Evaluation of germplasm of maize at seedling stage under salt stress.

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Abstract: Maize is the most important cereal crop in Pakistan after wheat and rice. Since salinity is a common stress factor in agricultural areas, the objective of this study was to evaluate the feasibility of morphological and physiological traits as selection criteria of maize genotypes under salt stress. The experiment was performed out at seedling stage under CRD with three replications. Three treatments were applied: One was normal and other two were saline. Normal treatment was consisted of 0mM salt concentration and other two salt stress contain 50mM and 100mM NaCl concentration After 21 days of sowing seedling data were recorded on following morphological and physiological seedling traits like fresh shoot length, fresh root length, root density, fresh shoot weight, fresh root weight, dry root weight, dry shot weight, fresh root shoot ratio, dry root shoot ratio, leaf temperature, leaf chlorophyll content. At higher levels of salinity maize growth is reduced drastically. Salinity delays seed germination which affects plant performance and health. Seed unable to germinate might deteriorate. Results also indicate that maize seedling's radical and plumule lengths are also shortened due to salinity, there was decrease in chlorophyll content, fresh root length, fresh shoot length, and fresh shoot weight fresh root weight dry shoot weight dry root weight with increase in salt concentration. Leaf temperature increases with increase in salinity level.
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Key words: Maize, salinity, seedling, stress

Introduction

Soil salinity is one of the major environmental abiotic stresses that limit agricultural productivity and food supply worldwide (Flowers, 2004). Owing to limited rainfall and high evapotranspiration demand, coupled with poor soil and water management practices, salt stress has become a serious threat to crop production in arid and semi-arid regions of the world (Flowers and Yeo1995; Munns2002). Although the general perception is that salinization only occurs in arid and semi-arid regions, no climatic zone is free from this problem (Rengasamy 2006). The total global area of salt-affected soils has recently been estimated to be approximately 830 million hectares (Martinez-Beltran & Manzur, 2005), of which about 20% salt affected are those of irrigated lands (Pitman & Läuchli, 2002). With the steady increase in population, especially in the under-developed countries of the world and the concomitant decline in new agriculture lands, the need to tackle such soil stresses is urgent (Ali et al., 2002). Salinity affects plants in different ways such as osmotic effects, specific-ion toxicity and/or nutritional disorders (Läuchli & Epstein, 1990). It is not only affects the morphology, but also modifies the metabolisms of plants by limiting their growth. Salinity affects both vegetative and reproductive development, which has profound implications depending on whether the harvest organ is a stem, leaf, root, shoot, fruit, fiber or grain. Salinity often reduces shoot growth more than root growth (Läuchli & Epstein, 1990). Toxic levels of sodium in plant organs damage biological membranes and subcellular organelles, reducing growth and causing abnormal development before plant mortality (Quintero et al.2007). Several physiological processes such as photosynthesis, respiration, starch metabolism, and nitrogen fixation are also affected under saline conditions leading to losses in crop productivity. Maize (Zea mays L.) is the third most important cereal crop after rice and wheat and is grown under a wide spectrum of soil and climatic conditions. Maize is a multipurpose crop that is used as food, fodder and commercial products like jellies, starch, corn oil, grain cake and alcohol. Rich supply of starch, vitamins, minerals and proteins is maize grain. Its floor is used for manufacturing breads, has a mild taste and acts as a thickening negotiator in custards and jellies. Popcorn is used as snack that is made from kernel. Stalks of maize are used for manufacturing insulators, paper and card boards while its rachis is used for the production of chemicals, methanol tar, furfural for mushroom cultivation and for manufacturing of pipes. It is an

important C4 plant from the Poaceae family and is moderately sensitive to salt stress (Chinnusamy et al.2005); nonetheless, wide intraspecific genetic variation for salt resistance exists in maize (Mansour et al. 2005). Quick screenings for salt resistance on the basis of some agronomic traits during early growth stages of maize are often deemed valuable (Khan et al. 2003). Maize grown under salinity was showed reduction in growth characteristic and yield production at all (Ouda et al., 2008). It is also reported that, genetic variability can exist for salt tolerance maize crop (Maiti et al., 1996) like other plant species such as alfalfa (McKimmie & Dorbrenz, 1991), Trifolium (Ashraf et al., 1987) and sunflower (Francois, 1996). Keeping this in view, this study was conducted to evaluate the performance of maize genotypes at seedling stage under the different levels of salinity (NaCl). Screening of large number of genotypes of a crop is necessary to identify the salt tolerant germplasm for breeding programs to evolve the salt tolerant and high yielding crop varieties.

Material And Methods

The experiment was performed out at greenhouse in the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad.

The Experimental material was consisted of 10 elite genotypes of maize namely as:

L-32	L-33	L-34	L-35	L-42
L-43	L-44	L-45	L-52	L-53

These genotypes were sown in sand filled polythene bags in green house. Each polythene bag was consisted of 500g of sand by using Completely Randomized Design in Factorial experiments with three replications. Two seeds were sown in each polythene bag to avoid any missing in germination. Three treatments were applied: One was normal and other two were saline. Normal treatment was consisted of 0mM salt concentration and other two salt stress contain 50mM and 100mM NaCl concentration In each treatment each genotype was consisted of five plants per replication. After 21 days of sowing seedling data was recorded on following morphological and physiological seedling traits like Fresh shoot length, Fresh root length, Root density, Fresh shoot weight, Fresh root weight, Dry root weight, Dry shot weight, Fresh root shoot ratio, Dry root shoot ratio, Leaf Temperature, Leaf chlorophyll content.

Results and discussion

Leaf temperature

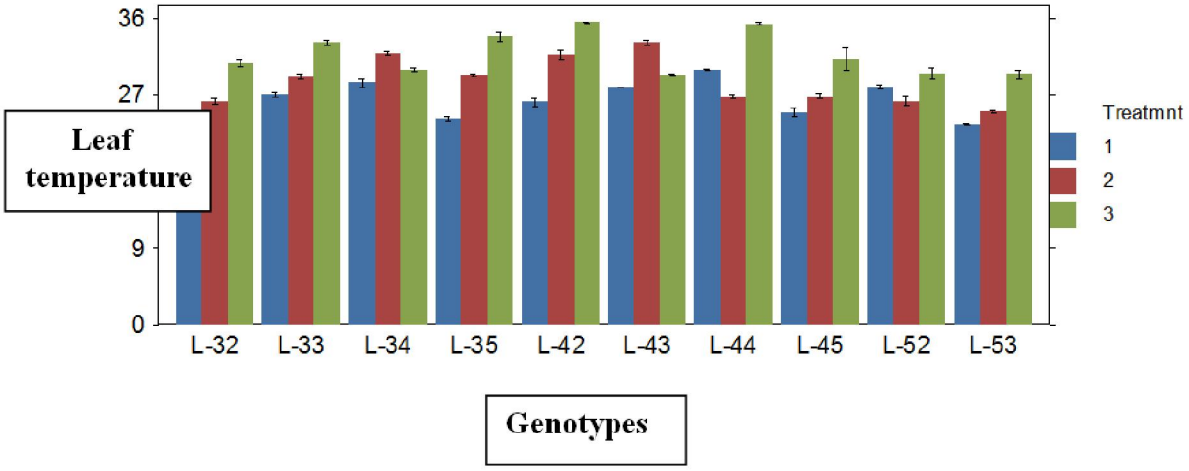

Figure 4.1.1 Mean comparisons chart for leaf temperature of different genotypes under normal and saline condition.

Leaf temperature is an important factor for the evaluation of genotypes under any abiotic or biotic stress. According to Completely Randomized Block Design with factorial arrangement all the treatments of NaCl 0, 50 and 100mM, inbred lines and interaction between inbred lines and treatments is significant for leaf temperature. While studying the Error bar Chart (Graph 4.1.1) Inbred line L-44showed highest leaf temperature 29.95 while L-32 showed lowest leaf temperature 22.75 at normal level of salinity. At

50mm level of salinity the all the genotypes showed increase in leaf temperature. The leaf temperature of L-44 increased from 29.95 to 31.2 at 50mm salinity level. Genotype L-43 showed highest leaf temperature 33.1 while L-53 showed lowest leaf temperature at 2nd level of salinity. But the leaf temperature of all the genotypes was high at 50mm NaCl concentration as compared to 0mm salt concentration.

At 100 mm salt concentration the leaf temperature increased up to 35.5 as compared to 1st and 2nd level of salinity. Inbred L-42 showed highest leaf temperature 35.5 while L-53 showed lowest mean leaf temperature at 3rd level of salinity. An increase in leaf temperature of all the genotypes was observed with increase in salt concentration. Leaf temperature high or low in inbred lines showed us the capacity of line to tolerate against the saline stress. Inbred lines with high leaf temperature are not good for salinity stress while lines with lowest leaf temperature are good for salinity tolerance, But only leaf temperature is not enough for selection.

4.2 Chlorophyll Content:

Chlorophyll content of leaves of maize seedlings is an important parameter for the evaluation of genotype against salinity stress. Performance of a genotype can be accessed according to chlorophyll content present in leaves of the plant. Salinity level in plants affects the chlorophyll content of the leaves by disturbing the different regulatory functions of the plant. The plant or line showed highest chlorophyll content under salt stress is usually salt tolerant genotype.

Table 4.1.2 All pair wise comparisons for treatment and inbred line interaction for leaf temperature under saline stress.

Genotype Treatment	Mean	Homogeneous Groups
L-42 3	35.5	A
L-44 3	35.35	A
L-35 3	33.8	AB
L-33 3	33.15	ABC
L-43 2	33.1	ABC
L-34 2	31.9	BCD
L-42 2	31.75	BCDE
L-45 3	31.25	CDEF
L-32 3	30.7	CDEFG
L-44 1	29.95	DEFGH
L-34 3	29.9	DEFGH
L-52 3	29.5	DEFGH
L-53 3	29.4	EFGHI
L-43 3	29.35	EFGHI
L-35 2	29.3	EFGHIJ
L-33 2	29.1	FGHIJK
L-34 1	28.4	GHIJKL
L-52 1	27.95	HIJKL
L-43 1	27.85	HIJKL
L-33 1	27	IJKLM
L-45 2	26.85	JKLM
L-44 2	31.1	KLM
L-32 2	26.25	LMN
L-52 2	26.25	LMN
L-42 1	26.1	LMN
L-53 2	25	MNO
L-45 1	24.95	MNO
L-35 1	24.15	NO
L-53 1	23.55	O
L-32 1	22.75	O

Note: Means sharing the same letters are not significantly different from each other t 5% level of probability.

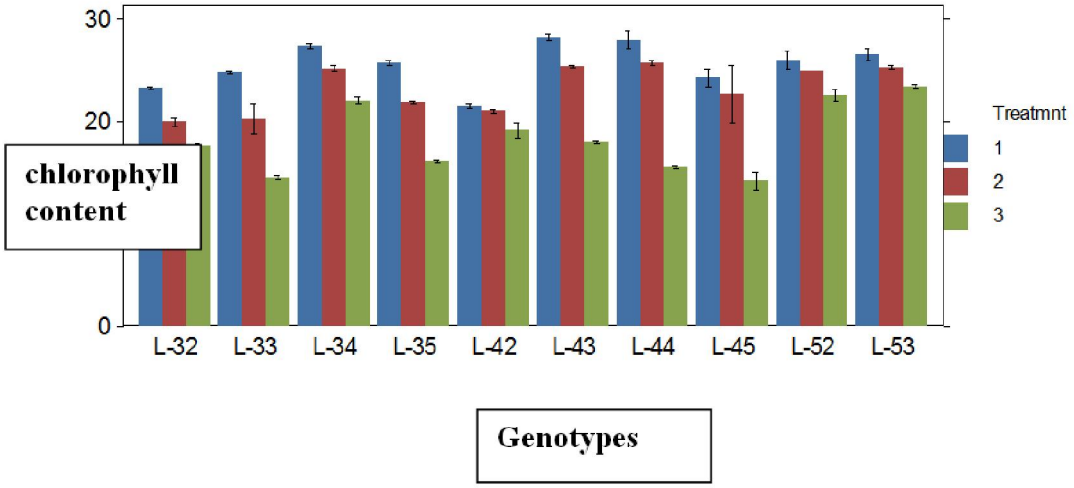

Figure 4.2.1 Mean comparisons chart for chlorophyll content of different genotypes under normal and saline condition

On observing (Graph 4.2.2) error bar chart and (Table 4.2.3) is observed that in treatment one or control level of salinity chlorophyll content was highest. At 0 mM level of salinity the highest chlorophyll content was observed in L-52 (26.55) while L-42 showed lowest chlorophyll content. At 50mm salt concentration all the genotypes showed decrease in chlorophyll content. The Genotype L-52 showed decrease in chlorophyll content from 26.55 to 24.9 while L-42 showed decrease in chlorophyll content from 28.2 to 25.5. The genotype L-44 showed highest chlorophyll content 25.65 while l-35 showed lowest chlorophyll content at 50mm level of salinity. At 3rd level of salinity the decrease was more obvious among all genotypes. The genotype L-52 showed decrease in chlorophyll content from 26.55(0mm) to 22.55 (100mm). The genotype L-34 showed highest chlorophyll content 22.05 and genotype L-45 showed lowest chlorophyll content 14.2 at 100mm salt concentration. In general, there was decrease in chlorophyll content with increase in salt concentration.

Table 4.2.2 All pair wise comparisons for treatment and inbred line interaction for chlorophyll content under saline conditions.

Treatment Genotype	Mean	Homogeneous Groups
1 L-43	28.2	A
1 L-44	27.95	A
1 L-34	27.35	AB
1 L-53	26.55	ABC
1 L-52	26	ABCD
1 L-35	25.7	ABCDE
2 L-44	25.65	ABCDE
2 L-43	25.4	ABCDE
2 L-53	25.3	ABCDE
2 L-34	25.2	ABCDEF
2 L-52	24.9	ABCDEF
1 L-33	24.8	ABCDEF
1 L-45	24.25	ABCDEFG
3 L-53	23.45	BCDEFGH
1 L-32	23.25	BCDEFGHI
2 L-45	22.7	CDEFGHI
3 L-52	22.55	CDEFGHI
3 L-34	22.05	DEFGHIJ
2 L-35	21.85	DEFGHIJK
1 L-42	21.55	EFGHIJK
2 L-42	21.05	FGHIJK
2 L-33	20.3	GHIJK
2 L-32	19.95	HIJKL
3 L-42	19.15	IJKLM
3 L-43	18	JKLMN
3 L-32	17.7	KLMN
3 L-35	16.1	LMN
3 L-44	15.55	MN
3 L-33	14.55	N
3 L-45	14.2	N

4.3. Shoot length:

Vegetative growth is an important factor for evaluation of any genotype against any abiotic or biotic stress. Plants having ability to tolerate any stress showed good vegetative growth. shoot length of maize seedling is an important vegetative factor for selection of genotype against stress along with other selection criteria. According to (Graph 4.3.2) Error Bar chart and (Table 4.3.3) inbred lines in normal conditions showed highest shoot length. Inbred L-44 showed highest shoot length 37.5 while L-32 showed lowest shoot length 31.1 under normal conditions. At 50mm salinity level, there was decrease in shoot length. The

shoot length of L-44was decreased from 37.5 to 31 at 2nd level of salinity while the shoot length of L-32 was decreased from 31.1 to 27.2. The genotype L-53 showed highest shoot length 28.5 while L-42 showed lowest shoot length 23.8 at 50mm salt concentration. At 100mm salt concentration the decrease in shoot length was more obvious as compared to 50mm salinity level. The shoot length of L-44 was decreased from 37.1(0mm) to 23.85 (100mm). The genotype L-53 showed highest shoot length 23.45 while L-33 showed lowest shoot length mean 18.4 at 3rd level of salinity. In general, there was decrease in shoot length with increase in salt concentration.

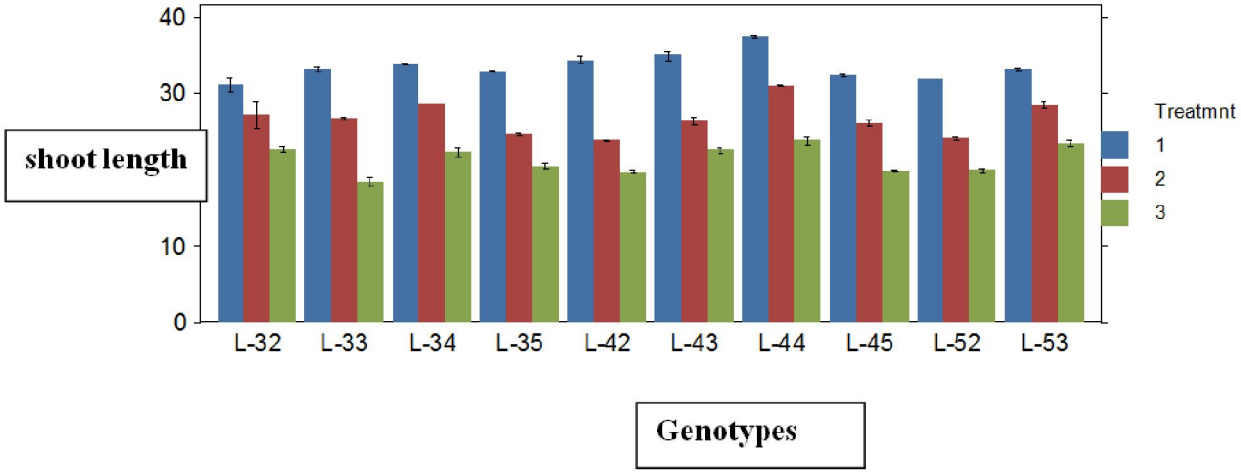

Figure 4.3.1Mean comparisons chart for shoot length of different genotypes under normal and saline condition

Table 4.3.2 All pair wise comparisons for treatment and inbred line interaction for shoot length under saline stress.

Genotype Treatment	Mean	Homogeneous Groups
L-44 1	37.5	A
L-43 1	35	AB
L-42 1	34.4	BC
L-34 1	33.85	BCD
L-33 1	33.2	BCDE
L-53 1	33.15	BCDE
L-35 1	32.9	BCDE
L-45 1	32.4	BCDE
L-52 1	31.9	CDE
L-32 1	31.1	DEF
L-44 2	31	EF
L-34 2	28.6	FG
L-53 2	28.5	FG
L-32 2	27.2	GH
L-33 2	26.75	GHI
L-43 2	26.4	GHIJ
L-45 2	26.2	GHIJK
L-35 2	24.7	HIJKL
L-52 2	24.15	IJKL
L-44 3	23.85	JKL
L-42 2	23.8	JKL
L-53 3	23.45	KL
L-32 3	22.75	LM
L-43 3	22.55	LMN
L-34 3	22.3	LMN
L-35 3	20.5	MNO
L-52 3	19.9	NO
L-45 3	19.85	NO
L-42 3	19.75	NO
L-33 3	18.4	O

4.4 Root length:

Roots are important part of plant used for the uptake of nutrients and water from the soil. Which then regulates in the plant stream for the regulation of plant mechanisms osmoregulation and other processes of the plant? Roots play important role in making plant strong and for the uptake of nutrients from the soil. Plants with higher roots lengths have ability to survive under salt stress. The differences among genotypes and among treatment levels were highly significant. At normal conditions the genotype L-53 showed highest mean root length 36.6 while L-32 showed lowest root length 28.5. At 50mm salt concentration there was decrease in root length in all inbred lines. The root length of genotype L-53 was decreased from 36.6 to 32.5 at 2nd level of salinity. The genotype L-35 showed highest mean root length 21.65 while L-34 showed lowest mean root length at 50mm salt concentration. At 100mm salt concentration, the decrease in root length was more obvious as compared

to 50mm NaCl concentration. The root length of L-53 was decreased from 36.6 to 24.25. The highest mean root length was observed in L-32 (20.97) while the L-45 showed lowest root length (13.25). In general, there was decrease in shoot length with increase in salt concentration.

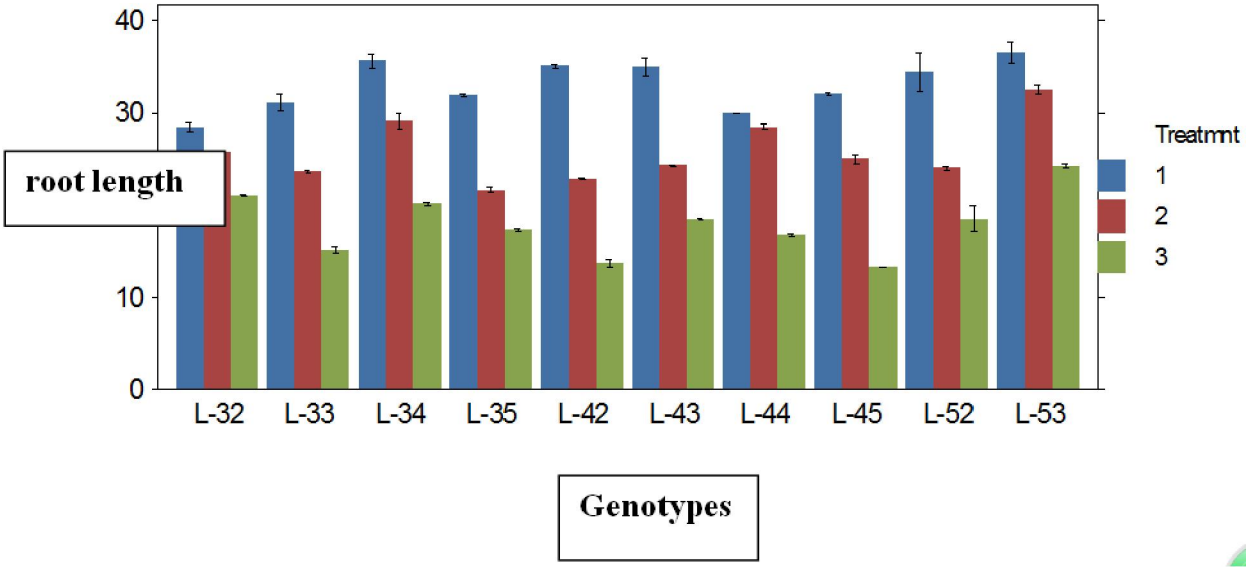

Figure 4.4.1Mean comparisons chart for root length of different genotypes at normal and saline condition

Table 4.4.2Tukey HSD all-pair wise comparisons test of root length for inbred *treatment under saline stress.

Genotype Treatment	Mean	Homogeneous Groups
L-53 1	36.6	A
L-34 1	35.65	AB
L-42 1	35.15	AB
L-43 1	35	AB
L-52 1	34.45	ABC
L-53 2	32.5	BCD
L-45 1	32.05	BCDE
L-35 1	31.95	BCDE
L-33 1	31.15	CDE
L-44 1	29.95	DE
L-34 2	29.1	DEF
L-32 1	28.5	EFG
L-44 2	28.5	EFG
L-32 2	25.7	FGH
L-45 2	25	GHI
L-43 2	24.35	HIJ
L-53 3	24.25	HIJ
L-52 2	24.05	HIJ
L-33 2	23.65	HIJK
L-42 2	22.85	HIJK
L-35 2	21.65	IJKL
L-32 3	20.95	JKLM
L-34 3	20.2	KLMN
L-43 3	18.55	LMNO
L-52 3	18.55	LMNO
L-35 3	17.35	MNOP
L-44 3	16.75	NOPQ
L-33 3	15.1	OPQ
L-42 3	13.65	PQ
L-45 3	13.25	Q

4.5 Root fresh weight:

Root fresh weight describes us about the biomass of roots that is an important factor for the evaluation of plant against any abiotic stress especially against salinity stress. More the roots more will be the root fresh weight or more will be the ability of plant to survive against the stress. The differences among genotypes and among treatment levels were highly significant while the genotype ×treatment differences were non-significant. At 0mm salt concentration, the genotype L-43 showed highest mean root fresh weight 3.15 followed by L-34 (2.65). At 50mm salt concentration there was decrease in the root fresh weight in all genotypes with variable extent. The root fresh weight of l-43 was decreased from 3.15 to 1.79 at 2nd level of salinity. The genotype L-32 and L-34 showed highest mean root fresh weight 1.15 while the genotype L-45 showed lowest value 0.75. At 100mm of salt concentration the decrease in root fresh weight

was more obvious. At 3rd level of salinity the root fresh weight of L-43 was reduced from 3.15(0mm) to 0.28(100mm). The inbred L-53 showed highest root fresh weight 0.53 while L-45 showed lowest root fresh weight 0.265 at 3rd level of salinity. In general, there was decrease in fresh root weight with increase in salt concentration.

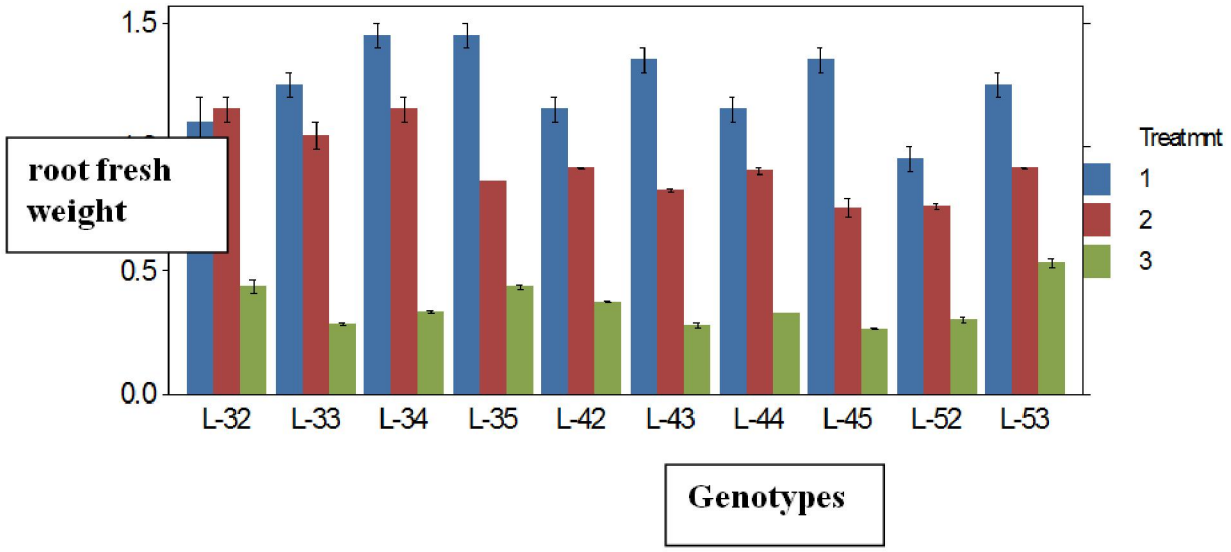

Figure 4.5.1Mean comparisons chart for root fresh weight of different genotypes at normal and saline condition.

Table 4.5.2Tukey HSD all-pair wise comparisons test of root fresh weight for inbred lines*treatment under saline stress.

Genotype Treatment	Mean	Homogeneous Groups
L-43 1	3.15	A
L-34 1	2.65	B
L-32 1	2.35	C
L-35 1	1.45	D
L-45 1	1.35	DE
L-33 1	1.25	DEF
L-53 1	1.25	DEF
L-32 2	1.15	EFG
L-34 2	1.15	EFG
L-42 1	1.15	EFG
L-44 1	1.15	EFG
L-33 2	1.045	FGH
L-52 1	0.95	GHI
L-42 2	0.915	GHI
L-53 2	0.915	GHI
L-44 2	0.905	GHI
L-35 2	0.86	HI
L-43 2	1.79	HI
L-52 2	0.76	IJ
L-45 2	0.755	IJ
L-53 3	0.53	JK
L-32 3	0.435	KL
L-35 3	0.435	KL
L-42 3	0.375	KL
L-34 3	0.335	KL
L-44 3	0.33	KL
L-52 3	0.3	KL
L-33 3	0.285	KL
L-43 3	0.28	KL
L-45 3	0.265	L

4.6Shoot fresh weight:

Shoot fresh weight is important for the evaluation of vegetative growth of inbred seedlings. It is necessary to take weight of shoots to access the salinity tolerance in plants. More shoot fresh weight more will be the vegetation. The differences among genotypes and among treatment levels were highly significant while the genotype × treatment differences for non-significant. On studying the all pair wise comparisons of interactions of inbred line and treatment inbred lines in treatment one or level one showed highest shoot fresh weight. At normal level, the genotype L-34 showed highest shoot fresh weight while genotype L-52 showed lowest mean fresh shoot weight 1.1. At 50mm NaCl concentration, there was decrease in shoot weight of all the genotypes. The mean fresh shoot weight of genotype was reduced from 3.05 to 0.955 at 2nd level of salinity. The genotype L-52 showed highest shoot fresh weight 1.09 while the L-43 showed lowest fresh shoot weight at 2nd level of salinity. At 100mm the decline in fresh shoot weight was more obvious among all the

genotypes. The genotype L-34 showed decrease in fresh shoot weight from 3.05(0mm) to 0.43(100mm). The genotype L-32 showed highest mean value 0.5353 while the genotype L-45 showed lowest mean value 0.275 at 3rd level of salinity. In general, there was decrease in fresh shoot weight with increase in salt concentration.

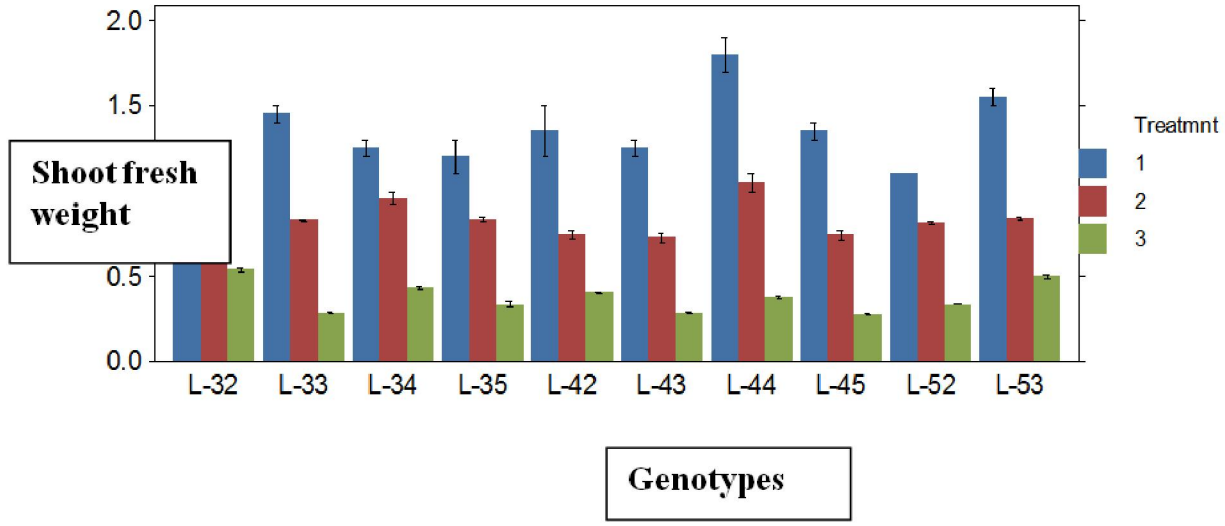

Figure 4.6.1 Mean comparisons chart for shoot fresh weight of different genotypes under normal and saline condition

Table 4.6.2 Tukey HSD All-pair wise comparisons test of sfw for genotype*treatment under saline stress.

Genotype Treatment	Mean	Homogeneous Groups
L-34 1	3.05	A
L-32 1	2.75	A
L-42 1	1.8	B
L-44 1	1.8	B
L-43 1	1.75	BC
L-53 1	1.55	BCD
L-33 1	1.45	BCDE
L-45 1	1.35	BCDEF
L-35 1	1.2	BCDEFG
L-52 1	1.1	BCDEFGH
L-44 2	1.045	CDEFGHI
L-34 2	0.955	DEFGHIJ
L-32 2	0.9	DEFGHIJ
L-53 2	0.835	DEFGHIJ
L-35 2	0.83	EFGHIJ
L-33 2	0.825	EFGHIJ
L-52 2	0.815	EFGHIJ
L-42 2	0.745	EFGHIJ
L-45 2	0.74	EFGHIJ
L-43 2	0.725	FGHIJ
L-32 3	0.535	GHIJ
L-53 3	0.5	GHIJ
L-34 3	0.43	HIJ
L-42 3	0.405	HIJ
L-44 3	0.375	IJ
L-52 3	0.335	IJ
L-35 3	0.335	IJ
L-33 3	0.285	J
L-43 3	0.285	J
L-45 3	0.275	J

4.7Root density:

The differences among genotypes and among treatment levels were highly significant while the genotype ×treatment differences were non-significance. Ahsan *et al.* (2011) and Golbashy*et al.* (2012) found same results as mentioned in the table. At 0mm NaCl concentration the genotype L-52 showed highest mean root density while L-35 showed lowest mean value for root density (0.995). At 50mm NaCl concentration there was decrease in root density in all genotypes with variable degree. The root density of genotype L-52 was decreased from 1.535 to 0.775 at second level of salinity. At treatment two genotype L-44 showed highest value 1 while L-43 showed lowest value 0.74. At 100mm the genotype L-32 showed highest value 0.685 while L-45 showed lowest value 0.325. There was decrease in root density with increase in salt concentration.

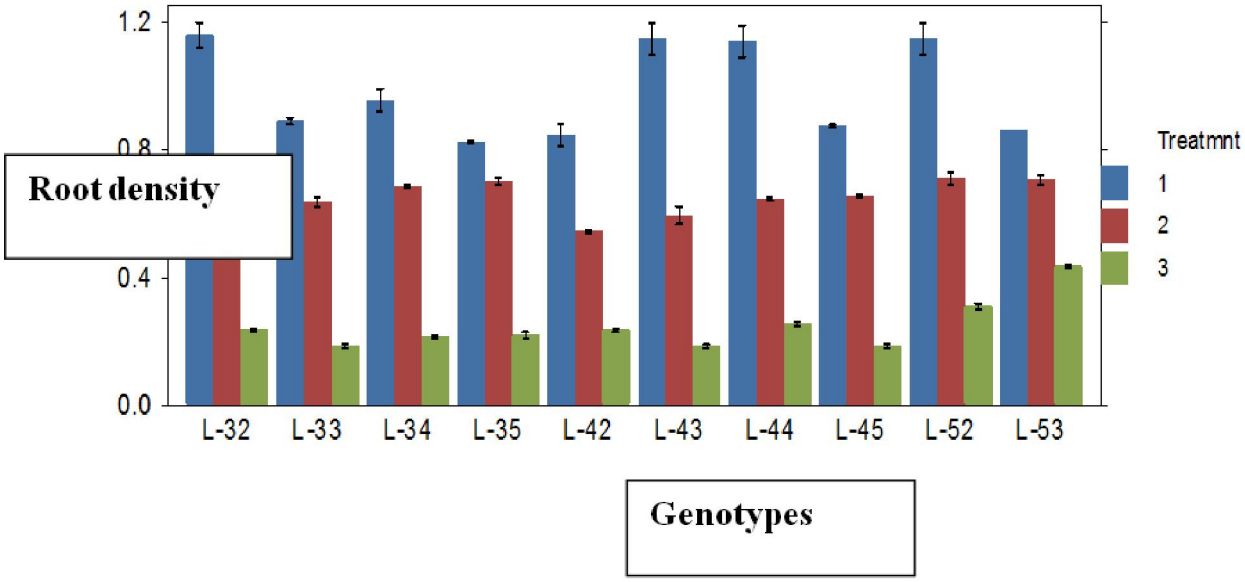

Figure 4.7.1Mean comparisons chart for root density of different genotypes at normal and saline condition

Table 4.7.2 Tukey HSD All-Pair wise comparisons test of rdw for inbred line*treatment under saline stress.

Genotype Treatment	Mean	Homogeneous Groups
L-32 1	1.16	A
L-43 1	1.15	A
L-52 1	1.15	A
L-44 1	1.14	A
L-34 1	0.955	B
L-33 1	0.89	BC
L-45 1	0.875	BC
L-53 1	0.86	BC
L-42 1	0.845	BC
L-35 1	0.825	CD
L-52 2	0.71	DE
L-53 2	0.705	DE
L-35 2	0.7	E
L-34 2	0.685	E
L-45 2	0.655	EF
L-44 2	0.645	EF
L-33 2	0.635	EF
L-43 2	0.595	EF
L-42 2	0.545	FG
L-32 2	0.535	FG
L-53 3	0.435	G
L-52 3	0.31	H
L-44 3	0.255	HI
L-32 3	0.235	HI
L-42 3	0.235	HI
L-35 3	0.22	HI
L-34 3	0.215	HI
L-33 3	0.185	I
L-43 3	0.185	I
L-45 3	0.185	I

4.8Root dry weight:

According to Analysis of Variance of Completely Randomized Design with factors for root dry weight results were highly significant for all three treatments of salinity, inbred lines and interaction between inbred lines and treatments. On observing the all comparisons of interactions between inbred line and treatment inbred lines in treatment one or level one showed highest dry root weight. Root dry weight is important for the assessment salt accumulation in root zone and for the comparisons of inbred line in normal and saline stress environment. At 0mm, the genotype L-32 showed highest mean root dry weight while the genotype L-35 showed lowest mean root dry weight. At 50mm salinity level there was decrease in dry root weight of all the genotypes with variable degree. The mean root dry weight of L-32 was reduced from 1.16 to 0.535 at 2nd level of salinity. The genotype L-52 showed highest mean dry root weight 0.71 while L-32 showed lowest dry root weight at 50mm NaCl concentration. AT 100mm NaCl concentration the decrease in dry root weight was more obvious as compared to 50mm salt concentration. The dry root weight of genotype L-32

was decreased from 1.16(0mm) to 0.235(100mm). The genotype L-53 showed highest value 0.435 while the genotype L-45 showed lowest value at 3rd level of salinity. In general, there was decrease in dry root weight with increase in salt concentration.

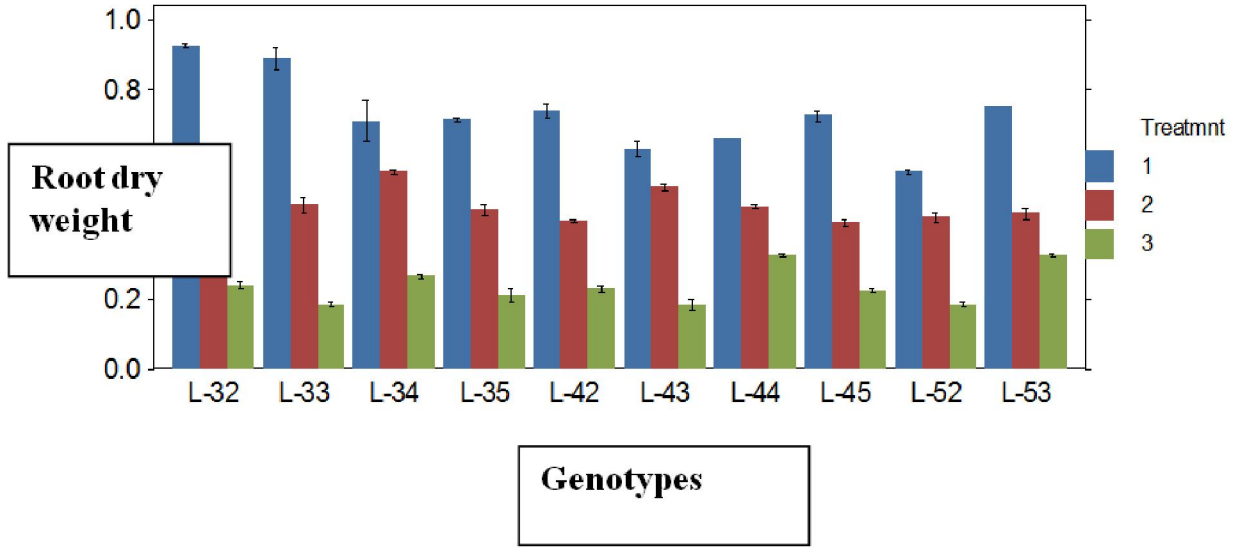

Figure 4.8.1 Mean comparisons chart for root dry weight of different genotypes at normal and saline condition

Table 4.8.2 Tukey HSD All-Pair wise comparisons test of shoot dry weight for inbred line*treatment under saline stress.

Genotype Treatment	Mean	Homogeneous Groups
L-32 1	0.925	A
L-33 1	0.89	A
L-53 1	0.75	B
L-42 1	0.74	B
L-45 1	0.725	BC
L-35 1	0.715	BC
L-34 1	0.71	BC
L-44 1	0.66	BCD
L-43 1	0.63	CDE
L-34 2	0.565	DEF
L-52 1	0.565	DEF
L-32 2	0.535	EFG
L-43 2	0.52	FGH
L-33 2	0.47	FGHI
L-44 2	0.465	GHI
L-35 2	0.455	GHI
L-53 2	0.445	GHI
L-52 2	0.435	HI
L-42 2	0.425	HI
L-45 2	0.42	IJ
L-44 3	0.325	JK
L-53 3	0.325	JK
L-34 3	0.265	KL
L-32 3	0.24	KL
L-42 3	0.23	KL
L-45 3	0.225	L
L-35 3	0.21	L
L-33 3	0.185	L
L-43 3	0.185	L
L-52 3	0.185	L

4.9Shoot dry weight:

At treatment one the genotype L-32 showed the highest mean dry shoot weight 0.925 while L-52 showed the lowest mean value. At 50mm salt concentration there was decrease in shoot dry weight in all genotypes. The mean shoot dry weight of L-32 was decreased from 0.925 to 0.535. The inbred line L-34 showed highest mean value 0.565 while the genotype L-45 showed lowest mean value 0.42. At 100mm salinity level the decrease in shoot dry weight was more prominent as compared to 50mm salt concentration. Genotype L-44 showed highest mean value 0.325 while the genotype L-52 showed the lowest value 0.185. There was decrease in shoot dry weight with increase in salt concentration.

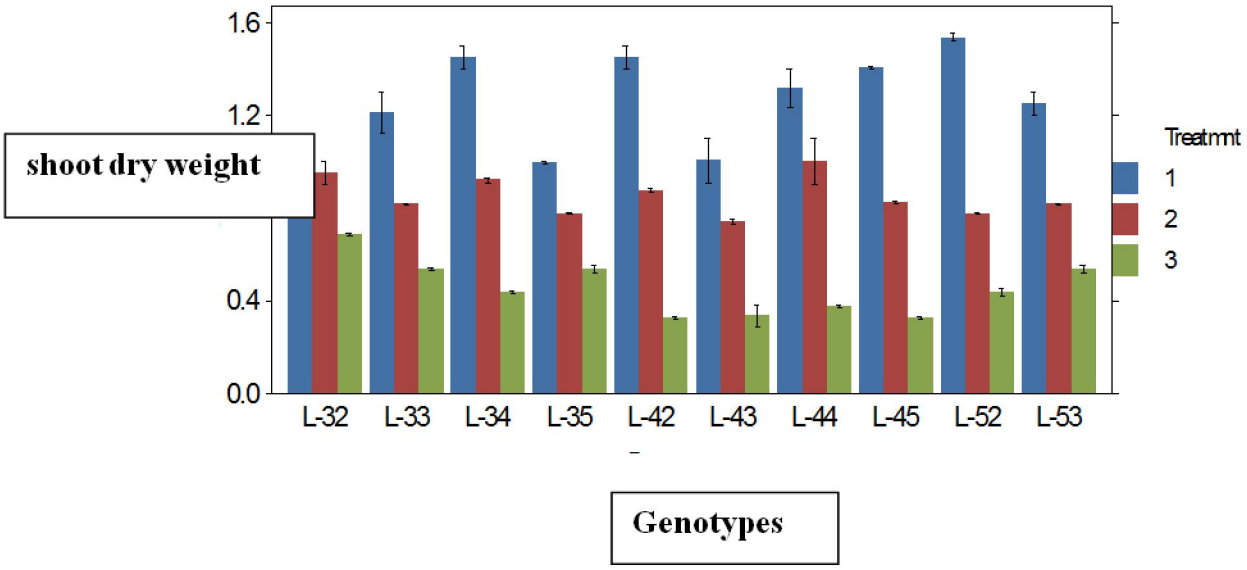

Figure 4.9.1 Mean comparisons chart for shoot dry weight of different genotypes at normal and saline condition

Table 4.9.2 All pair wise comparisons for treatment and inbred line interaction for Root Density.

Genotype Treatment	Mean	Homogeneous Groups
L-52 1	1.535	A
L-32 1	1.45	AB
L-34 1	1.45	AB
L-42 1	1.45	AB
L-45 1	1.405	ABC
L-44 1	1.315	ABC
L-53 1	1.25	BC
L-33 1	1.21	CD
L-43 1	1.005	DE
L-44 2	1	DE
L-35 1	0.995	DE
L-32 2	0.975	E
L-34 2	0.92	EF
L-42 2	0.875	EFG
L-45 2	0.825	EFG
L-33 2	0.815	EFG
L-53 2	0.815	EFG
L-35 2	0.775	EFG
L-52 2	0.775	EFG
L-43 2	0.74	FGH
L-32 3	0.685	GH
L-33 3	0.535	HI
L-35 3	0.535	HI
L-53 3	0.535	HI
L-34 3	0.435	I
L-52 3	0.435	I
L-44 3	0.375	I
L-43 3	0.335	I
L-42 3	0.325	I
L-45 3	0.325	I

4.10 Fresh Root shoot ratio:

At normal level the genotype L-43 showed highest mean value for Root shoot ratio while genotype L-44 showed lowest mean value 0.6424. At 50mm level the genotype L-32 showed mean value of 1.27 while L-44 showed lowest 0.867. At 100mm level the genotype L-35 showed highest mean value of 1.30 while L-34 showed lowest mean value of fresh root shoot ratio 0.7778. There was decrease in fresh root shoot ratio with increase in salt concentration.

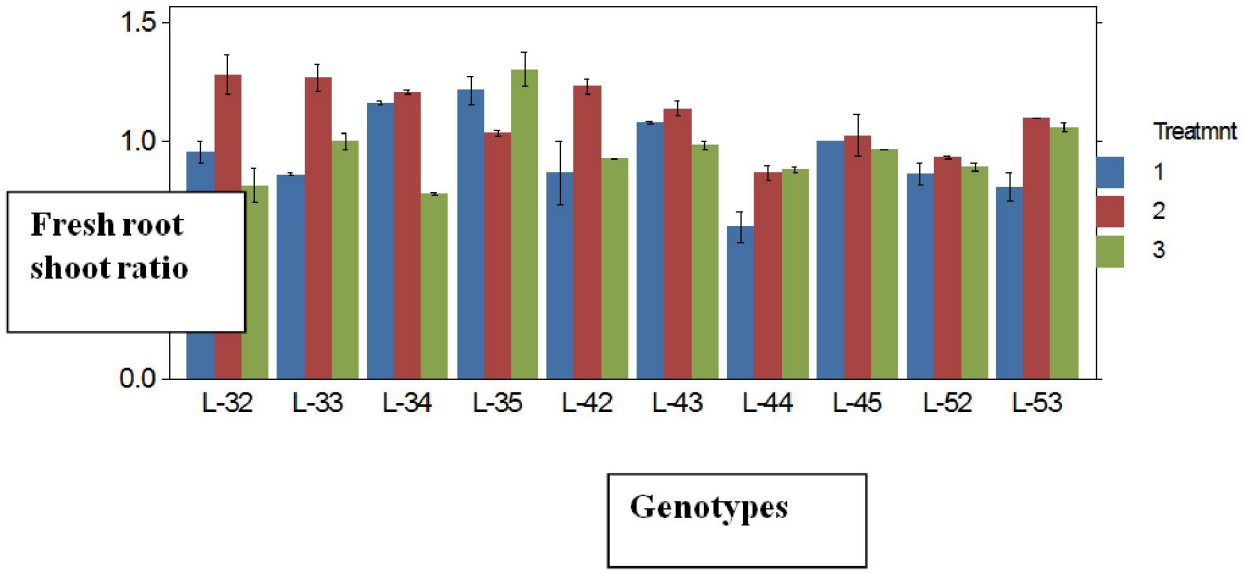

Figure 4.10.1 Mean comparisons chart for fresh root shoot ratio of different genotypes at normal and saline condition

Table 4.10.2 All pair wise comparisons for treatment and inbred line interaction for fresh root shoot ratio under saline stress.

Genotype Treatment	Mean	Homogeneous Groups
L-43 1	2.0072	A
L-35 3	1.3018	AB
L-32 2	1.2796	AB
L-33 2	1.2663	AB
L-42 2	1.2293	B
L-35 1	1.2133	B
L-34 2	1.2039	B
L-43 2	1.139	B
L-53 2	1.0958	B
L-53 3	1.0596	B
L-35 2	1.0363	B
L-45 2	1.0239	B
L-33 3	1.0006	B
L-45 1	1	B
L-43 3	0.9821	B
L-45 3	0.9636	B
L-52 2	0.9325	B
L-42 3	0.9259	B
L-52 3	0.8953	B
L-44 3	0.8802	B
L-34 1	0.8718	B
L-44 2	0.8677	B
L-52 1	0.8636	B
L-33 1	0.8619	B
L-32 1	0.8558	B
L-32 3	0.815	B
L-53 1	0.8083	B
L-34 3	0.7792	B
L-42 1	0.6524	B
L-44 1	0.6424	B

4.11 Dry Root shoots Ratio:

At normal level the genotype L-52 showed highest mean value for Root shoot ratio while genotype L-33 showed lowest mean value 1.001. At 50mm level the genotype L-52showed mean value of 1.63 while L-32showed lowest 1.00. At 100mm level the genotype L-52showed highest mean value of 1.27 while L-44 showed lowest mean value of dry root shoot ratio 0.78. There was decrease in dry root shoot ratio with increase in salt concentration.

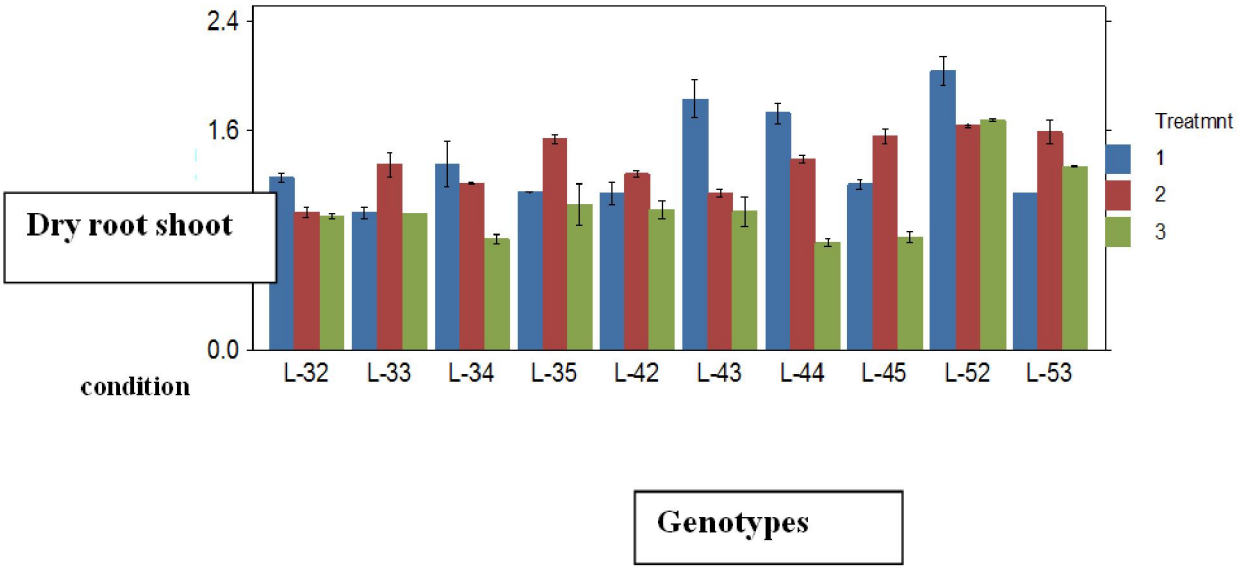

Figure 4.11.1 Mean comparisons chart for dry root shoot ratio of different genotypes at normal and saline condition

Table 4.11.2All pair wise comparisons for treatment and inbred line interaction for dry root shoot ratio under saline condition.

Genotype Treatment	Mean	Homogeneous Groups
L-52 1	2.0363	A
L-43 1	1.8298	AB
L-44 1	1.7273	ABC
L-52 3	1.2754	ABCD
L-52 2	1.6325	BCDE
L-53 2	1.5872	BCDEF
L-45 2	1.5607	BCDEF
L-35 2	1.5394	BCDEFG
L-44 2	1.3874	CDEFGH
L-34 1	1.3589	CDEFGHI
L-33 2	1.3549	CDEFGHI
L-53 3	1.3385	CDEFGHI
L-42 2	1.2827	DEFGHI
L-32 1	1.2539	EFGHI
L-34 2	1.2124	FGHIJ
L-45 1	1.2076	FGHIJ
L-35 1	1.1539	GHIJK
L-53 1	1.1467	GHIJK
L-42 1	1.144	GHIJK
L-43 2	1.1437	HIJK
L-35 3	1.0618	HIJK
L-42 3	1.0246	HIJK
L-43 3	1.0088	HIJK
L-33 1	1.0015	HIJK
L-32 2	1.001	HIJK
L-33 3	1	HIJK
L-32 3	0.98	IJK
L-45 3	0.8231	JK
L-34 3	0.812	K
L-44 3	0.785	K

Conclusion:

Our results provide guidelines for the selection of salt tolerant maize hybrids and this information is relevant and very important to breeders and plant physiologists interested in improving salt tolerance of maize. A refinement of current screening tool could be desirable to facilitate germplasm evaluation. The screened material can be used to evolve high yielding salt tolerant maize hybrids or can directly be introduced for cultivation on saline areas.

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