J. Appl. Environ. Biol. Sci., 1(11)500-506, 2011

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ISSN: 2090-4215
Journal of Applied Environmental and Biological Sciences
www.textroad.com

Evaluation of Some Salt Tolerance Criteria in Wheat Lines

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ABSTRACT

A field experiment was conducted at Shahid Bahonar University of Kerman during 2010 growing season to determine salt tolerance of wheat (*Triticum aestivum* L.) selected lines. 56 promising lines of wheat with two standard checks (Bam and Kavir) were grown in salinity and normal conditions, based on lattice experiment with two replicates. The EC of saline and normal soil was 9 and 1.1 ds m^{-1} respectively. Studied characteristics were total dry weight, shoot and root dry weight, plant height, 1000-seed weight and grain yield. Moreover salt tolerance indices such as SSI, TOL, GMP, and STI were calculated. The results showed that there were significant differences between the genotypes for grain yield in salty and normal conditions ($p < 0.01$). Also, the interaction between genotypes and stress on shoot and root dry weight and grain yield was significant. In general, lines 38, 40, 49, 83, 87 and 94 with better agronomic performance, lowest SSI, TOL and higher STI and GMP were salinity tolerance, which can be recommended as the promising lines in Kerman for introduction to the farmers and future studies.

Keywords: Promising lines; Salinity; Wheat; Yield.

INTRODUCTION

Salinity is usually exacerbated by intensive irrigation and is one of the most important constraints in agricultural lands. Salinity has a considerable effect on world agriculture, significantly reducing productivity of agricultural plants. Since amelioration of saline soils is so expensive, among various strategies to overcome salinity problem, the possibility of selection and breeding for enhanced salinity tolerance in crop species has received considerable attention as it is an economic and efficient alternative (Ashraf, 2009). Wheat (*Triticum aestivum* L.) is the most essential crop in food pattern of Iran and has always been the focus in policy-makings. Producing nutrients especially wheat has a close relation with political and economical power of a country (Ghasemi *et al.,* 2010). Global wheat planting area is 228 million hectares. It is ranked first both in cultivated area and production among all crops in Iran. The effect of high salinity on plant can be observed at the whole plant level in terms of plant death and/or decrease in productivity (Parida *et al.*, 2004). The general effect of salinity is to reduce the growth rate resulting in smaller leaves, shorter stature, and sometimes fewer leaves. The initial and primary effect of salinity, especially at low to moderate concentrations is due to its osmotic effects (Munns and Termaat, 1986; Jacoby, 1994). Shoot growth decreases with salinity due to inhibitory effect of salt on cell division and enlargement in growing point (Mucue and Hanson, 1990). Early flowering reduced dry matter, increased root, shoot ratio and leaf size caused by salinity may be considered as possible ways of decreasing yield in wheat under salt stress condition (Mass and Poss, 1989). Salt stress result in a considerable decrease in the fresh and dry weights of leaves, stems, tillers, fertile tillers and roots (Chartzoulakis and Klapaki, 2000). It is now realized that sustaining as well as increasing productivity may be essential, therefore, attaining higher yield levels, the breeder is required to deal the complex situation through handling of the yield components. Various indices have been introduced for evaluating the response of different genotypes to environmental stresses. Fernandez (1992) introduced the salt tolerance index (STI). More stable genotypes have higher STI values. Rosielle and Hamblin, (1981) concluded the GMP and STI are the most suitable indices for evaluation of plant response to environmental stress. Fischer and Maurer, (1978) introduced stress susceptibility index (SSI). The genotypes which are more stable across stress and non stress environments, show lower SSI values. The aim of this study was evaluation of some drought tolerant criteria in 56 wheat lines and to screen out best salinity resistant wheat lines.

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MATERIALS AND METHOD

56 promising lines of wheat (*Triticum aestivum* L.) with two standard checks namely Bam and Kavir were studied, which were supplied by Grain Research Department of Seed and Seedling Research and Supply Institute. The study was carried out at two research field at Mahan (located in 56º34´ longitude, 29º55´ latitude and 2044 m altitude from sea level, normal soil) and Ekhtiar-Abad (located in 56º58´ longitude, 30º15´ latitude and 1740 m altitude from sea level, saline soil) in Kerman. Experiment was conducted in a simple lattice design with two replicates. Fertilizers were applied 41 kg ha^{-1} N and 46 kg ha^{-1} P_2O_5 according to the provincial soil test recommendations before sowing (Table 2 and 3). The characteristics include: total dry weight, shoot dry weight, root dry weight, plant height, 1000-seed weight and grain yield, were calculated or counted on each plot and salinity resistance indices based grain yield in both normal and saline conditions were calculated using the following equations (Fischer and Maurer, 1978):

$$SSI = \frac{1 - \left(\frac{Ys}{Yp}\right)}{SI}$$

$$SI = 1 - \left(\frac{\overline{Ys}}{\overline{Yp}}\right)$$

In the above equation: Ys is yield of lines under stress condition, Yp is yield of lines under normal condition, $\overline{Ys}$ and $\overline{Yp}$ are the mean yields of all lines under stressed and non-stressed conditions respectively, and SI is stress intensity.

$\mathrm{TOL} = Yp - \mathrm{Ys}$ (Hossain *et al.,* 1990),

$GMP = \sqrt{\mathrm{Yp.Ys}}$ (Fernandez, 1992)

$STI = \frac{Yp.Ys}{(Yp)2}$ (Fernandez, 1992)

The first data were analysis based on the lattice design and then according the usefulness with the RCBD, experiment was analyzed based on randomized complete block design by using SAS and SPSS software.

Table 1. Soil analysis result for physical and chemical characteristics (normal soil)

Characteristic	Soil depth	Soil texture	EC	pH	N	Fe	K	P
	cm		ds m^{-1}		%		ppm	
Value	0-30	Sandy	1.11	7.70	0.22	8	112	0.98

Table 2. Soil analysis result for physical and chemical characteristics (saline soil)

Characteristic	Soil depth	Soil texture	EC	pH	N	Fe	K	P
	cm		ds m^{-1}		%		ppm	
Value	0-30	Loamy	9	7	0.012	7	165	0.42

RESULTS AND DISCUSSION

Total dry weight

Total dry weight of all genotypes was substantially decreased with salinity stress ($p < 0.01$), but significant differences between lines was not found in total dry weight (Table 3). Total dry weight under salt stress was decreased 58.2% compared to normal condition (Table 4). The highest amount of total dry weight was obtained respectively in lines 65, 91, 19, 83, 16, 81, 1, 6, 21 and 90 (Table 5). Salinity stress decreased the leaf area and durability, which decreased photosynthesis and dry matter accumulation (Singh, 1994). Results were in agreement with finding most of the workers (Rahnama *et al.,* 2010).

Shoot dry weight

Shoot dry weight of all wheat lines significantly decreased with salinity ($p < 0.01$). Shoot dry weight was 8.40 g under normal condition, while decreased averaged to 6.92 g under salt condition, which means a 21.4% reduction in shoot dry weight (Table 4). Growth processes are especially sensitive to the effects of salt, so that growth rates and biomass production provide reliable criteria for assessing the degree of salt stress and the ability of

a plant to withstand it as reported by (Amor *et al*, 2005). Salinity has inhibited the root and shoots elongation due to slowing down the water uptake for overall osmotic adjustments of the plant body under high salt stress condition (Datta *et al.,* 2009). All lines responded in different manner to salinity stress. Maximum shoot dry weight was recorded in lines: 40, 87, 49, 91, 96, 79, 35 and 41 and minimum shoot dry weight was in lines: 17, 1, 78, 21, 57, 65 and 56 (Table 5).

Root dry weight

Salinity caused a significant ($p < 0.01$) reduction on root dry weight. Root dry weight than shoot dry weight was more decreased (59.7%). In the current investigation salinity had more pronounced effect on root dry weight respect to shoot dry weight as roots were directly exposed to salt solution. There were significant differences among lines in root dry weight. Root dry weight of all lines severely reduced under salt stress compared to the normal condition. Salinity by lines interaction indicated that lines responded differently to salinity. The highest values of root dry weights under normal and saline conditions were observed in lines; 23, 79, 100, 99, 20, 90, 27, 29, 91, 35, 83 and 87 (Table 5).

Table 3. Combined analysis for yield of wheat lines in salt stress

SOV	df	Total dry weight	Shoot dry weight	Root dry weight	Plant height	Grain yield	1000–seed weight
Place	1	106713.13**	132.57**	61.77**	7372.22**	2258.49**	14140.73**
Repeat × Place	2	50.78	1.58	0.87	26.54	4.26	5.59
Lines	57	169.39ns	27.52**	2.59**	255.1**	6.7**	75.94**
Lines × Place	56	191.39ns	35.83**	1.36**	71.36ns	7.2**	67.89*
Error	111	161.08	3.72	0.4	105.96	2.39	44.63
CV%	-	13.16	25.27	28.1	14.94	24.81	19.17

ns= non significant ** = $p < 0.01$ and * = $p < 0.05$

Table 4. Comparison of wheat yield in saline and normal conditions

Treat	Total dry weight (g)	Shoot dry weight (g)	Root dry weight (g)	Plant height (cm)	Grain yield (ton ha^{-1})	1000–seed weight (g)
Normal	118.11a[1]	8.40a	2.78a	74.64a	9.39a	42.83a
Stress	74.63b	6.92b	1.74b	63.15b	3.1b	26.86b

1- Column means followed by the same letter are not significantly different at 0.01 probability level

1000-seed weight

The results showed that salinity had a significant effect on 1000-seed weight ($p < 0.01$). Moreover interaction of salinity and lines was significant ($p < 0.05$ (Table 3). Salinity stress decreased 1000-seed weight to 26.86 g, which was 59.4% lower than normal condition (Table 4). Grain weight reduction was related to injury in translocation system due to high concentrations of saline ions; although grain weight loss affected by environmental conditions and more is as the genetic control. Zeng and Shannon, (2000) reported few differences for grain weight in rice (*Oryza sativa* L.) genotypes in salinity conditions, so severity of salt stress effect on grain weight is related to plant genus and genotype. Results were in agreement with other finding (Sohrabi *et al*., 2008; Taffouo *et al*., 2009). The highest decrease in1000-seed weight under salinity stress was recorded in lines; 4, 5, 19, 41, 23, and Kavir. The highest amount of 1000-seed weight were observed in lines; 65, 56, 29, 49, 76, 83, 90, 87 and 12 (Table 4).

Plant height

According to the results, plant height was significantly affected by salinity stress ($p < 0.01$), (Table 3). Plant height under salt stress decreased to 18.2% in compared to normal condition. Mean plant height of controls were 59.35 and 54.45 cm in Bam and Kavir respectively, while the lines; 85, 87, 67, 90, 79, 64, 56, 65, 78 and 83 with plant heights of 87.45, 82.20, 81.95, 81.15, 81, 80.85, 79.45, 78.60, 78.20 and 78 were tall lines (Table 4). The difference in plant heights of lines was due to synthetic wheat lines used in the study originated from different hybrids. Plant height of lines 17 and 16 was 56.25 and 50.30 cm, which were the most dwarf lines. Lower plant height of lines in plants infected by lodging or sensitive to fungal diseases can minimize the spread of lodging and fungal diseases (Ghasemi *et al.,* 2010).

Table 5. Comparative yield of different wheat lines

line	Total dry weight (g)	Shoot dry weight (g)	Root dry weight (g)	Plant height (cm)	Grain yield (ton ha^{-1})	1000–seed weight (g)
1	105.91a-e	3.90s[1]	1.15n	58.10i	4.97i	33.65b
3	89.56c-f	8.10e	1.93f	58.95i	5.97c	35.89b
4	79.84f	5.95j	1.45l	56.75j	5.68d	30.25d
5	96.96b-f	6.10j	1.93f	69.85a	6.84a	29.89d
6	102.30a-f	7.48f	2.00f	67.75b	5.67d	31.46b
7	97.12b-f	7.98e	1.60j	72.20a	7.41a	37.08b
9	90.31c-f	7.25g	1.85g	60.55g	6.16c	36.48b
10	92.89b-f	7.23g	2.33e	63.50b	6.48c	35.45b
12	97.93b-f	9.18c	2.68c	63.30c	7.81a	39.54b
13	93.63b-f	9.03d	2.00f	71.60a	6.42c	38.19b
14	95.47b-f	5.18o	1.70h	61.40f	5.45e	32.23b
15	96.59b-f	10.40b	1.83h	65.70b	8.82ab	36.56b
16	107.97a-d	7.20g	1.96f	50.30l	5.93c	33.72b
17	94.37b-f	3.95s	1.68i	56.25j	5.52e	32.57b
19	109.14a-c	7.78f	2.45e	74.35a	6.58c	26.66f
20	96.68b-f	8.58d	3.58b	67.60b	7.05a	30.92c
21	105.09a-e	3.68u	1.90f	62.00e	5.26f	32.20b
23	95.68b-f	10.10b	5.75a	63.90b	5.66d	28.60e
24	89.83c-f	6.70h	2.25e	66.75b	4.62kl	34.18b
25	97.87b-f	8.50d	1.88g	68.95a	5.95c	37.44b
27	101.15a-f	8.98d	3.05c	74.10a	7.87a	32.14b
28	94.78b-f	9.68g	2.13f	75.90a	9.37a	38.08b
29	98.61b-f	9.70c	3.00c	76.00a	8.19a	43.17bc
33	93.99b-f	5.85k	2.05f	56.85j	4.89i	37.78b
35	95.43b-f	10.93a	2.80c	61.80f	6.65a	35.99b
36	99.26b-f	5.30o	1.95f	64.50b	6.19b	35.45b
37	92.51c-f	7.38g	1.78h	69.00a	5.81c	34.37b
38	95.15b-f	8.45d	2.40e	69.05a	8.38a	35.41b
40	97.10b-f	13.85a	1.73h	72.70a	8.50a	37.73b
41	95.67b-f	10.93a	2.13f	69.05a	5.65d	20.65h
43	97.19b-f	7.03g	1.85g	73.65a	5.06g	32.01b
49	93.63b-f	12.55a	2.50d	76.25a	8.57a	41.73b
50	98.04b-f	7.55f	2.13f	67.75b	6.03c	34.16b
51	88.55c-f	6.63h	2.05f	70.55a	4.96i	33.02b
52	92.19c-f	4.03r	1.95f	62.45d	6.10c	37.46b
54	91.64c-f	5.05p	1.81	69.90a	4.87i	36.93b
56	98.46b-f	2.70w	1.28m	79.45a	4.42l	43.43b
57	97.73b-f	3.58u	1.73h	65.15b	4.35l	34.56b
58	84.51ef	9.43c	1.90f	57.40i	4.63k	33.82b
60	105.70a-e	4.23r	2.10f	74.10a	5.96c	35.77b
61	93.14b-f	5.50o	1.55k	60.90f	4.99i	32.15b
64	85.12e-f	5.75l	1.53k	80.85a	4.80j	33.59b
65	122.44a	3.20v	0.80o	78.60a	8.09a	61.04a
67	86.07c-f	5.30o	2.53d	81.95a	7.56a	39.58b
76	99.71b-f	6.40i	1.95f	70.75a	5.30f	41.15b
77	87.05c-f	5.55m	2.53d	75.10a	4.70kl	33.56b
78	89.31c-f	3.88t	1.70h	78.20a	4.46l	32.52b
79	87.05c-f	10.95a	4.45b	81.00a	7.72a	32.69b
81	106.42a-e	7.78f	1.83h	73.30a	5.28f	31.20b
83	108.67a-c	5.95j	2.80c	78.00a	8.03a	39.57b
85	93.90b-f	9.33c	1.48l-o	87.45a	5.53e	37.01b
87	101.35a-f	13.38ab	2.73c	82.20ab	9.35a	38.47b
90	102.88a-f	8.08e	3.30c	81.15a	5.90e	38.48b
91	115.84ab	11.78a	2.85c	70.35a	5.60d	33.11b
94	98.81b-f	8.98d	2.38e	67.20b	7.01a	34.68b
96	93.02b-f	11.35a	2.18f	74.25a	5.78c	36.61b
99	94.51b-f	9.98c	3.70bc	59.35h	6.21b	35.38b
100	94.50b-f	10.48b	3.75bc	54.45kl	5.89c	23.26gh

1- Column means followed by the same letter are not significantly different at 0.01 and 0.05 probability level

Grain yield

Grain yield decreased by salinity stress. Maximum and minimum grain yield were 9.39 and 3.1 kg ha^{-1} and obtained by normal and salt stress condition respectively (Table 4).Variance analysis of grain yield indicated that there were significant differences between lines ($p < 0.01$), moreover interaction of salinity with lines was significant ($p < 0.01$), (Table 3). These results about crop yield reduction under salinity are consistent with previous findings (Taffouo *et al*., 2009). Sohrabi *et al*. (2008) also reported similar result. Lines; 28, 87, 15, 49, 40, 38, 29, 65, 83 and 27 with grain yields of 9.37, 9.34, 8.82, 8.56, 8.50, 8.38, 8.18, 8.1, 8.03 and 7.87 ton ha^{-1} had the highest grain yield, while mean grain yields of controls were 6.20 and 5.88 ton ha^{-1} in Bam and Kavir respectively (Table 5).

Table 6. Indicators of salt stress tolerance of wheat lines

lines	SSI	TOL	GMP	STI	YP	YS
1	0.87	4.10	4.53	2.18	7.02	2.92
3	0.94	5.50	5.29	2.98	8.72	3.22
4	0.62	2.99	5.48	3.19	7.18	4.18
5	0.60	3.44	6.61	4.65	8.55	5.11
6	1.23	7.96	4.03	1.73	9.64	1.69
7	0.85	5.92	6.79	4.91	10.37	4.45
9	0.57	2.93	5.98	3.81	7.62	4.70
10	0.94	5.95	5.76	3.53	9.46	3.51
12	1.04	8.36	6.60	4.63	11.99	3.63
13	1.19	8.56	4.77	2.43	10.69	2.13
14	1.12	6.53	4.36	2.03	8.72	2.19
15	0.99	8.79	7.65	6.22	13.21	4.43
16	0.86	4.77	5.43	3.14	8.32	3.55
17	0.81	4.13	5.11	2.78	7.58	3.45
19	0.84	5.14	6.05	3.90	9.14	4.00
20	0.59	3.44	6.84	4.97	8.77	5.33
21	1.26	7.72	3.57	1.35	9.12	1.39
23	1.28	8.52	3.72	1.47	9.92	1.40
24	1.27	6.83	3.11	1.03	8.04	1.21
25	1.09	6.83	4.87	2.52	9.36	2.53
27	1.09	9.05	6.44	4.41	12.40	3.34
28	0.59	4.62	9.08	8.77	11.68	7.06
29	1.17	10.63	6.23	4.12	13.50	2.87
33	1.26	7.13	3.34	1.19	8.45	1.32
35	1.22	9.23	4.79	2.44	11.26	2.03
36	0.94	5.68	5.49	3.21	9.03	3.34
37	0.86	4.71	5.31	3.00	8.16	3.45
38	0.03	0.20	8.38	7.47	8.48	8.28
40	0.01	0.08	8.50	7.69	8.54	8.46
41	0.68	3.31	5.40	3.10	7.30	3.99
43	1.24	7.14	3.58	1.36	8.62	1.49
49	-0.02	-0.13	8.57	7.81	8.50	8.64
50	0.86	4.89	5.51	3.23	8.48	3.58
51	1.25	7.20	3.42	1.24	8.56	1.36
52	1.30	9.36	3.90	1.62	10.78	1.41
54	1.27	7.19	3.27	1.14	8.46	1.27
56	1.34	7.17	2.58	0.71	8.01	0.83
57	1.10	6.73	4.67	2.32	9.12	2.39
58	1.39	7.60	2.12	0.48	8.16	0.55
60	1.11	7.04	4.74	2.39	9.43	2.39
61	0.97	5.03	4.60	2.25	7.76	2.73
64	0.98	5.17	4.58	2.24	7.85	2.68
65	1.23	8.36	4.20	1.88	10.11	1.75
67	1.20	8.74	4.77	2.42	10.84	2.10
76	1.26	7.77	3.60	1.38	9.19	1.41
77	1.31	7.30	2.95	0.93	8.34	1.04
78	1.31	7.01	2.76	0.81	7.97	0.96
79	1.40	13.71	3.55	1.34	14.57	0.87
81	0.89	4.48	4.78	2.43	7.52	3.04
83	0.93	7.23	7.17	5.47	11.65	4.42
85	1.21	7.55	4.03	1.73	9.30	1.75
87	0.43	3.11	9.21	9.03	10.90	7.79
90	1.32	9.33	3.61	1.38	10.56	1.23
91	1.02	5.80	4.80	2.45	8.50	2.71
94	0.48	2.69	6.88	5.04	8.36	5.67
96	1.24	8.25	4.04	1.74	9.90	1.65
99	1.24	8.78	4.38	2.04	10.60	1.81
100	1.30	9.08	3.75	1.49	10.43	1.35

Index of drought tolerance

Resistance indices were calculated on the basis of GY of lines (Table 5). As shown in Table 5, a greater TOL value was related to (13, 15, 29, 35, 67, 79, 90 and Kavir) indicating that this lines had a larger GY reduction under stress condition and higher salt sensitivity; lowest SSI was found in (20, 28, 38, 40, 49, 87, 9 and 94). Therefore, these lines had a lower GY reduction under stress condition. Highest GMP and STI indices were observed in (7, 12, 15, 20, 27, 28, 38, 40, 49, 83, 87, and 94). Jaradat *et al.* (2004) selected salt tolerant barley cultivars based on high values of STI and GMP indices**.** In general, lines 38, 40, 49, 83, 87 and 94 with better agronomic performance and lowest SSI, TOL and higher STI and GMP were salinity tolerance which can be recommended as the promising lines in Kerman for introduction to the farmers and future studies.

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