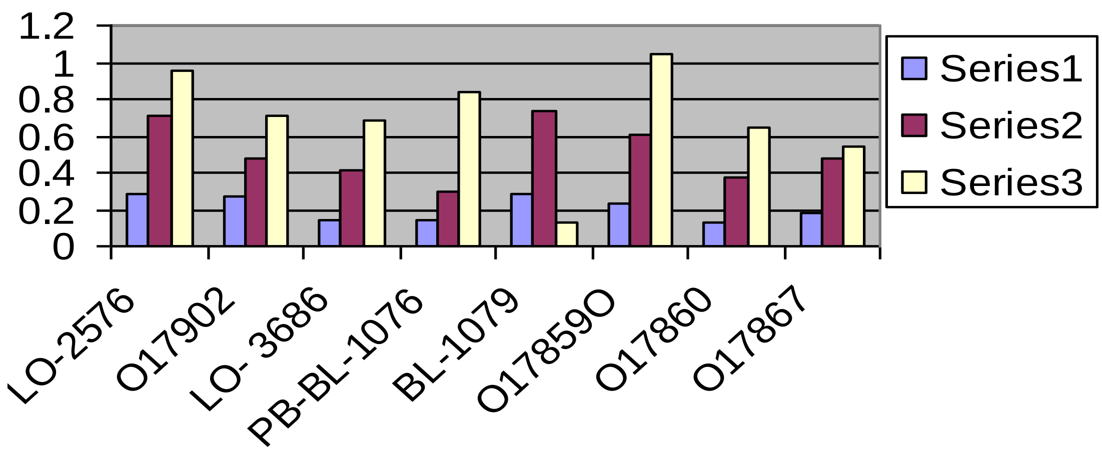

Figure 7. Mean of K+/Na+ contents of eight tomato accessions at two salt concentrations.

DISCUSSION

Abiotic stresses are commonly experienced by crop plants during their growth and development. The spread of soil salinity in arid and semi arid areas is posing a serious threat to crop production (Khan, 2001). The present study was carried out to evaluate genetic variability for salt tolerance among eight tomato genotypes measuring morphological and physiological characters. For enhancing salt tolerance in crop plants, it is important to find variation and devise such screening techniques which are reliable to identify tolerant genotypes. In previous studies, variation in salt tolerance has been reported in tomato (Saranga et al., 1992; Akinci et al., 2004; Turhan and Seniz, 2010) and in wheat (Epstein et al., 1980; Watanable et al., 1992; Martin et al., 1994; Noori and McNeilly, 2000; Akinci et al., 2004). The current study revealed the adverse effects of NaCl on tomato genotypes. It was observed that there was progressive decrease in the growth parameters with increase in salt concentration. It was also reported that verities differed in their response to salinity depending upon the salt concentration (Epstein et al., 1980; Watanable et al., 1992; Martin et al., 1994; Noori and McNeilly, 2000; Akinci et al., 2004). The investigations on the basis of mean values of absolute performance, and relative performance of different genotypes performed differently as genotype 0178590 produced maximum number of fruits in two salinities in 10 and 15 dS/m and was less affected by increased salt levels which clearly indicates the salt tolerance (Cuartero et al, 2006). In 15 dS/m salinity, genotype 0178590 is earliest and requires minimum number of days for fruit setting.

K^+ accumulation and K^+/Na^+ ratio being one of the best physiological indicator proved that PB-BL-1076 and O17859O are salt tolerant because of more K^+ contents accumulation and similarly though all the entries not differed significantly in K^+/Na^+ ratio but genotype LO-2576 and 0178590 were most tolerant genotypes based upon more K^+/Na^+ ratio and were less affected by increased salt level as was reported by Chookhampaeng et al. (2007). High values of heritability and genetic advance indicate that the character is governed by additive genes and genetic variance is fixable and selection would be useful for the improvements of traits (Singh and Narayanan, 2009). Heritability and genetic advance for different genotypes was also calculated for different characters and it was clear that the genotype, O17860 was screened on the basis of high heritability 0.99% and genetic advance 981.46. The over all performance of the genotype O17859O was significantly different from all other genotypes and also performing better in two NaCl concentrations for the number of traits like number of fruits/plant, number of flowers, K^+ concentration and K^+/Na^+ ratio and similar studies were reported by Mori et al. (2007); Cuartero and Fernández-Muñoz (1998) and this genotype may be incorporated in the further breeding programme for the salinity improvement.

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