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Evaluation of salt stress effect in 50 genotypes of durum wheat (*Triticum durum* Desf.) using different parameters

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Abstract

The identification of traits of tolerance to salinity may contribute to the selection of genotypes that can enhance the saline environments. In this experiment 50 genotypes of durum wheat consisting of 4 Australian lineages, 6 Tunisian cultivars and 40 lines of the ICARDA were evaluated in saline (150 Mm) and normal condition (tap water). Different agronomic traits, including the total number of tillers per plant, number of tillers per ear, the dry weight (g), the number of spikelets per spike, the average weight of ears, number of seeds per ear, kernel weight (g) and yield (g) were measured to distinguish salt tolerance between genotypes. Salt tolerance indexes (STI) was evaluated. A variable response to salt stress was observed. The air dry matter, the number of tillers per ear, tillering capacity and the kernel weight were the most informative and useful traits for screening for salt tolerance in durum wheat. This analysis allowed us to distinguish 4 lines from ICARDA and 2 Tunisian varieties as the most tolerant to saline stress among all the genotypes analyzed

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Introduction

In arid and semi-arid regions, water is the main factor limiting the expansion and intensification of crops (Alem *et al.*, 2002). This affects about 7% of the total area in the world (Munns, 2002). In Tunisia, salty soils cover about 10% of the global land area (Hachicha *et al.*, 1994; Botia *et al.*, 1998). Also, there's a dangerous trend of an increase in the saline area of 10% per year worldwide (Ponnamieruma, 1984). Indeed, salts accumulated in soil may limit the growth of the plant following a rise in the osmotic pressure of the medium and/or specific toxic effect of the ions (Gouny and Cornillon, 1973). The ionic stress is caused by high salt accumulation in cells (Ueda *et al.*, 2003) Therefore, this event could be harmful on the total productivity of plants (Allakhverdiev *et al.*, 2000). Obviously, the most effective way to increase wheat yield is to improve salt tolerance in wheat genotypes (Pervaiz *et al.*, 2002). Salt tolerance in genotypes may also occur at different stages of growth (Zeng *et al.*, 2002). Indeed, Kingsbury and Epstein (1984) found that individual lines from 5000 accessions of spring wheat showed differing tolerance during their life cycle.

Therefore, salt tolerance should be assessed at different stages of growth. Grain production should be studied in relation to all other determinants characters, thus Alam *et al.* (2007) suggests that the total number of tillers, fertile ears, spikelets per spike and grains per ear are determining cultivar potential of production. the work of El-Hendawy *et al.* (2009) shows that the grain weight of plant, grain number and the number of fertile spikelets are good screening criteria in field conditions. These assessments can facilitate salt tolerance improvement of tested genotypes in breeding programs.

The objectives of this study were to evaluate the behavior of 50 durum wheat genotypes in saline conditions, to identify those that are more tolerant to this stress and to define reliable agronomic parameters associated with salt tolerance, to distinguish between salt tolerant genotypes under controlled environmental conditions.

Materials and methods

Rootstock

The present study examined the seeds of fifty varieties of durum wheat: 4 Australian lines, 6 Tunisian cultivars and 40 lines of the ICARDA (International Center for Agricultural Research in the Dry Areas) which have been identified by the FIGS. This new tool was developed in 2012 jointly by ICARDA, the Vavilov Institute of Plant Industry in Russia, and the Grains Research and Development Corporation in Australia, a new tool for rapid mining of agricultural genebank. Indeed FIGS combines agro-ecological information with data on plant traits. FIGS datasets identify sets of plant genotypes with a higher probability of containing specific 'target' traits (Table 1). These genotypes were assessed for their levels of salt tolerance using.

Culture conditions

The experiment was conducted in conditions of semi-controlled (INRAT Experimental Station El Menzeh, Ariana). Seeds were sown in December 14th, 2013 at 3 plants per pot (pots are of 125 mm diameter and 1 m length, and filled with previously sift and homogenized soil containing 1/4 sand, 1/4 peat soil and ½). The pots are placed on a trolley for sheltering the pots in terms of rainfall. Plants are subjected to two treatments (fresh and salt water at 150 mM NaCl). Before the saline treatment and up to 3-leaf stage the plants were irrigated with fresh water until field capacity (CC) twice a week. From the 3-leaf stage salt (NaCl) is brought into irrigation water at 150 mM NaCl. Watering is done every three days, to compensate losses due to evapotranspiration.

Measured parameters

Aerial dry mater (DM), total number of tillers (TT), Number of tiller-ear (TE), Number of spikelets/ spike (S/S), number of grains per spike (NGS), ear weight (EW), 1000 grains weight (KW) and Yield (Y) were measured. The Salt tolerance indices (STI), defined as the ratio of the saline treatment and the average of the controls, are also used in parallel with measured parameters. Which index, allow to compare the genotype for their tolerance to salt.

Statistical analysis

The experimental design used was a completely randomized block design, with 100 experimental units per block (EU/Block) and 3 replications (total 300 pots). Variance analysis and mean comparison were conducted with Statistica program version 5.1. Correlations between traits were also analyzed.

Results

Effect of Saline Stress on Morphological Parameters

The air dry matter per plant, the total number of tillers and tiller-ear number were measured at the vegetative stage to determine their variation by genotype in salt stress (150 mM). Results showed that salt stress significantly affected ($P < 0.05$) these parameters (Table 2). In fact, these measured parameters were reduced in most genotypes. Compared to control, average reduction of total number of tillers (Fig. 1), tiller-ear number (Fig. 2) and dry matter production (Fig. 3) were respectively 11%, 9% and 20% in salt stress conditions.

Table 1. Description of plant material and behavior of different varieties inverse of salt stress (35 landrace supposed tolerant, 5 supposed sensitive and 10 not specified, on the basis of FIGS).

Order/ origin	ICARDA	Site code	Origin	subset	Dhe	Set type
1	89017	ETH64:131	ETH	0	135	random_set
2	96203	MAR87-1:31	MAR	0	119	random_set
3	43330	OMN87:142	OMN	0	132	random_set
4	95853	SYR87-1:55	SYR	0	149	random_set
5	94651	TUN77::9	TUN	0	132	random_set
6	93977	DZA75::43	DZA	1	135	salinity_set
7	93963	DZA75::43	DZA	1	137	salinity_set
8	93978	DZA75::43	DZA	1	138	salinity_set
9	93151	DZA75::95	DZA	1	139	salinity_set
10	87457	EGY::12	EGY	1	140	salinity_set
11	83479	EGY-S55	EGY	1	140	salinity_set
12	83477	EGY-S55	EGY	1	141	salinity_set
13	87438	EGY-S56	EGY	1	142	salinity_set
14	83366	EGY-S57	EGY	1	146	salinity_set
15	85847	ESP-S1603	ESP	1	140	salinity_set
16	85846	ESP-S1603	ESP	1	146	salinity_set
17	85020	ESP-S1946	ESP	1	147	salinity_set
18	85028	ESP-S1947	ESP	1	142	salinity_set
19	85714	GRC56::11	GRC	1	134	salinity_set
20	85715	GRC56::12	GRC	1	136	salinity_set
21	84830	IND47/48::45	IND	1	148	salinity_set
22	84882	IND47/48::6	IND	1	140	salinity_set
23	86075	IND-S413	IND	1	134	salinity_set
24	85632	IRN-S235	IRN	1	145	salinity_set
25	85457	IRN-S406	IRN	1	149	salinity_set
26	83091	IRQ-S176	IRQ	1	155	salinity_set
27	96252	JOR83-2::46	JOR	1	117	salinity_set
28	96367	MAR85:112	MAR	1	NA	salinity_set
29	95843	SYR87-1:49	SYR	1	132	salinity_set
30	95839	SYR87-1:49	SYR	1	149	salinity_set
31	96150	SYR88-2:2	SYR	1	132	salinity_set
32	84454	TUR48::255	TUR	1	141	salinity_set
33	84776	TUR48::588	TUR	1	145	salinity_set
34	82878	TUR48D:1	TUR	1	139	salinity_set
35	82738	TUR48D:242	TUR	1	141	salinity_set

36	82181	UZB::10	UZB	1	148	salinity_set
37	82233	UZB-S149	UZB	1	148	salinity_set
38	82553	ESP27::46	ESP	1	193	salinity_set
39	82635	IRN40::12	IRN	1	189	salinity_set
40	95836	SYR87-1:49	SYR	1	194	salinity_set
41	var01	Mahmoudi				Unknown
42	var02	Nasr				Unknown
43	var03	Selim				Unknown
44	var04	Kerim				Unknown
45	var05	NAX1_027				Unknown
46	var06	NAX1_207				Unknown
47	var07	NAX2_041				Unknown
48	var08	NAX2_042				Unknown
49	var09	Khiar				Unknown
50	var10	Maali				Unknown

Relative values of salt tolerance index at vegetative stage for all measured parameters show significant variation among genotypes (Table 3). Newman-Keuils classification test of salt tolerance indices classified the varieties into (five) classes significantly different at significant level of 0.05(Table 4).

The results at the vegetative stage showed that genotypes GRC56::11, SYR87-1:55, EGY-S55, IRN40::12, UZB-S149, maali) were the most tolerant to salt stress (150 mM). For example, the total number of tillers, tiller-ear number and aerial biomass were respectively stimulated by +44, +52 and + 27% for genotype GRC56::11, and +34, +35 and + 0.08% for genotype SYR87-1:55 compared to control. However, genotypes NAX1-207, IRN-S406, Kerim, NAX1-027 and MAR85:112 were the most affected by the salt stress at this stage. For example, the total number of tillers, tiller-ear number and aerial biomass were decreased by 57, 65 and 38% for genotype NAX1-207 and 50, 39 and 43% for genotype IRN-S406.

Effect of saline stress on yield component

During the final harvest, Salt stress significantly affected ($P < 0.05$) the number of spikelets per spike, ear weight, 1000 grains weight and the final yield per plant (Table 2). The number of grains/spike was less affected by salinity (Table 2).

Table 2. Analysis of variance of different studied traits and their Salt tolerance indexes (STI).

Source	Df	total tiller	Tiller ear	Ear weight	Spiklet/ spike	Grain/ spike	Kernel weight
Genotype	49	2.82^{**}	1.66^{**}	0.71^{**}	15.01^{**}	116.4^{**}	194.56^{**}
Salinity	1	15.47^{**}	7.94^{**}	8.19^{**}	264.2^{**}	6.49^{ns}	5921.2^{**}
G x S	49	1.17^{ns}	0.95^{ns}	0.27^{ns}	7.73^{**}	52.86^{ns}	$110{,}21^{ns}$
Erreur	200	1.03	0.8	0.31	4.66	53.93	86.42
ITS du caractère							
Génotype	49 100	0.17^{**}	0.2^{**}	0.09^{**}	0.04^{**}	0.09^{**}	0.07^{*}

G: Genotype and S: Salinity.

Indeed 150 mM averages recorded by the number of varieties of spikelets per spike (Fig. 4), ear weight (Fig. 5) and 1000 grains weight (Fig. 6) was reduced by 10, 13, and 16% sequentially compared to the control,

For the grain yield (Fig. 7) averages overall genotypes were reduced by about 27%. However, the average number of grain/spike (Fig. 8) showed an increase of 3.8% compared to control for all analyzed genotypes.

Table 3. Average of salinity tolerance indexes (STI) of agronomic traits at different growth stages.

Genotype	Dry Mater	Total tiller	Tiller ear	Ear weight	Spiklet/spike	Grain/spike	Kernel weight	Yield
1	0.86	1.29	1.47	0.8	0.97	1.12	0.66	0.81
2	0.72	0.68	0.72	0.93	0.90	1.18	0.79	0.78
3	0.79	0.72	0.88	0.70	1	0.82	0.65	0.54
4	1.08	1.34	1.35	0.77	0.88	0.92	0.77	0.91
5	0.89	0.84	1.03	0.80	0.88	0.91	0.78	0.73
6	0.99	1.1	0.69	0.67	0.58	0.72	0.92	0.72
7	0.87	1.12	1.12	0.72	0.80	0.94	0.70	0.75
8	0.70	0.81	0.80	0.73	0.77	0.97	0.79	0.76
9	0.77	0.83	0.76	0.95	1.08	1.11	0.81	0.74
10	1.01	1.13	0.86	1.01	0.95	1	0.93	0.79
11	0.60	0.57	0.66	0.95	0.80	1.03	0.98	0.69
12	0.90	1.3	1.25	0.69	0.68	0.74	0.85	0.74
13	0.84	0.94	0.91	0.89	0.99	1	0.95	0.84
14	0.81	1.03	0.95	0.81	0.81	0.82	0.96	0.75
15	0.64	0.66	0.86	0.76	0.73	0.94	0.97	0.74
16	0.63	0.71	0.88	0.89	0.87	1.07	0.84	0.77
17	0.75	0.95	0.83	0.79	0.71	0.97	0.87	1.11
18	0.79	1.05	1.11	0.66	0.75	0.85	0.80	0.70
19	1.27	1.44	1.52	0.98	0.89	1.27	0.78	1.11
20	0.87	0.60	0.67	1.08	0.88	1.06	1.12	0.86
21	0.83	0.85	1.09	0.83	0.97	0.98	0.78	0.83
22	1.04	1.1	1.04	0.80	1.09	0.92	0.86	0.84
23	0.73	0.86	0.86	0.94	1.06	0.97	0.85	0.69
24	0.67	0.7	0.83	0.79	0.87	1.19	0.55	0.61
25	0.57	0.5	0.61	0.86	0.86	0.85	0.85	0.46
26	0.88	0.95	1.11	0.79	0.88	0.9	0.87	0.86
27	0.76	1	1.10	0.95	0.77	0.9	1.06	0.80
28	0.59	0.72	0.60	1	1.02	1.2	0.75	0.57
29	0.83	1.25	1.07	0.74	0.88	0.97	0.76	0.77
30	0.72	0.98	1	0.57	0.69	0.61	0.80	0.67
31	0.53	0.65	0.66	0.82	0.82	0.95	0.83	0.53
32	0.53	0.65	0.74	0.42	0.77	0.42	0.45	0.23
33	0.72	0.68	1.03	0.99	0.99	1.13	0.82	0.93
34	0.82	0.95	0.75	0.84	0.84	0.78	1.12	0.71
35	0.85	1.05	1.02	0.79	0.86	0.91	0.83	0.77
36	0.87	0.73	0.82	1.33	1.05	1.5	0.89	0.96
37	0.99	1.21	1.61	0.67	0.94	0.95	0.57	0.73
38	0.74	1.04	0.95	0.61	0.91	0.92	0.51	0.43
39	0.94	1.12	1.22	0.81	0.85	1.07	0.75	0.97
40	0.77	0.78	0.97	0.78	0.87	0.96	0.76	0.67
41	0.69	0.71	0.71	0.79	0.93	1	0.67	0.53

42	1	0.94	0.93	0.98	1.09	1.24	1.18	0.85
43	0.59	0.72	0.56	0.89	1.03	1.08	0.75	0.46
44	0.60	0.53	0.5	1.15	0.89	1.17	0.96	0.60
45	0.60	0.66	0.58	0.99	0.92	1.04	0.91	0.60
46	0.62	0.43	0.35	1.30	1.02	1.16	1.17	0.55
47	0.63	0.64	0.65	1.12	0.94	1.28	0.91	0.78
48	0.82	0.88	0.85	0.88	0.98	1	0.87	0.73
49	0.87	0.80	0.78	1.05	1.05	1.03	1.01	0.82
50	1.24	1.12	1.04	1.22	1.23	1.24	0.91	0.94

The values of tolerance to salinity indices varied significantly ($P < 0.05$) among varieties for all performed parameters (Table 3). The analysis of variance of salt tolerance index of the different performed parameters followed by the Newman-Keuils classification (Table 4) was used to significantly classify the varieties into five classes ($P < 0.05$) for the number of spikelets per spike, four class for ear weight, five classes for the number of grain/ear. Based on 1000 kernel weight four classes were appeared. For grain yield genotypes were classified into four classes significantly ($P < 0.05$). It is reported that genotypes ESP-S1946 and GRC56::11 increased their grain production by 11% under salt stress compared to control and were most tolerant to salt stress.

Table 4. Mean comparison of measured traits for all studied varieties (Newman Keuils test at 5%).

Genotype	Total tiller	Tiller/ear	Dry Mater	Ear weight	Spiklet/spike	Grain/spike	Kernel weight	Yield
1	VT	VT	MT	MT	T	T	S	MT
2	MS	MT	MS	T	MT	VT	S	MS
3	MS	MT	MS	MS	T	MS	S	S
4	VT	VT	T	MS	MT	MT	S	T
5	MT	T	MT	MT	MT	MT	S	MS
6	T	MS	T	S	S	MS	MT	MS
7	VT	VT	MT	MS	MT	MT	S	MS
8	MT	MT	MS	MS	S	MT	S	MS
9	MT	MT	MS	T	T	T	MS	MS
10	VT	MT	T	T	MT	T	MT	MS
11	S	MS	S	T	MT	T	MT	MS
12	VT	VT	T	S	S	MS	MS	MS
13	MT	S	MT	MT	T	T	MT	MT
14	T	T	MT	MT	MT	MS	MT	MS
15	S	MT	S	MS	S	MT	MT	MS
16	MS	MT	S	MT	MT	T	MS	MS
17	MT	MT	MS	MS	S	MT	MS	T
18	T	T	MS	S	S	MS	MS	MS
19	VT	VT	T	T	MT	VT	S	T
20	S	MS	MT	T	MT	T	T	MT
21	MT	T	MT	MT	T	MT	S	MT
22	T	T	T	MT	T	MT	MS	MT
23	MT	MT	MS	T	T	MT	MS	MS
24	MS	MT	MS	MS	MT	VT	S	MS
25	S	S	S	MT	MT	MS	MS	S
26	MT	T	MS	MS	MT	MT	MS	MT
27	T	T	MS	T	S	MT	T	MT
28	MS	S	S	T	T	VT	S	S
29	VT	T	MT	MS	MS	MT	S	MS

30	T	T	MS	S	S	S	MS	MS
31	S	MS	S	MT	MT	MT	MS	S
32	S	MT	S	S	S	S	S	S
33	MS	T	MS	T	T	T	MS	T
34	VT	MT	MT	MT	MT	MS	T	MS
35	T	T	MT	MS	MT	MT	MS	MS
36	MS	MT	MT	VT	T	VT	MS	T
37	VT	VT	T	S	MT	MT	S	MS
38	T	T	MS	S	MT	MT	S	S
39	VT	VT	T	MT	MT	T	S	T
40	VS	T	MS	MS	MT	MT	S	MS
41	VS	MT	MS	MS	MT	T	S	S
42	VT	T	T	T	T	VT	T	MT
43	VS	S	S	MT	T	T	S	S
44	S	S	S	VT	MT	VT	MT	S
45	S	S	S	T	MT	T	MT	S
46	S	S	S	VT	T	VT	T	S
47	S	MS	S	VT	MT	VT	MT	MS
48	MT	MT	MT	MT	T	T	MS	MS
49	MT	MT	MS	T	T	T	T	MT
50	VT	VT	T	VT	T	VT	MT	T

T= tolérant ; S= sensitive ; MT= Moderately tolerant; MS= Moderately sensitive;
VT = Very tolerant.

Compared with the results of the vegetative stage, grain yield per plant at 150 mM NaCl was reduced by 10 % for the most tolerant genotypes in the vegetative stage, when it was reduced on average by 44.4% for the most susceptible genotypes at this stage. Thus, all the genotypes that showed high sensitivity to NaCl (150 mM) at the vegetative stage include in the most sensitive class for grain yield. However genotypes SYR87-1:55, Maali, IRN40::12 and GRC56::11 behave as tolerant to salt stress at different growth stages.

The study of correlations showed the most significant relationship ($r = 0.74^{**}$) between aerial dry matter and yield (Table 5). Positive and weak correlation between yield and KW ($r = 0.29$), and average association between ear weight and KW ($r = 0.53$) were also revealed (Table 5).

Table 5. Correlation matrix (Coefficient of Pearson: r) of salt tolerance index of different studied traits.

TT	0.76^{*}						
TE	0.76^{*}	0.85^{*}					
EW	0.02	-0.40	-0.38				
S/S	0.09	-0.19	-0.14	0.57			
NGS	0.04	-0.26	-0.21	0.80^{*}	0.60^{*}		
KW	0.04	-0.19	-0.24	0.53	-0.02	0.13	
Yield	0.74^{*}	0.46	0.52	0.29	0.05	0.29	0.36
Traits	DM	TT	TE	EW	S/S	NGS	KW

* = Significant at level 5%.

Discussion

The evaluation of the behavior of 50 durum wheat genotypes in semi controlled conditions revealed a diversity of response against salt stress of 150 mM. The work of (Richards *et al.*, 1987; Slavich *et al.*, 1990; Garcia-Legaz *et al.*, 1993; Mallek-Maalej *et al.*, 1998;) showed a similar effect of salt on the development of many plant species.

According to Gregorio *et al.* (2002) this genetic variability within species offers a valuable tool to study the salt tolerance mechanisms.

Effect of Saline Stress on Morphological Parameters

The effect of salinity usually occurs in most plants cultivated by a depressive effect on growth and development. Therefore, the three agronomic parameters (aerial dry matter, total tillers and number of tiller ear) were used to evaluate the salt tolerance of these genotypes. Thus, we observed a significant decrease in different growth parameter studied. This depressive effect of salinity on growth and development of wheat is consistent with similar study (Bhatti *et al.*, 2004) on wheat, (Munns *et al.*, 2006) on barley.

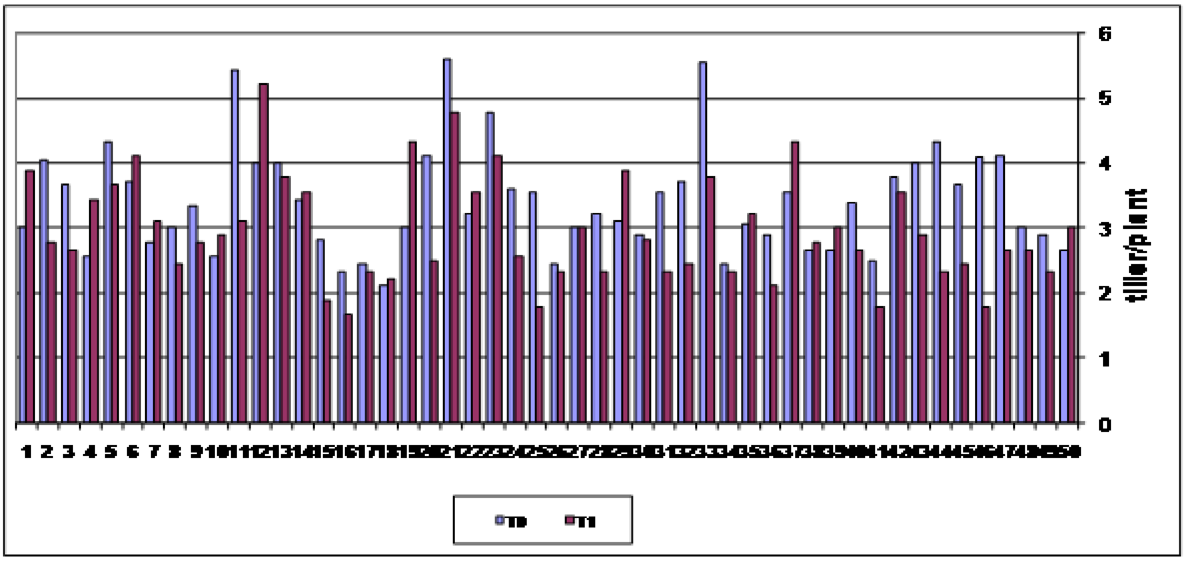

Fig. 1. Total number of tiller of different genotypes under two treatments (T0=control; T1=Salinity).

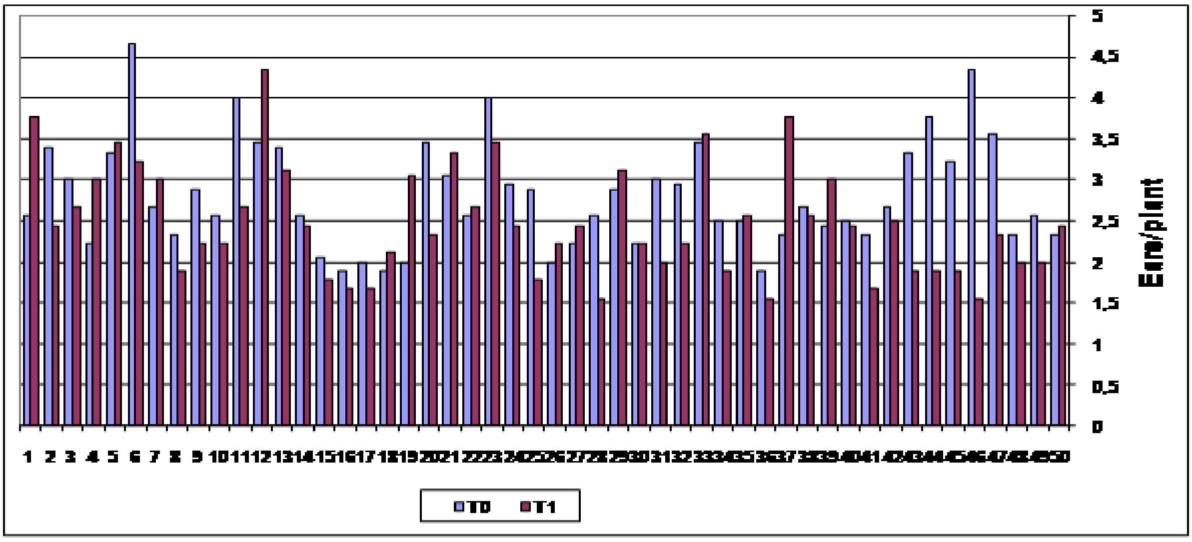

Fig. 2. Tiller-ear number of different genotypes under two treatments (T0=control; T1=Salinity).

Improve grain yield of wheat is still the main target of plant breeding (El-Hendawy *et al.*, 2005). Therefore, a trait is considered useful for evaluating salt tolerance must be significantly influenced by the salt stress and affects the final performance.

Our results revealed that Salt stress decreased significantly the Aerial dry matter production; this may be explained by physiological disorders caused by the salt that induces the elevation of osmotic pressure and consequently the use of additional energy (ATP) by the plant for osmotic adjustment.

This is necessary to fight against this stress causing a decline in aerial biomass (Wyn Jones and Gorham, 1993). Benamar (2009) attribute the decrease of dry matter production to a decrease in the number of cell divisions. Correlations between measured traits showed that aerial dry matter was the most informative (r = 0.74**) on yield prediction. This indicates that the dry biomass can be considered as good criteria of selection under salt stress, which confirm the work of (Ahmad *et al.*, 2011) on bread wheat.

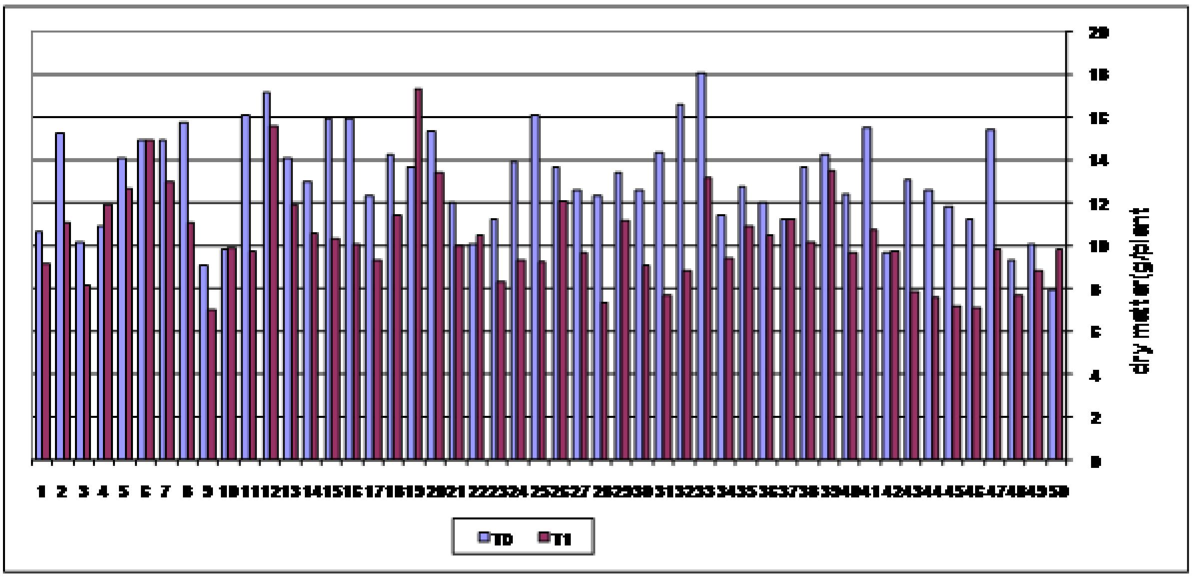

Fig. 3. Aerial biomass per plant of different genotypes under two treatments (T0=control; T1=Salinity).

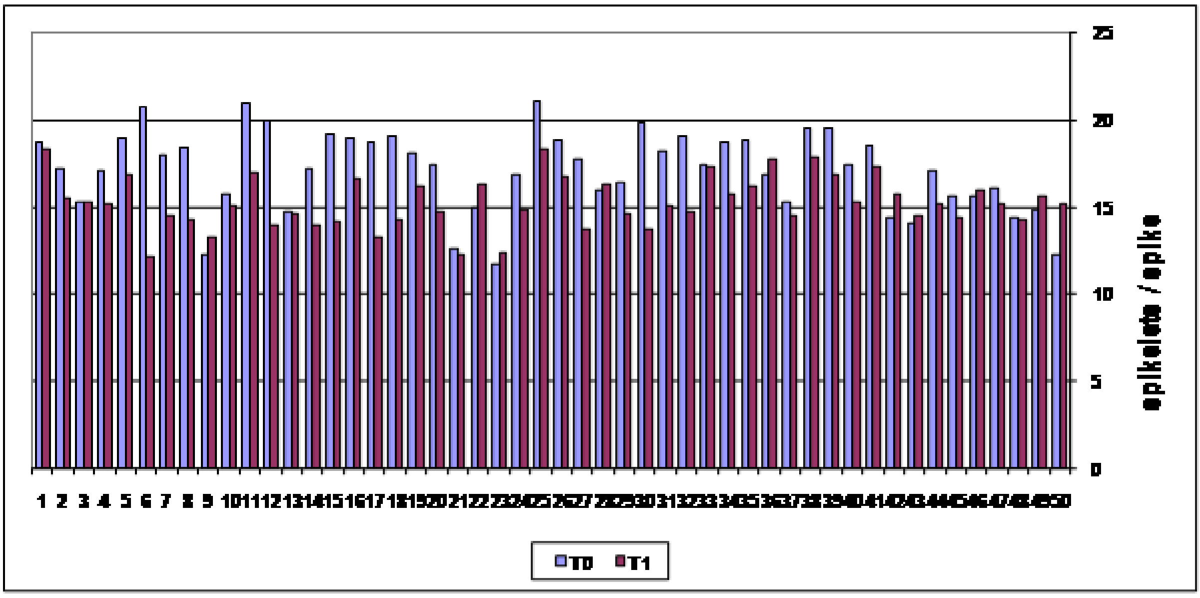

Fig. 4. Number of spikelets per spike of different genotypes under two treatments (T0=control; T1=Salinity).

The total number of tillers per plant is the most sensitive trait to salinity in wheat (El-Hendawy *et al.*, 2005). Therefore, salinity reduces total number of tillers by delaying and reducing the emergence of tillers in the vegetative stage and inhibited its growth in later stage by affecting the metabolic activity of plants (Mass and Poss, 1989).

Indeed a concentration of salt water from the ground greater than 50 mM could destroy most of the secondary tillers and significantly inhibited the formation of tertiary and side tiller. The percentage of tiller ear were reduced (9%), but not as much as the reduction of total tillers (11%) which confirms the work of Mass and Grieve (1994).

According to Simons and Hunt (1983), tiller number regulates the grain yield by influencing the number of ear (tillers ear) in wheat. Correlation analysis in our study confirm this finding and shows that the number of total tillers is the most decisive of the genotype ability to produce ear (r = 0.85**), these results are consistent with that found by (Bchini *et al.*, 2009) in barley, aerial dry matter is also a key to this ability, but to a lesser degree than the total number of tillers (r = 0.76**).

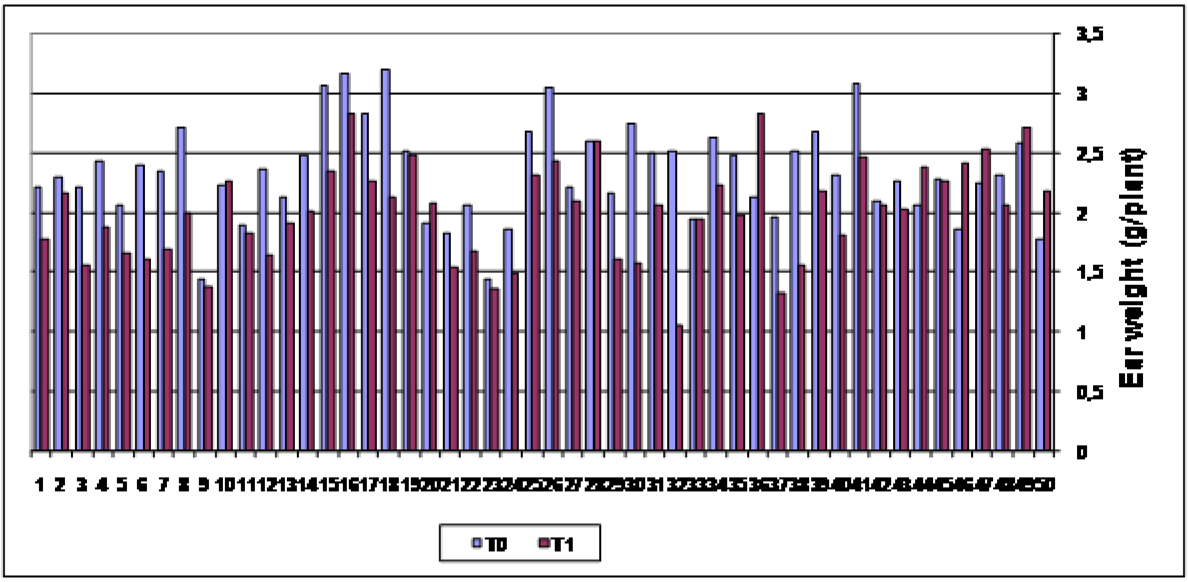

Fig. 5. Ear weight of different genotypes under two treatments (T0=control; T1=Salinity).

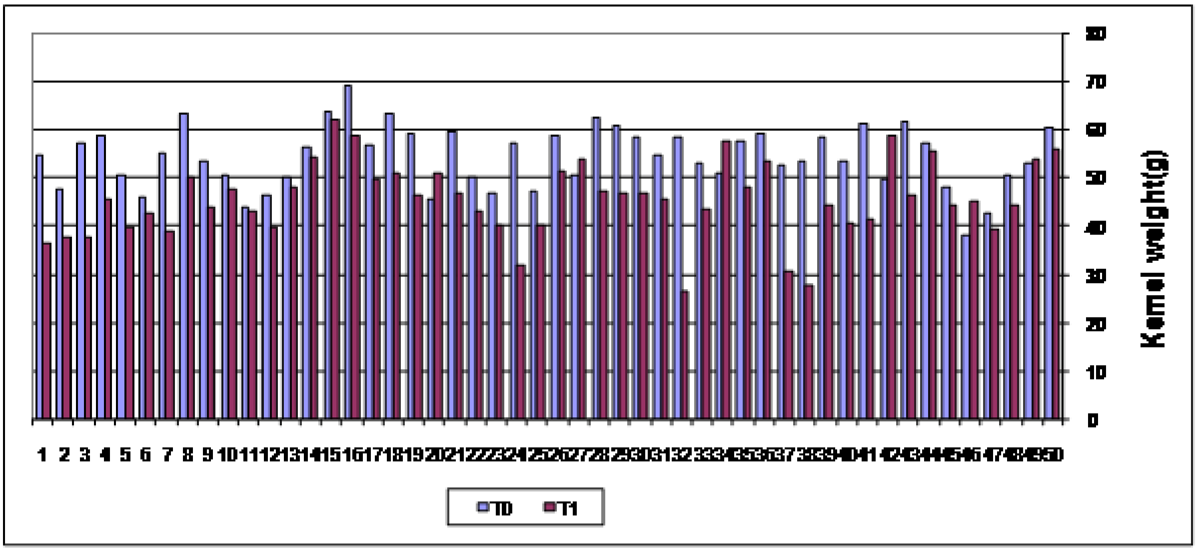

Fig. 6. 1000 grains weight of different genotypes under two treatments (T0=control; T1=Salinity).

Effect of saline stress on yield component

Grain yield is the main criteria used by farmers for genotypes selection to salt stress. Many scientists had selected species grown under salt stress based on the grain yield (Sadiq *et al.*, 1994; Jafari-Shabestari *et al.*, 1995; Anderson *et al.*, 1996). Our results prove that the various components of yield (the weight of the spike, number of spikelets/spike, number of grains/spike and KW) showed different responses to salinity. Similar results were reported by (Slavich *et al.*, 1990). The number of grain/spike was the least sensitive to salinity, while the KW was the most significant component. Unlike, rice observations (Zeng and Shannon, 2000) and wheat (El-Hendawy *et al.*, 2009) show that KW was the least sensitive components, while the number of spikelets was the most sensitive to salt. Concerning the number of spikelets per spike recorded sensitivity can be explained by the salt inhibiting effect on the initiation of spikelets during heading stage and therefore the number of spikelets (Mans and Rawson, 2004).

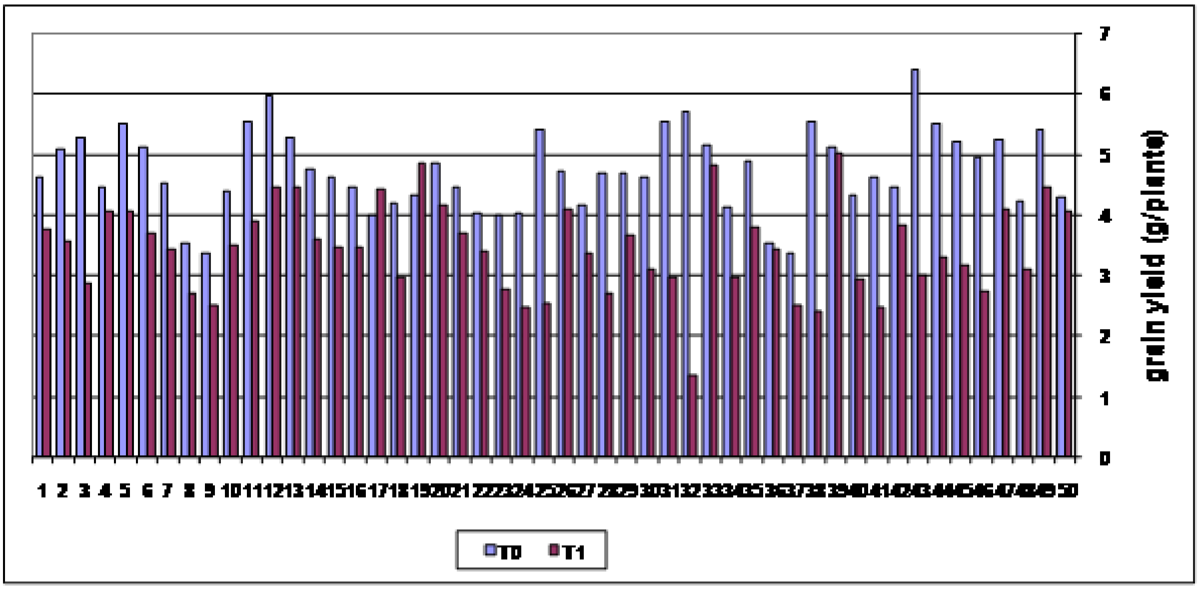

Fig. 7. Final yield per plant of different genotypes under two treatments (T0=control; T1=Salinity).

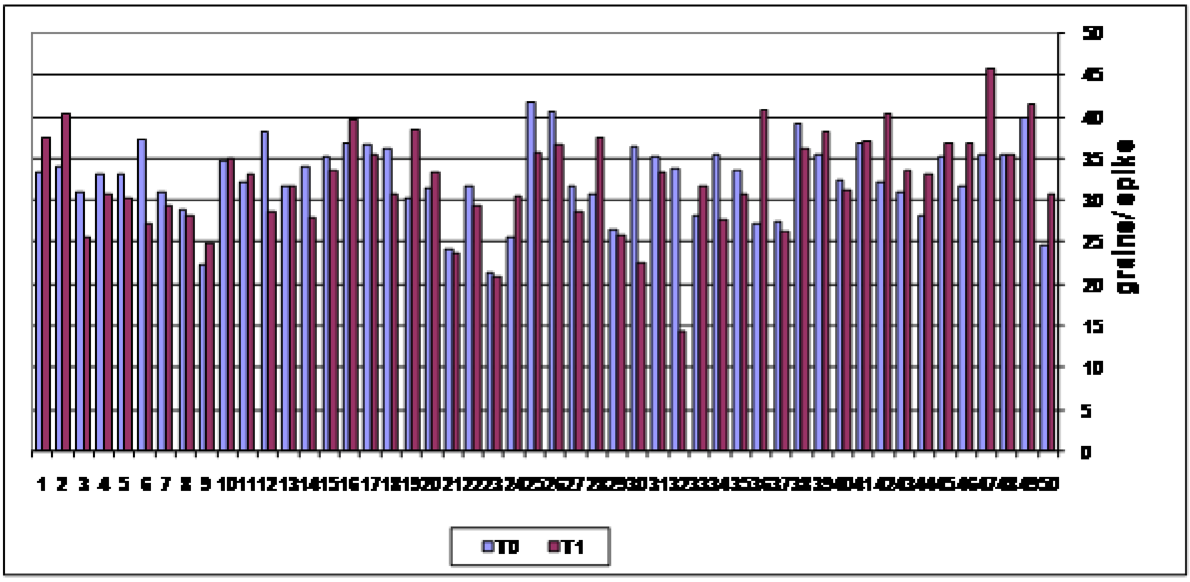

Fig. 8. Number of grains per spike of different genotypes under two treatments (T0=control; T1=Salinity).

The negative effect of salt on the average ear weight and KW can be explained mainly by the salt effect on fertility of the spike, the grain filling period and efficiency of remobilization of reserves and therefore the yield reduction in final grain. These results are consistent with the work of Handy (2005) which showed that salinity has a detrimental effect on the remobilization reservations courtyard of the grain filling phase and that the reduction of grain yield is mainly attributed to the decline of the weight of ear and 1000 seed weight as revealed in our results. According to (El-Hendawy *et al.*, 2005) the weight reduction of 1000 seeds in salt stress condition could be the result of food shortage deficiency (food shortage English) for seed filling late cycle of development.

Conclusion

According to our results using salt tolerance index of different agronomic traits we distinguish genotypes "SYR87-1:55, Maali, IRN40::12 and GRC56::11 " as the most tolerant to salt stress and have a similar salt tolerance at different stages of growth. Genotype ESP-S1946 increased 11% grain production under the effect of salt distinguishes it as a source of tolerance. Among Tunisian varieties only Maali and Naser showed salt tolerance for all studied traits. The other varieties are among the most sensitive. In parallel, varieties "TUR48::255, ESP27::46, IRNS406, Selim, Mahmoudi, SYR88-2:2, OMN87:142, NAX1_207, MAR85:112, Kerim and NAX1_027 it ranks as the most sensitive among all genotypes analyzed a different stage of development.

Aerial dry matter is the most informative and useful traits to evaluate the tolerance of durum wheat to salinity and screening genotypes sources for Salt stress tolerance. However, the number of tiller-ear, tillering capacity and kernel weight showed a moderate effect on yield.

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