PJN

ISSN 1680-5194

PAKISTAN JOURNAL OF NUTRITION

ANSInet

308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Mob: +92 300 3008585, Fax: +92 41 8815544

E-mail: editorpjn@gmail.com

Pakistan Journal of Nutrition 10 (6): 539-542, 2011
ISSN 1680-5194

Behaviour of Tunisian Durum Wheat (*Triticum turgidum* L.) Varieties under Saline Stress

Ramzi Chaabane[1], Houcine Bchini[2], Houda Ouji[1], Hammadi Ben Salah[1], Khalil Khamassi[1], Sahari Khoufi[1], Elyes Babay[1] and M'barek Ben Naceur[1]
[1]National Agronomic Research Institute of Tunisia
[2]Regional Field Crop Research Center of Beja

Abstract: An experimental study was carried out under semi controlled conditions at National Agronomic Research Institute of Tunisia in Ariana experimental station. Eight main Tunisian Durum wheat (*Triticum turgidum* L.) varieties were grown under salinity conditions. The objectives of this research were to compare the behaviour of the varieties under salt stress. Many agronomic and physiological traits were evaluated under both saline (10 g NaCl/l) and non saline conditions (control). Results showed that salinity negatively affected all of the studied parameters. The tiller number, chlorophyll contents, height growth rate, shoot dry weight, spikes per plant, 1000-grain weight and total grain yield were significantly affected by salinity. However the plant height, spikelets per spike and grains per spike were much less affected by salinity. Correlation studies showed significant positive and negative correlations between salt tolerance indexes of different evaluated parameters. These results strongly suggest that the number of fertile tillers and shoot dry weight might be useful for salinity tolerance improvement programs of the analyzed genotypes.

Key words: Tunisian durum wheat, salinity, grain yield

INTRODUCTION

In the Mediterranean area, with an arid or semi-arid climate, water is the principal factor limiting the extension and the intensification of cereal culture. Under such circumstances, one possible way of increasing productivity of wheat is to apply supplemental irrigation during the reproductive part of the crop cycle. However the Mediterranean area water resources are increasingly rare, thus saline water is used in agriculture (Alem *et al.*, 2002). Effects of salinity are more obvious in these regions where limited rainfall, high evapo-transpiration and high temperature associated with poor water and soil management practices are the major contributing factors (Azevedo *et al.*, 2006). Salt stress causes reduction in plant growth, development and compromise yield. The major environmental factor that currently reduces plant productivity is salinity (Majeed *et al.*, 2010). Saline water management requires that species and salt tolerant varieties should be identified (Minhas, 1996). This is particularly important in durum wheat, since it is much more salt sensitive than other cereals such as barley or even bread wheat (Munns, 2002). It is known that durum wheat genotypes respond differentially to salinity, which necessitates the identification of high yielding stable varieties under saline conditions. For this purpose the agronomic and physiological traits may be important, not only to be used as quick and easy screening criteria if they are closely associated to grain yield (Munns and James, 2003) but also improves the salt tolerance. In our work, we aim to compare the behaviour of eight main Tunisian varieties of durum wheat under saline stress and to look for the most affected parameters by this stress. Many agronomic and physiological traits were evaluated under saline and non saline stress conditions.

MATERIALS AND METHODS

Eight Tunisian varieties of Durum wheat (*Triticum Durum* L.) were used in this study: Ben Bechir, Karim, Khiar, Maali, Nasr, Om Rabiaa, Razzek and Salim. These varieties are local and introduced released by the National Agronomic Research Institute of Tunisia (INRAT). The varieties were grown under semi controlled conditions, during 2009/2010 growing season in pots (Four plants per pot) filled by a loamy sand soil collected from the soil surface (0-15 cm) at the Ariana experimental station of the INRAT. The soil was air-dried, ground, passed through a 5 mm mesh screen and thoroughly mixed. The experiment was conducted in triplicate with a completely randomized design. Two treatments were used, saline treatment (10 g/l NaCl) and the control. The salinity treatment has been initiated at four leaves stage. Agronomic and physiological measurements were conducted at different growth stages. The data were also converted to salt tolerance indices to allow comparisons among genotypes for salt sensibility. Chlorophyll content was measured on the flag leaves at 60, 80, 100, 110 and 120 days after sowing. Three different measurements were performed at the base the middle and the top of the leaf using a

Corresponding Author: Ramzi Chaabane, Biotechnology and Physiology Laboratory, National Agronomic Research Institute of Tunisia

portable meter (Minolta SPAD 502 Meter). In this protocol the rate of chlorophyll is estimated per unit SPAD. The height of the main shoot of each plant was measured with a ruler at 50, 60, 70, 80 and 90 days after sowing. The tiller number was recorded at 120 days after sowing. After harvesting, shoots were oven dried at 70°C for 48 h for the determination of dry weight. The spike number per plant, the spikelets number per spike, the grain number, the grain weights per spike and the 1000 grain weight were also determined. ANOVA analysis, means comparison, Pearson correlations coefficients and their significance were achieved by the program Statistica 5.0 version '98 Edition.

RESULTS AND DISCUSSION

Salinity affected all of the considered parameters at different growth stages. The tiller number and chlorophyll contents at salinity treatment varied significantly from those of the control (Table 1).

The mean tiller number for all varieties at salinity treatment was reduced by 28.78% compared with the control treatment. These results are in accordance with those obtained by several authors: El-Hendawy *et al.* (2005) reported that tiller number was significantly more affected by salinity than leaf number and leaf area at the vegetative stage; Eugene *et al.* (1994) reported that salinity stress strongly influenced the distribution of spike-bearing tillers; Nicolas *et al.* (1994) found that salt stress during tiller emergence can inhibit their formation and can cause their abortion at later stages; Jones and Kirby (1977) reported that breeding genotypes with fewer, but less vulnerable tillers could substantially increase yields on salt-affected soils. The salt tolerance indices of tiller number (Table 2) ranged from 0.6 (Nasr) to 0.88 (Razzek). For tiller number, Nasr was the most affected genotype by salinity and Rezzek was the least affected one. For instance, tiller number at salinity was decreased by 40% for Nasr and 12.5% for Rezzek, as compared with the control.

The average chlorophyll content of the flag leaf had a decreasing trend with time. At salinity treatments the average chlorophyll content of the 8 varieties was increased by 3.25%, 4.66% and 7.086% at 60, 80 and 100 days after sowing. At 110 and 120 days after sowing the average chlorophyll content of the 8 varieties was decreased by 39.03% and 56.01%. This reveals that senescence processes were promoted by salinity.

The decrease in chlorophyll content under stress at these development stages is a commonly reported phenomenon in various studies. This may be due to different reasons: membrane deterioration (Ashraf and Bhatti, 2000); inhibition of chlorophyll synthesis or an acceleration of its degradation (Reddy and Vora, 1986); destruction of chlorophyll pigments and the instability of the pigment protein complex (Levit, 1980); interference of salt ions with the de novo synthesis of proteins, the structural component of chlorophyll, rather than the breakdown of chlorophyll (Jaleel *et al.*, 2007); reduce in gas exchange of the leaves that has been attributed to salt damage of the photosynthetic tissue, to stomatal effects and consequent restriction of the availability of CO_2 for carboxylation, or to acceleration of senescence

Table 1: Variance analysis of tiller number and Chlorophyll content

Source of variation	d.f	MS	F. cal	P	MS	F. cal	P	MS	F. cal	P
		--------- Tiller number ---------			---- Chlorophyll content day 60 ----			--- Chlorophyll content day 80 ---		
Genotypes (Gen)	7	1.16	1.64	0.160	33.01	9.73	0.00***	31.87	6.33	0.00***
Treatments (Treat)	1	13.02	18.38	0.00***	15.93	4.70	0.04*	31.46	6.25	0.01*
Gen x Treatments	7	0.59	0.84	0.57	5.33	1.57	0.18	5.56	1.10	0.38
Error	32	0.71			3.39			5.033		
	d.f	-- Chlorophyll content day 100 --			-- Chlorophyll content day 110 --			--- Chlorophyll content day 120 ---		
Genotypes (Gen)	7	64.18	7.58	0.00***	196.22	5.29	0.00***	153.37	3.15	0.012
Treatments (Treat)	1	83.33	9.85	0.00**	1951.42	52.65	0.00***	3040.92	62.41	0.00***
Genx Treat	7	11.00	1.30	0.28	44.10	1.19	0.34	9.92	0.20	0.98
Error	32	8.46			37.06			48.72		

*,**,***Significant at 0.01 and 0.001 levels, respectively

Table 2: Salt tolerance indices of different measured parameters in wheat genotypes at different growth stages

	CC day 60	CC day 80	CC day 100	CC day 110	CC day 120	Growth rate	Tiller number	Final shoot weight	Spklt. per spike	1000-grain weight	Grain yield	Grains per spike	Spikes per plant
Ben Bechir	0.99	1.01	0.92	0.31	0.34	0.91	0.68	0.67	1.05	0.99	0.69	1.07	0.66
Karim	1.01	1.00	1.07	0.47	0.31	0.93	0.68	0.70	0.97	0.85	0.64	1.00	0.74
Khiar	1.07	1.07	1.07	0.58	0.39	0.87	0.74	0.70	0.97	0.89	0.68	0.92	0.77
Maali	1.04	1.06	1.12	0.69	0.49	0.89	0.81	0.74	1.00	0.90	0.72	0.98	0.81
Nasr	1.01	1.15	1.14	0.34	0.19	0.92	0.60	0.68	1.06	0.97	0.71	1.06	0.65
Om Rabiaa	0.96	1.06	1.11	0.81	0.41	0.75	0.72	0.66	0.97	0.93	0.67	0.97	0.75
Razzek	1.10	1.00	1.05	0.81	0.63	0.84	0.88	0.71	0.96	0.89	0.67	0.89	0.88
Salim	1.06	0.99	1.04	0.75	0.62	1.01	0.67	0.77	1.03	1.06	0.76	1.04	0.68

CC = Chlorophyll content; Spklt. = Spikelets

(Pessarakli, 1994); inhibition of photosynthesis through stomatal closure, which decreases biomass (Yousfi *et al*., 2010). The averaged salt tolerance indices (Table 2) of chlorophyll content for all varieties ranged from 0.96-1.1, from 0.98-1.15, from 0.92-1.13, from 0.31-0.81 and from 0.19-0.63 at 60, 80, 100, 110 and 120 days after sowing respectively. The plant height was much less affected by salinity. However the Relative Growth Rates (RGR) calculated for plants height at salinity treatment varied significantly from those of the control. The average of the RGR at salinity treatment of the 8 varieties was reduced by 11.43% compared with the control treatment. The salt tolerance indices of growth rates ranged from 0.75 (Om Rabiaa) to 1.01 (Salim). For height growth rate, Om Rabiaa was the most affected genotype by salinity while Salim was the least affected one.

At final harvest different parameters (shoot dry weight, number of spikes per plant, 1000-grain weight and total grain yield) decreased significantly from those of the control (Table 3). The shoot dry weight was reduced by 29.69%, the number of spikes per plant was reduced by 26.85%, the 1000-grain weight was reduced by 6.67% and the total grain yield was reduced by 29.96%, as compared with the control treatment. However, some yield components (spikelets/spike, grains/spike) were much less affected by salinity. The number of spikelets per spike was reduced by 0.03% and the number of grains per spike was reduced by 1.44% as compared with the control treatment. The spikelets per spike and grains per spike were the least sensitive to salinity, whereas spikes per plant, 1000-grain weight and total grain yield were the most sensitive yield components. Therefore the various yield components showed different responses to salinity. Because spikelets and tiller number initiate at the vegetative stage, the negative effect of salinity on spikelet number, tiller number and shoot dry weight indicates that these parameters are sensitive parameters of vegetative stage that affects final yield. These results are similar to those obtained by El-Hendawy *et al*. (2005). The salt tolerance indices (Table 2) of final harvest parameters varied among genotypes. For instance, salt tolerance indices ranged from 0.66 (Om Rabiaa) to 0.77 (Salim) for Shoot dry weight; from 0.64 (Karim) to 0.76 (Salim) for grain yield; from 0.85 (Karim) to 1.06 (Salim) for 1000-grain weight; from 0.65 (Nasr) to 0.88 (Razzek) for spikes per plant; from 0.96 (Razzek) to 1.06 (Nasr) for spikelets per spike; from 0.89 (Razzek) to 1.07 (Ben Bechir) for grains per spike. These results showed that Salim was the least sensitive variety to salinity for three final harvest parameters (shoot dry weight, 1000-grain weight and grain yield). However for reproductive yield under salinity Salim (4.04 g/plant) occupies the third position after Ben Bechir (4.52 g/plant) and Maali (4.16 g/plant). The least productive variety under salt stress was Om Rabiaa (3 g/plant).

Pearson's Correlations tests were computed between salt tolerance indexes of different parameters. Salt tolerance index of grain yield showed a very highly significant positive correlation ($r = 0.90$, $p<0.001$) with salt tolerance index of shoot dry weight and a highly correlation ($r = 0.43$, $p<0.05$) with tiller number and spikelets per spike. A highly significant positive correlation ($r = 0.55$, $p<0.01$) was found between STI of tiller number and STI of shoot dry weight as well as between STI of shoot dry weight and STI of spikes per plant ($r = 0.55$, $p<0.01$). However a significant negative correlation was found between STI of tiller number and STI of grains per spike ($r = -0.50$, $p<0.05$) as well as between STI of grains per spike and STI of spikes per plant ($r = -0.59$, $p<0.05$). Correlation studies showed that the grain yield sensibility to salt stress is highly correlated with the sensibility of shoot dry weight, tiller numbers and spiklets per spike. In other terms the sensibility to salt stress of these three components was responsible for reduction in the grain yield under salinity stress. The negative effect of salinity on spikelet number, tiller number and shoot dry weight indicates that these parameters are sensitive parameters of early vegetative stages that affect final yield. This suggests that evaluation for salt tolerance among genotypes can be based on the genetic diversity in tiller number, spikelet number and dry weight at early vegetative stages.

Finally, appropriate selection and breeding programs for further improvement in salt tolerance of these Tunisian wheat genotypes should improve their tiller number, spikelets per spike and shoot dry weight under salt stress. But care should be taken for the negative correlation between the salt tolerance index of grains per spike and tiller number. Because high tiller number genotypes might have very low number of grains per spike under salt stress.

Table 3: Variance analysis of shoot dry weight, number of spikes per plant, grain yield and 1000-grain weight

		Shoot dry weight			Spikes per plant			Grain yield			1000-grain weight		
Source of variation	d.f	MS	F. cal	P	MS	F. cal	P	MS	F. cal	P	MS	F. cal	P
Genotypes (Gen)	7	3.70	1.96	0.09	0.67	3.08	0.01*	1.48	2.48	0.04*	145.89	7.64	0.00***
Treatments (Treat)	1	140.54	74.34	0.00***	6.63	30.43	0.00***	36.29	60.67	0.00***	141.42	7.41	0.01*
Gen x Treat	7	0.45	0.24	0.97	0.15	0.71	0.67	0.13	0.21	0.98	19.41	1.02	0.44
Error	32	1.89			0.21			0.59			19.09		

*,**,***Significant at 0.05, 0.01 and 0.001 levels, respectively

Conclusion: Salinity affected all of the considered parameters. The different measured parameters showed differential response to salt stress in the different wheat cultivars. The tiller number, chlorophyll contents, height growth rate, shoot dry weight, spikes per plant, 1000-grain weight and total grain yield were significantly affected by salinity. However the plant height, spikelets per spike and grains per spike were much less affected by salinity. Correlation studies showed that the Salt Tolerance Index (STI) of grain yield was highly correlated with the STIs of shoot dry weight, tiller numbers and spiklets per spike. These results strongly suggest that the number of fertile tillers and shoot dry weight might be useful for salinity tolerance improvement programs of the analyzed genotypes. The results showed also significant negative correlations between the salt tolerance index of grains per spike and STI of tiller number. Therefore when improving for tiller number under salt stress, care must be taken for the depressive effect of this improvement on grain number and consequently on yield. Finally the results showed that Ben Bechir, Maali and Salim were the most productive varieties under salinity stress. These verities could be used conveniently under salt stress conditions by adjusting the sowing densities, to increase the number of fertile tillers per unit area and counterbalance the negative effect of salinity on tillering.

REFERENCES

Alem, C., L. Mustapha, B. Kouider, M. Jlibene, N. Nasralha and F.M. Abdelkarim, 2002. Adaptations hydrique et photosynthétique du ble dur et du ble tendre au stress salin. C. R. Biologies, 325: 1097-1109.

Ashraf, M.Y. and A.S. Bhatti, 2000. Effect of salinity on growth and chlorophyll content of rice. Pak. J. Sci. Ind. Res., 43: 130-131.

Azevedo, J.T. Neto, A.D. Prisco, J. Eneas-Filho, C. Abreu and E.G. Filho, 2006. Effect of salt stress on antioxidative enzymes and lipid peroxidation in leaves and roots of salt-tolerant and salt-sensitive maize genotypes. Environ. Exp. Bot., 56: 87-94.

El-Hendawy, S.E., H. Yuncai, M.Y. Gamal, M.A. Ahmed, E.H. Salah and U. Schmidhalter, 2005. Evaluating salt tolerance of wheat genotypes using multiple parameters. Eur. J. Agron., 22: 243-253.

Eugene, V.M., M.L. Scott, E.F. Leland and M.G. Catherine, 1994. Tiller development in salt-stressed wheat. Crop Sci., 34: 1594-1603.

Jaleel, C.A., P. Manivannan and G.M.A Lakshmanan, 2007. NaCl as a physiological modulator of proline metabolism and antioxidant potential in *Phyllanthus amarus*. C. R. Biologies, 330: 806-813.

Jones, H.G. and E.J.M. Kirby, 1977. Effects of manipulation of number of tillers and water supply on grain yield in barley. J. Agric. Sci. (Cambridge), 88: 391-397.

Levit, J., 1980. Responses of Plants to Environmental Stresses, Academic Press, Vol. II, New York.

Majeed, A., M.F. Nisar and K. Hussain, 2010. Effect of saline culture on the concentration of Na^+, K^+ and Cl^- in *Agrostis tolonifera*. Curr. Res. J. Biol. Sci., 2: 76-82.

Minhas, P.S., 1996. Saline water management for irrigation in India. Agric. Water Manage., 38: 1-24.

Munns, R., 2002. Comparative physiology of salt and water stress. Plant Cell Environ., 25: 239-250.

Munns, R. and R.A. James, 2003. Screening methods for salinity tolerance: A case study with tetraploid wheat. Pl. Soil, 59: 1-18.

Nicolas, M.E., R. Munns, A.B. Samarakoon and R.M. Gifford, 1994. Elevated CO_2 improves the growth of wheat under salinity. Aust. J. Plant Physiol., 20: 349-360.

Pessarakli, M., 1994. Handbook of Plant and Crop Stress. - Marcel Dekker, New York - Basel, Hong Kong.

Reddy, M.P. and A.B. Vora, 1986. Changes in pigment composition, Hill reaction activity and saccharides metabolism in Bajra (Pennisetum typhoides S & H) leaves under NaCl salinity. Photosynthetica, 20: 50-55.

Yousfi, S., S. Maria Dolores, V. Jordi and J. Luis Araus, 2010. Effect of salinity and water stress during the reproductive stage on growth, ion concentrations, $D^{13}C$ and $d^{15}N$ of durum wheat and related amphiploids. J. Exp. Botany, 61: 3529-3542.