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DEVIATION IN GENETIC RESPONSE OF SEEDLING GROWTH PARAMETERS OF SUNFLOWER HYBRIDS TO KCL AND NACL STRESS

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ABSTRACT
In world, crop productivity is severely affected by prevailing salinity issues, particularly in arid and semi-arid regions. Screening sunflower hybrids against salinity was a good approach to develop salt tolerant varieties. The proposed research was performed in experimental field of the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad. Genetic material was comprised of eight genotypes of sunflower (5 Lines and 3 Testers). Fifteen hybrids were developed by using these genotypes in 15 possible combinations. Glasshouse experiment was carried out to evaluate the effect of salinity stress different physiological and morphological parameters, like germination (%), shoot length, shoot dry weight, shoot fresh weight, root length, root dry weight, root fresh weight, relative water contents, chlorophyll contents and cell membrane permeability at seedling stage in sunflower hybrids. These fifteen hybrids were grown in glasshouse in complete randomized design with three repeats and three treatments. Salinity stress was developed artificially with NaCl and KCl concentrations of $7 dsm^{-1}$. After 45 days seedlings were uprooted and data were recorded for analysis of variance and to estimate the genotypic association among the seedling traits to develop selection criteria for salinity stress. Parents and hybrids showed significant variability for all the traits under study for three treatments of salinity.

KEYWORDS: sunflower, salinity stress, seedling.

INTRODUCTION
Edible oil is an important component of diet being rich in several essential components. But unfortunately, a severe shortage in edible oil production is faced by Pakistan. Import bill is posing a huge burden on country's economy, being the second largest import after petroleum and is continuously accelerating. During the last decades, edible oil imports showed an average increase of 4.07 percent per annum. Domestic production of edible oil was 0.546 million tons during 2014-15 which is only 23 per cent of the total requirement of the country. The imported oil is 1.789 million tons (almost 77%) worth Rs.139.33 billion which is a great burden on economy (Economic Survey of Pakistan, 2014-15). The production of edible oil at local level can be increased by increasing the area under production, per acre yield and genetic potential of varieties against various abiotic and biotic stresses. Among abiotic stresses salinity and sodicity is a great challenge. Salinity is a major issue, especially of arid and semi-arid areas (FAO, 2013). Sunflower seed contains 25-48% oil (Skoric and Marinkovic, 1986) and is also a rich source of protein *i.e.* 23% (Vranceanu *et al*., 1987). Its oil has high concentration of unsaturated fatty acids (Weiss, 1993). Pakistan's climatic conditions are extremely suitable for its production, due to its short maturity period i.e. 90 to 110 days. Therefore it can be grown twice a year without disturbing existing crop rotation. It is noteworthy that sunflower crop stands second to soybean for oil production worldwide. But unfortunately its yield per hectare in our country is 1345.2 kg ha^{-1} which is far less than other countries like Turkey, China and USA having 2036.0 kg ha^{-1}, 1752.6 kg ha^{-1} and 1567.1 kg ha^{-1} respectively (FAO, 2013). Sunflower is a major commercial crop; its growth is negatively affected by the various abiotic stresses including soil salinity. So, maximum yield of crop is not attained by the farmers.

About 10% worlds's agricultural land has affected by sodicity and salinity (Szabolcs, 1991). In Pakistan about 6.67 mha land is salt affected (Khan 1998), out of which 60% is saline sodic (Economic survey of Pakistan, 2012-13). High concentration of salts declines the accessibility of water and nutrients to the plants and causes an increase in osmotic pressure in the root zone. These circumstances affected plant physiological activities, and reduced crop yield (Hebbara *et al*., 2003).We require to develop such hybrids that can perform well in salinity along with high seed yield and oil production. Keeping in view, all above mentioned factors the experiment was conducted to evaluate and screen the sunflower hybrids against salinity stress at seedling stage.

MATERIALS & METHODS
The research work was carried out in the Department of Plant Breeding and Genetics, University of Agriculture Faisalabad during the year 2013-14. The experiment was consisted of eight genotypes of sunflower *viz*; 193, B1.1, 124, A2.4, C3.22, C3.1, C2.9 and C2.11 produced by the Oilseed Research Program of the Department of Plant Breeding and Genetics, University of Agriculture Faisalabad. The genotypes were sown in the field keeping row to row and plant to plant distance of 0.75m and 0.25m respectively. 5 lines were crossed with 3 testers in Line × Tester scheme to develop 15 hybrids by hand emasculation and pollination. Hybrid seeds were harvested

at maturity and stored separately. In the next growing season, these hybrids were evaluated against the salinity stress developed through the application of $7dsm^{-1}$ of KCl (treatment 2) and NaCl (treatment 3) in pots along with the control (treatment 1). Data were recorded on different morphological and physiological parameters *viz;* germination %, root length, shoot length, fresh root weight, fresh shoot weight , dry root weight, dry shoot weight, relative water contents, chlorophyll contents and cell membrane permeability at seedling stage. Recorded data were subjected to analysis of variance (Steel *et al*., 1997) and stress tolerance index were estimated by evaluating the means of three treatments.

RESULTS & DISCUSSION

Success of any plant breeding program depends upon variations present in crop germplasm. Higher the genetic variations more will be the chances of success of breeding material through selection. Therefore, modes of inheritance along with the genetic variations of polygenic characters help the plant breeders to conduct a successful crop improvement program. Sunflower genotypes revealed highly significant differences (Table 1) for all plant characters *viz*., shoot length, root length, fresh shoot weight, fresh root weight, dry shoot weight, dry root weight, relative water contents, chlorophyll contents and cell membrane permeability, both under normal as well as salt stress conditions. Parents and hybrids also showed significant differences for all the plant characters under study.

TABLE 1. Analysis of variance for three treatments of salt

Treatment 1 (Control)												
SOV	DF	GP%	SL	RL	R/S	FRW	FSW	DRW	DSW	RWC	TCC	CMP
Replications	2	16.518	5.251*	0.189	237.340	0.001	0.086	0.000	0.000	22.602	9.610	20.730
Genotypes	22	146.647*	211.959*	12.345*	36.403*	0.169*	2.210*	0.003*	0.029*	208.175*	197.896*	296.503*
Parents	7	171.925*	100.262*	7.088*	0.020	0.170*	3.696*	0.003*	0.036ns	221.799*	184.022*	304.301*
Crosses	14	137.243*	249.697*	15.426*	48.251*	0.167*	1.569*	0.003*	0.023*	202.204*	215.928*	312.185*
Parents vs Crosses	1	101.353ns	465.506*	6.007*	125.195*	0.189*	0.788*	0.002ns	0.060*	196.415*	42.557ns	22.367*
Lines	4	94.434ns	356.408*	11.397*	49.997*	0.38*	2.518*	0.008*	0.011ns	192.070*	303.03ns	534.015*
Testers	2	162.991*	311.779*	4.180*	103.524*	0.069ns	1.184ns	0.000*	0.022*	209.897*	16.955*	206.684*
Line×Tester	8	152.210*	180.821*	20.252*	33.561*	0.086*	1.191*	0.001ns	0.029*	205.348*	222.121*	227.646*
Error	44	29.252	5.767	0.327	36.785	0.003	0.094*	0.000	0.001	32.429	13.369	25.238
Treatment 2 (KCl)												
SOV	DF	GP%	SL	RL	R/S	FRW	FSW	DRW	DSW	RWC	TCC	CMP
Replications	2	15.882	4.511	0.144	0.002	0.001	0.026	0.000	0.029	0.002	13.476	24.147
Genotypes	22	144.368*	177.526*	9.587*	0.024*	0.155*	2.184*	0.069*	18.188*	0.171*	325.169*	361.117*
Parents	7	207.112*	88.495*	7.718*	0.016*	0.172*	2.459*	0.188*	0.015*	0.221*	207.573*	352.660*
Crosses	14	123.211*	207.162*	10.716*	0.029ns	0.14*	1.871*	0.002ns	27.929*	0.157*	401.115*	378.619ns
Parents vs Crosses	1	1.348ns	385.845*	6.859*	0.000ns	0.242*	4.641*	0.172*	9.015ns	0.019*	85.096ns	175.272*
Lines	4	175.381*	255.912*	14.507*	0.041*	0.27*	1.709*	0.005*	27.871*	0.035*	525.903*	376.920*
Testers	2	4.325ns	232.392*	4.720*	0.009*	0.094ns	2.805ns	0.00ns	28.427*	0.393*	117.089ns	556.299*
Line×Tester	8	126.848*	176.480*	10.320*	0.029*	0.086*	1.718*	0.001*	27.834*	0.158*	409.729*	335.049*
Error	44	25.998	4.666	0.264	0.001	0.002	0.048	0.000	0.028	0.005*	11.292	29.650
Treatment 3 (NaCl)												
SOV	DF	GP%	SL	RL	R/S	FRW	FSW	DRW	DSW	RWC	TCC	CMP
Replications	2	12.999	3.553	0.119	0.028	0.002	0.048	0.00	0.029	0.587	7.262	21.974
Genotypes	22	164.889*	199.296*	10.919*	0.036*	0.150	2.460	0.004	18.188*	361.597*	193.320*	322.142*
Parents	7	172.251*	87.256*	8.161*	0.025*	0.150*	4.453	0.002	0.015ns	0.184*	178.361*	333.591*
Crosses	14	172.976*	236.430*	12.591*	0.044*	0.158*	1.468	0.005	27.929*	554.440*	213.384*	338.912*
Parents vs Crosses	1	0.136ns	463.689*	6.826*	0.00ns	0.040ns	2.391	0.002	9.015ns	191.693*	17.123ns	7.222ns
Lines	4	224.647*	318.994*	10.341*	0.047*	0.195*	2.192	0.009	27.871*	553.165*	247.339*	522.401*
Testers	2	42.097*	206.868*	3.006*	0.013ns	0.423*	0.661	0.002	28.427*	552.157*	13.410ns	373.883ns
Line×Tester	8	179.860*	202.538*	16.112*	0.050*	0.074*	1.309	0.003	27.834*	555.648*	246.400*	238.424*
Error	44	24.470	4.303	0.242	0.001	0.002	0.051	0.000	0.028	0.731	9.959	26.615

Male × female interaction showed highly significant differences for all traits. Genetic variations between genotypes × salt stress interaction were highly significant for all plant characters. Parents × salt stress and hybrids × salt stress interactions also revealed highly significant differences for all characters. Testers showed non-significant differences for all plant traits and lines also showed non-significant differences for all traits except relative water contents. These results showed presence of sufficient genetic variations for different traits under salinity stress. Table 2, shows germination percentage of parents and hybrids. The hybrid 124 × C3.1 had maximum and hybrid B1.1×C2.11 had minimum germination percentage under normal soil conditions. For treatment 2, genotype 124 had maximum and hybrid B1.1 × C2.11 had minimum germination percentage. For salinity treatment 3 genotype 124 had maximum and hybrid 124×C2.9 had minimum germination percentage. Adiloglu *et al*. (2007), Kateiji *et al*. (1994) and Turhan and Ayaz (2004) found similar results of germination percentage. Salinity delayed the seedling emergence by reducing plant growth metabolism and cell division (Maas & Nieman, 1978). At higher levels of salinity stress, a reduction in seedling emergence was observed and some of the seedlings did not emerge at all. Table 2 revealed that hybrid B1.1 × C3.1 had maximum and hybrid C3.22 × C3.1 had minimum root length under normal soil conditions. Hybrid B1.1×C2.9 had maximum and genotype 124 had minimum root length under 1st level of salt stress. Hybrid A2.4×C3.1 had maximum and hybrid 124×A2.11 had minimum root length at 2nd level of salt stress. These results were similar with the findings of Adiloglu *et al*. (2007) and Djanaguiraman *et al*. (2004).

TABLE 2. Mean comparison of parents and hybrids at three treatments of salinity

	G%			RL			SL			FRW			FSW		
Genotypes	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3
193	77.40	75.34	70.54	7.60	6.50	5.6	33.40	27.30	29.2	0.27	0.20	0.15	3.35	2.11	2.1
B1.1	64.55	61.20	58.69	9.73	7.23	5.8	28.90	25.37	23.3	0.35	0.23	0.161	2.85	2.09	2.79
124	87.23	84.35	83.8	6.50	3.80	5.3	43.27	31.29	33.7	0.97	0.49	0.344	1.97	2.80	0.87
A2.4	65.67	61.20	63.4	10.10	4.52	8.7	38.20	39.89	21.34	0.53	0.78	0.75	1.60	1.04	3.07
C3.22	72.23	71.23	70.1	5.50	5.98	6.3	28.30	22.19	19.5	0.81	0.99	0.65	1.70	0.96	0.56
C3.1	80.07	79.30	73.7	8.30	6.30	7.5	19.80	18.80	18.5	0.80	0.51	0.27	3.67	3.10	2.78
C2.9	78.36	78.01	75.5	9.34	9.00	8.8	31.68	30.70	27.3	0.67	0.31	0.46	4.28	2.35	3.09
A2.11	77.45	71.23	70.1	6.50	5.98	6.34	37.40	35.50	34.4	0.64	0.49	0.45	4.03	4.05	4.82
193×C3.1	81.00	77.24	77.8	10.30	10.01	9.56	36.63	30.29	27.9	0.53	0.52	0.35	2.78	2.50	1.9
193×C2.9	84.57	79.67	78.8	11.77	10.50	9.3	27.50	21.87	22.35	0.48	0.65	0.24	2.65	2.30	1.34
193×A2.11	71.28	76.54	80.12	8.23	8.10	7.86	28.18	19.60	18.6	0.95	0.48	0.76	1.90	0.75	0.54
B1.1×C3.1	76.34	71.89	70.9	12.50	5.41	3.75	28.30	32.80	23.56	0.52	0.98	0.93	2.70	1.90	0.92
B1.1×C2.9	79.67	67.30	66.45	11.34	10.56	6.78	43.20	21.76	40.76	1.13	0.61	0.23	3.56	2.03	2.27
B1.1×A2.11	63.13	58.18	58	6.70	5.71	6.01	22.50	33.24	43.42	0.89	0.67	0.58	2.30	0.56	2.98
124×C3.1	88.00	80.42	83	6.60	6.10	5.2	48.10	21.45	20.27	0.76	0.53	0.24	1.87	2.78	1.33
124×C2.9	79.13	69.45	57.5	7.10	6.30	5.5	40.03	19.11	30.27	0.49	0.44	0.41	3.80	1.12	2.93
124×A2.11	78.34	72.71	70	10.77	6.30	2.80	26.80	22.30	44.29	0.98	0.69	0.51	3.10	1.40	3.53
A2.4×C3.1	70.90	66.56	64.5	9.80	8.80	10.1	36.30	39.21	30.4	0.64	0.79	0.92	4.30	2.45	4.41
A2.4×C2.9	87.34	69.65	74.5	7.21	6.20	7.34	48.30	39.20	45.6	0.41	0.17	0.31	3.42	3.88	1.7
A2.4×A2.11	78.33	83.35	74.14	8.10	7.90	6.5	44.50	37.34	39.35	0.38	0.53	0.75	2.88	2.10	1.5
C3.22×C3.1	71.12	70.98	66.2	5.40	9.02	5.38	40.30	23.63	21.5	0.92	0.79	0.86	2.09	4.75	0.9
C3.22×C2.9	76.34	76.00	68.4	8.90	8.10	7.8	29.70	22.90	23.4	0.80	0.64	0.57	1.78	0.98	0.78
C3.22×A2.11	83.23	75.45	75.02	6.70	4.38	2.83	27.10	20.10	18.87	0.87	0.17	0.42	2.25	3.80	1.33

G% = Germination percentage, RL = Root length, SL= Shoot length, FRW = Fresh root weight, FSW = Fresh shoot weight.

Higher concentrations of salt probably affected root permeability and integrity due to displacement of Ca^2+ from plasmalemma, which declined the root growth and root length (Azaizeh and Stendele, 1991). Another reason might be that the salinity stress reduced the cell enlargement and cell division (Nieman, 1965). Variations in shoot length showed that, all genotypes had significant genetic potential for tolerance to salt stress. Table No 2 revealed that hybrid 124×C3.1 had maximum and genotype C3.1 had minimum shoot length for the normal soil conditions. For 1^{st} salinity level, genotype A2.4 had maximum whereas genotype C3.1 had minimum shoot length. For 2^{nd} salinity level, hybrid A2.4×C2.9 had maximum and genotype C3.1 had minimum shoot length. Djanaguiraman *et al*. (2004) in rice and Francois (1996) and Ghumman (2000) in sunflower observed that reduction in shoot length was due to increase of salts in cell wall that changed the metabolic pathways, decreased the cell wall flexibility and ultimately decreased shoot length. Secondary cells appeared immediately under salt stress and made cell wall strict. Immediately, under salt stress secondary cells appeared and made the cell wall strict. As a result, efficiency of turgor pressure in cell enlargement decreased. These changes ultimately reduced the shoot length (Aslam *et al*., 1993).

Table 2 showed that hybrid B1.1×C2.9 had maximum and 193 had minimum fresh root weight under normal conditions. Genotype C 3.22 had maximum and hybrid A2.4×C2.9 had minimum fresh root weight under 1^{st} level of salt stress. Hybrid B1.1×C3.1 had maximum and 193 genotype had minimum fresh root weight under 2^{nd} level of salt stress. Under salt stress a significant decrease in fresh root weight was observed, as salt concentration increased. Reduction in fresh root weight was due to the addition of salts in older leaves which caused earlier death and decreased photosynthetic leaf area of a plant, which reduced the growth (Munns, 2002). These results were in agreement with Haq *et al*., 2009 and Adiloglu *et al*., (2007).

Table 2 showed that hybrid A2.4×C3.1 had maximum and A2.4 had minimum fresh shoot weight under normal conditions. Hybrid C3.2 × C3.1 had maximum fresh shoot weight and hybrid B1.1 × C2.11 had minimum fresh shoot weight under 1^{st} level of salt stress. Genotype A 2.11 had maximum and hybrid 193×C2.11 had minimum fresh shoot weight under 2^{nd} level of salt stress. Reduction in fresh shoot weight was due to the less availability of water in shoot media which decreased the osmotic potential and inhibited the growth under salt stress (Munnas, 1995). Haq *et al*. (2004) and Adiloglu *et al*. (2007) found similar results. Table No 3 showed that hybrid 124×A2.11 had maximum and B1.1 × C3.1 had minimum dry root weight under normal conditions. Hybrid B1.1×C3.1 had maximum and genotype 124, hybrid 124×C3.1, 193 × C2.9, 193 × C3.1 had minimum dry root weight under 1^{st} level of salt stress. Hybrid A2.4× A2.11 had maximum and A 2.4 had minimum dry root weight under 2^{nd} level of salt stress. Under salinity there was a significant decrease in dry root weight with an increased NaCl concentration. These results were similar with the findings of Adiloglu *et al*. (2007) and Arshadullah and Zaidi (2007) who examined same significant results of dry root weight. Under salinity stress decrease in dry root weight was correlated with decrease in fresh root weight. Higher concentration of Na^+ and CI^- ions in root could suppress uptake of K^+, Ca^+ and NO^{-3} and ultimately results in reduced growth (Gorham and Wyn Jones, 1993).

Table 3 showed that hybrid 124 × A2.11 had maximum and B1.1 × C3.1 had minimum dry shoot weight under normal conditions. Hybrid B1.1 × C3.1 had maximum and genotype 124, hybrid 124 × C3.1, 193 × C2.9, 193 × C3.1 had minimum dry shoot weight under 1^{st} level of salt stress. Hybrid A2.4× A2.11 had maximum and A 2.4 had minimum dry shoot weight under 2^{nd} level of salt stress

TABLE 3. Mean comparisons of parents and hybrids

	DRW			DSW			RWC			CC			CMP		
Genotypes	S0	S1	S2	S0	S1	S2	S0	S1	S2	S0	S1	S2	S0	S1	S2
193	0.14	0.09	0.07	0.29	0.2	0.16	0.6	0.35	0.39	33.40	31.24	28.37	55.45	59.35	53.35
B1.1	0.10	0.04	0.03	0.25	0.15	0.12	0.6	0.35	0.65	28.56	31.24	33.67	60.35	60.05	59.34
124	0.11	0.03	0.05	0.26	0.14	0.14	1.12	0.87	0.55	47.67	25.45	42.5	60.34	62.45	58.35
A2.4	0.06	0.09	0.02	0.21	0.2	0.11	0.88	0.68	0.78	38.87	43.67	43.55	39.24	53.56	36.55
C3.22	0.15	0.13	0.11	0.3	0.24	0.2	1.15	0.95	0.39	26.53	47.35	30.55	42.35	43.55	40.24
C3.1	0.10	0.07	0.21	0.25	0.18	0.3	0.63	0.43	0.98	41.32	24.35	42.34	56.75	58.87	57.76
C2.9	0.09	0.05	0.06	0.24	0.16	0.15	1.02	1.02	1.06	33.79	38.87	33.48	47.34	53.27	42.67
A2.11	0.13	0.08	0.03	0.28	0.19	0.12	0.78	0.78	0.67	46.45	31.23	54.11	39.25	44.28	37.87
193×C3.1	0.09	0.03	0.02	0.24	0.14	0.11	1.12	1.12	0.68	43.89	53.89	47.35	38.55	43.89	30.23
193×C2.9	0.08	0.03	0.05	0.23	0.14	0.14	0.72	0.55	1.03	39.78	50.25	45.22	54.34	54.85	51.65
193×A2.11	0.07	0.05	0.04	0.22	0.16	0.13	0.89	0.72	0.43	31.47	43.54	42.87	43.58	48.45	40.35
B1.1×C3.1	0.04	0.15	0.03	0.19	0.26	0.12	0.65	0.48	0.56	25.34	28.35	27.46	61.54	62.25	52.34
B1.1×C2.9	0.44	0.06	0.03	0.59	0.17	0.12	0.81	0.64	0.88	35.67	35.56	35.39	62.15	63.65	53.45
B1.1×A2.11	0.09	0.07	0.028	0.24	0.18	0.11	1.17	1.07	0.86	30.48	38.54	46.66	47.53	53.73	44.53
124×C3.1	0.10	0.03	0.03	0.25	0.14	0.12	0.55	0.98	0.51	24.59	26.76	14.76	52.38	54.46	45.67
124×C2.9	0.11	0.07	0.021	0.26	0.18	0.11	1.06	0.36	0.68	48.39	21.30	55.35	60.25	63.37	57.76
124×A2.11	0.93	0.06	0.03	1.08	0.17	0.12	1.05	0.87	0.93	41.34	43.40	34.68	51.32	63.65	37.57
A2.4×C3.1	0.13	0.11	0.051	0.28	0.22	0.14	1.02	0.86	0.78	43.23	36.49	57.12	38.45	44.76	32.47
A2.4×C2.9	0.17	0.14	0.16	0.32	0.25	0.25	0.75	0.59	0.54	39.02	40.87	41.55	50.20	52.87	41.25
A2.4×A2.11	0.07	0.10	0.23	0.22	0.21	0.32	0.92	0.76	0.4	37.23	39.66	53.47	33.75	37.23	30.13
C3.22×C3.1	0.08	0.07	0.05	0.23	0.18	0.14	0.71	0.47	0.49	52.43	34.78	53.2	52.43	53.08	50.06
C3.22×C2.9	0.07	0.06	0.04	0.22	0.17	0.13	0.8	0.56	0.81	36.75	65.65	36.51	36.75	39.65	30.87
C3.22×A2.11	0.10	0.09	0.03	0.25	0.2	0.12	1.12	0.88	0.88	51.23	32.45	56.55	51.23	54.89	50.35

DRW = Dry root weight, DSW = Dry shoot weight, RWC = Relative water content, CC = Chlorophyll contents, CMP = Cell membrane permeability.

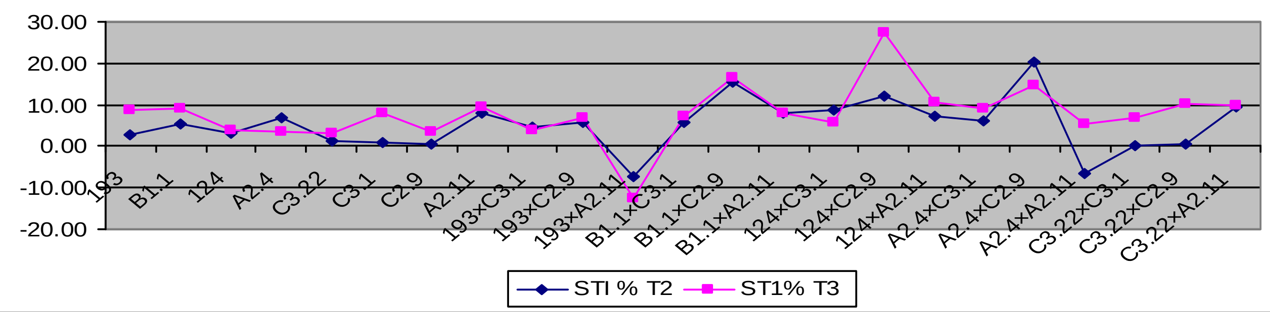
Table 3 showed that hybrid B1.1× A2.11 had maximum and hybrid 124×C3.1 had minimum relative water contents under normal conditions. Hybrid 193 × C3.1 had maximum and genotype B 1.1 and 193 had minimum relative water content under 1st level of salt stress. Hybrid A2.4 × C3.1 had maximum whereas genotype 193 and C3.22 had minimum relative water content under 2nd level of salt stress. Salt stress negatively affects RWC and leaf osmolality. Leaf enlargement, stomatal opening, and associated leaf photosynthesis are essential physiological and morphological processes. These processes are directly affected due to the reduction of leaf turgor potential which was due to the loss of water from leaf tissue (Jones and Turner, 1978). These results were similar with the findings of Adiloglu *et al*. (2007).

Table 3 showed that hybrid C3.22 × C3.1 had maximum and 124 ×C 3.1 had minimum total chlorophyll contents under normal conditions. Hybrid C 3.22× C2.9 had maximum and 124 × C2.9 had minimum total chlorophyll contents under 1st level of salt stress. Hybrid A 2.4 × C3.1 had maximum and 124×C3.1 had minimum total chlorophyll contents under 2nd level of salt stress. There was a reduction in chlorophyll contents under salt stress because of membrane bounded molecules. These results were in agreement with the findings of Iqbal *et al*, (2006) and Ashraf *et al*. (2005) who reported a decreased level of chlorophyll contents under saline conditions. That decrease was more significant in sensitive genotypes in comparison to tolerant.

Table 3 showed that hybrid B 1.1 × C2.9 had maximum and A 2.4×A2.11 had minimum cell membrane permeability under normal conditions. Hybrid 124 × A2.11 and B1.1 × C2.9 had maximum and A2.4 × A2.11 had minimum cell membrane permeability under 1st level of salt stress. Genotype B 1.1 had maximum cell membrane permeability and hybrid 193×C3.1 had minimum cell membrane permeability under 2nd level of salt stress. There was a reduction in cell membrane permeability under salt stress because of membranous bounded molecules; its stability was dependant on membrane stability.

As indicated in (Fig 1-10) it was revealed that, hybrid A2.4×C2.9 followed by hybrid B1.1 × C2.9 had maximum stress tolerance index at 1st level of stress whereas hybrid 124 ×C2.9 and B1.1 × C2.9 had maximum stress tolerance index for germination (%) at 2nd level of salinity. Hybrid B1.1 × C3.1 and Genotype A2.4 had maximum stress tolerance index at 1st level whereas hybrid 124 ×A2.11 and B1.1 ×C3.1 had had maximum stress tolerance index at both levels of salt stress for shoot length.

Fig 1: Stress tolerance index and susceptibility index for germination percentage



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It was revealed from recorded data, that hybrid B1.1 × C2.9 had good germination ability at both types of saline soil conditions. Hybrid 124 ×C2.9 can perform better on KCl affected soils for chlorophyll contents, relative water contents and fresh shoot weght whereas it can have ability to perform well on NaCl affected soils for Germination (%), Dry root and shoot weight. Hybrid 124×A2.11 had better ability to tolerate both stress for Dry root and shoot weight. Hybrid C3.22 ×A2.11 and A2.4×C2.9 had maximum stress tolerance index for 1st level of salt stress whereas the hybrid B1.1×C2.9 and 124×C3.1 had maximum stress tolerance index for fresh root weight at 2nd level of salt stress. Hybrid B1.1×C2.11 and 124 × C2.9 had maximum stress tolerance index for 1st level whereas hybrid 193×C2.11 and genotype C3.22 had maximum stress tolerance index for fresh shoot weight. Hybrid 124 × A2.11 and B1.1×C2.9 had maximum stress tolerance for 1st level whereas hybrid 124 × A2.11 and 124×C2.9 had maximum stress tolerance at 2nd level for dry root and shoot weight. The hybrid 124 ×C2.9 had maximum stress tolerance for 1st level and genotype 193 and hybrid A2.4 × A2.11 had maximum stress tolerance for relative water contents. Hybrid 124×C2.9 had highest stress tolerance for 1st level and hybrid 124×C3.1 had highest chlorophyll contents at 2nd level of stress. Genotype B1.1 had highest stress tolarance for 1st level whereas hybrid 124 ×A2.11 had highest cell membrane permeability at 2nd level of stress.

Fig 2: stress tolerance index and susceptibility index for root length

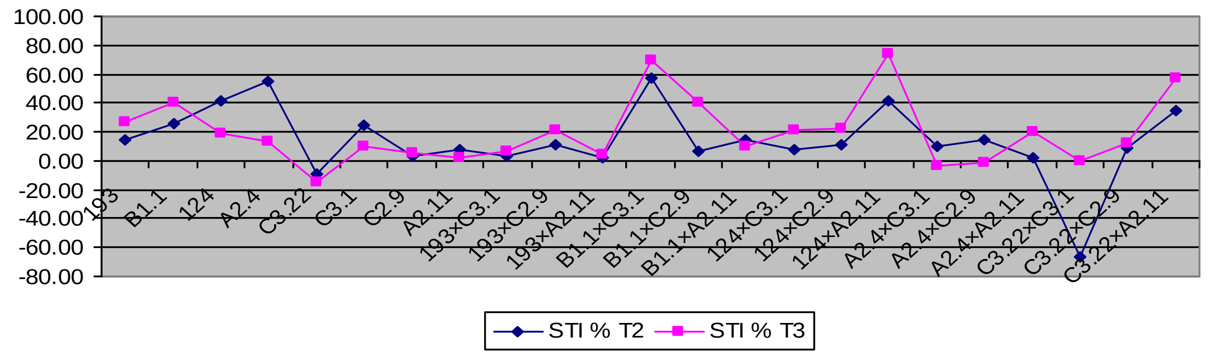


Fig 3: Stress tolerance index and susceptibility index for shoot length

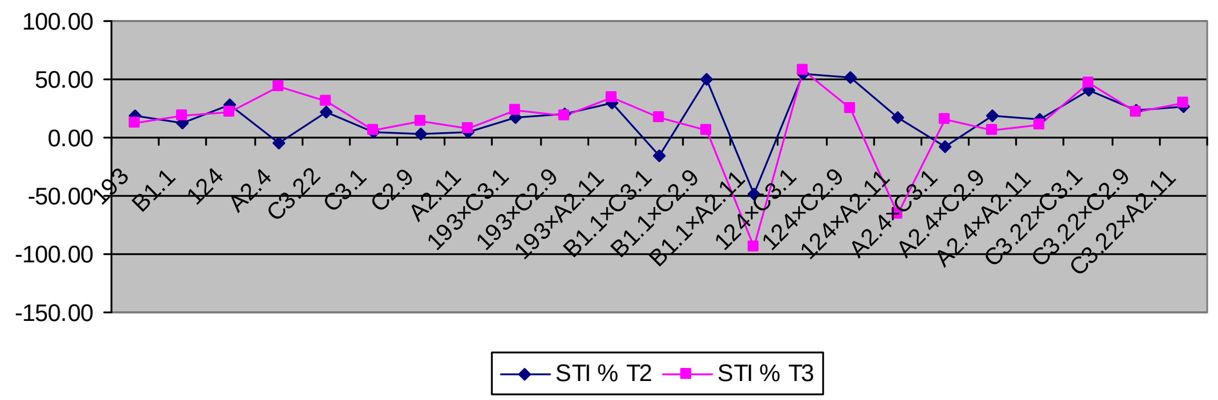


Fig 4 : Stress tolerance index and susceptibility index for fresh root weight

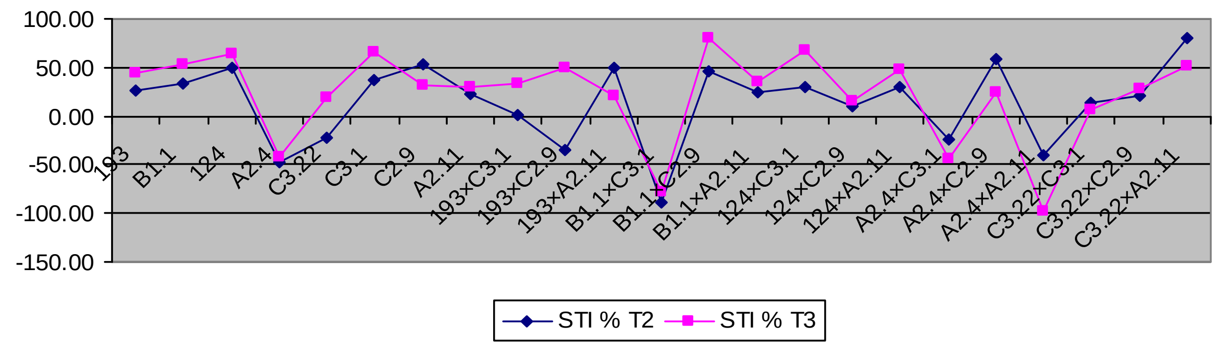


Fig 5: Stress tolerance index and susceptibility index for fresh shoot weight

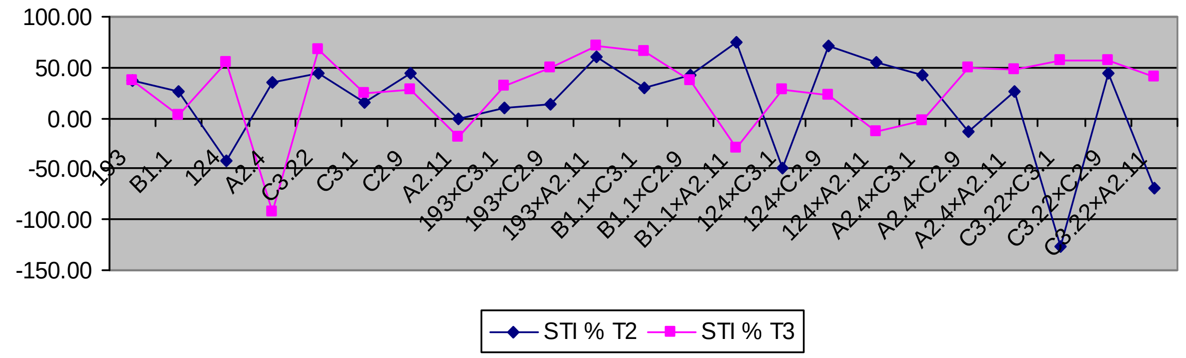


Fig 6: Stress tolerance index and susceptibility index for dry root weight

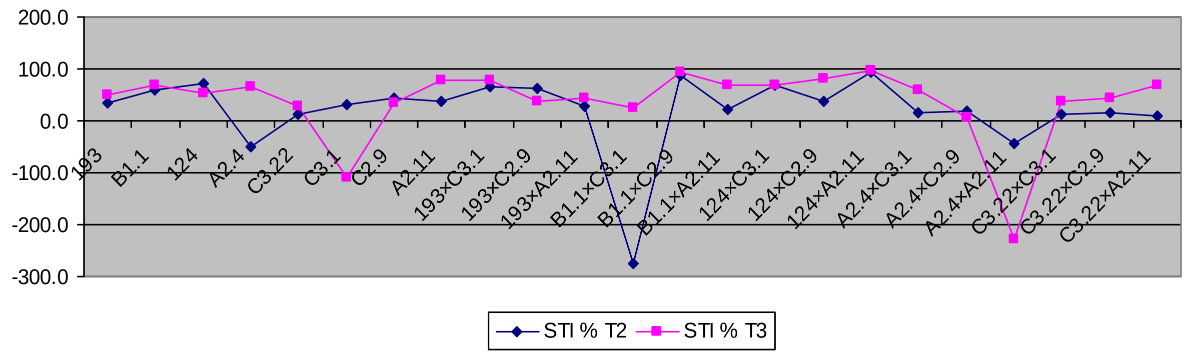


Fig 7: Stress tolerance index and susceptibility index for dry shoot weight

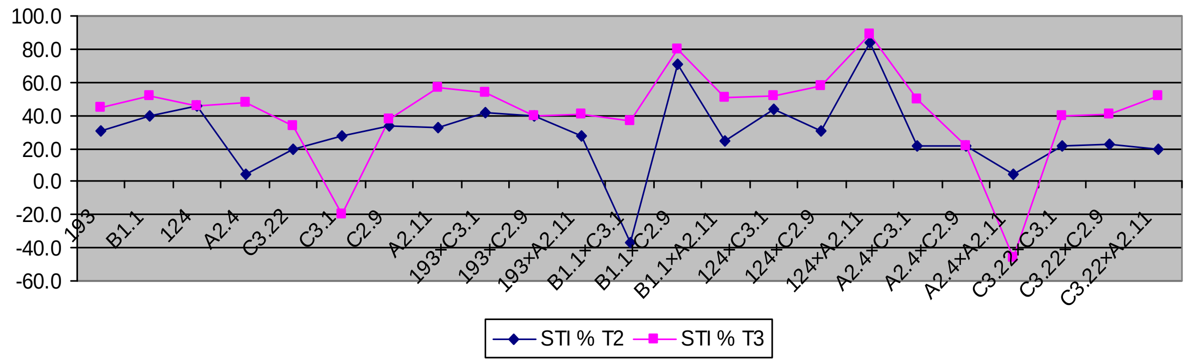
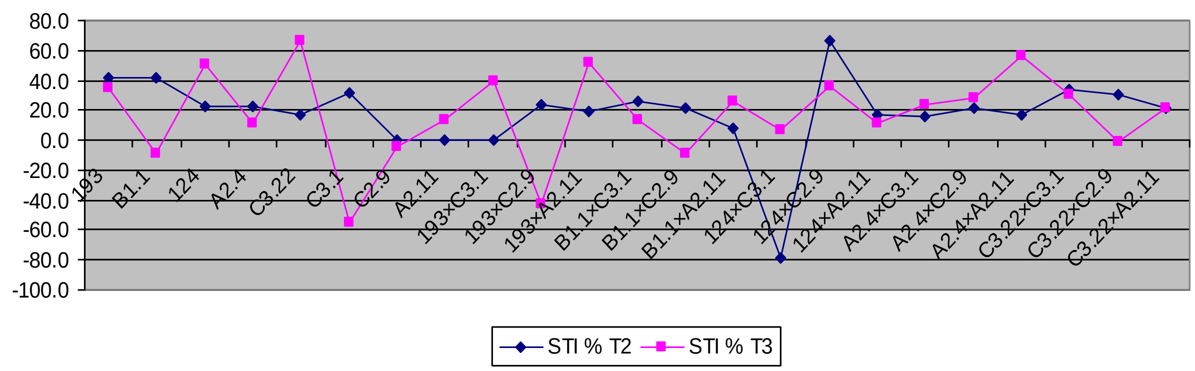


Fig 8: Stress tolerance index and susceptibility index for relative water content



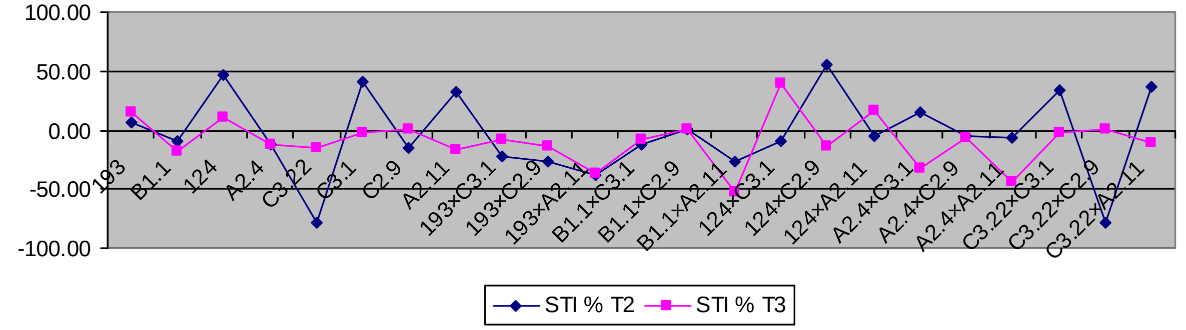


Fig 9: Stress tolerance index and susceptibility index for chlorophyll contents

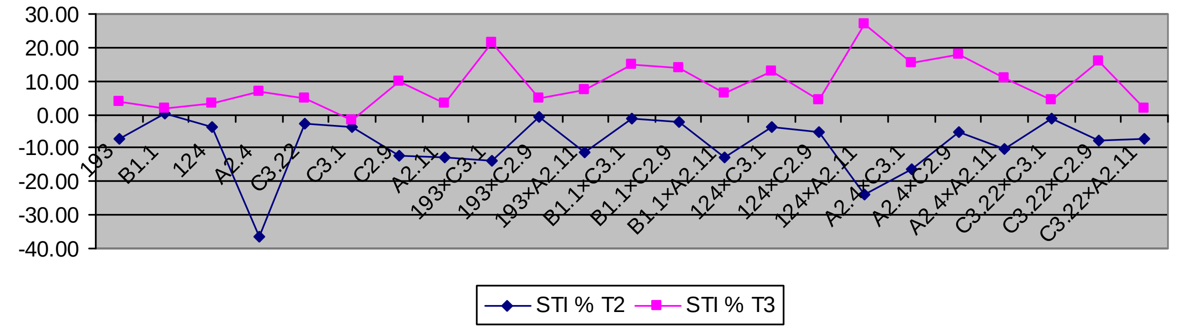


Fig 10: Stress tolerance index and susceptibility index for cell membrane permeability

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