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RESEARCH ARTICLE

Testing of Wheat Genotypes for Salt Tolerance

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Abstract

Parameters that show a significant genotypic variation and are associated with salt tolerance may be used as rapid and economic screening criteria in breeding programs. The objective of this study was to test growth and yield components for evaluating the salt tolerance of wheat genotypes. Five genotypes of winter wheat (*Triticum aestivum* L.) were used in this study, that differ from their salt tolerance were grown in soil with salinity 28 dS m^{-1} ,and irrigated by well water with salinity 7.5 ds m^{-1}soil . The results showed that salt concentration in the soil was reduced with plant growth stages from 28 dS m^{-1} before sowing to 8, 7.5 and 7.6 dS m^{-1} for N1 , N2 and N3 genotypes, respectively. Whereas reached to 16 and 17 dS m^{-1} for sensitive cultivars Tumos2 and Mexipak , respectively at maturity**.** Concerning germination percentage under saline conditions , wheat genotypes N1 , N2 and N3 showed the highest percentage 89 , 90 and 90 % , respectively which significantly different than wheat cultivars Tumos2 and Mexipak 79 and 83 % , respectively**.** Statistical analysis of the data revealed that genotype N2 required maximum days for germination 14 days, while cultivar Tumos2 required less days for germination 12 days**.** For spikes formation duration growth the genotype N3 was the late 119 days**,** while for physiological maturity N1 genotype the latest 153 days **.** Number of spikes per 6 m^2 , grains $spike^{-1}$ and grain weight were reduced significantly in sensitive cultivars Tumos2 and Mexipak**.** Higher grain yield with N2 genotype 2739.43 g with a no significant differences with the genotypes N1 and N2 , and with significant differences with the rest sensitive cultivars Tumos2 and Mexipak 346.61 and 242.98 g, respectively. Therefore, we conclude that the measurements of growth and yield components may be effective criteria for screening wheat genotypes for salt tolerance. And because N1 , N2 and N3 genotypes were identified as the most salt tolerant genotypes in this study , they can be utilized through appropriate selection and breeding programs for further improvement in salt tolerance of Iraqi wheat genotypes.

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Introduction

Wheat is one of the major food crops of the world. The crop has been established as a staple cereal food of Iraq. In addition to supplying carbohydrates, it provides protein, minerals and other important vitamins. Soil salinity is a severe problem in agriculture as it results in a noticeable reduction in the productivity of poor drainage in cultivated soils resulted in the accumulation of salts. Over 6% of the world's total land area and 20% of the irrigated land are salt-affected (FAO, 2008). Most importantly, between 35% and 50% of the world's population in about 80 countries are in semiarid areas where salinization is a major problem. In saline environment, NaCl is usually the most

injurious and predominant salt but also other salts including Mg^{+2}, Ca^{+2} and SO_4^{-2} may be presented (Yamaguchi and Blumwald, 2005). About 8×108 hectares (ha) area worldwide is affected by salinity (Munns, 2005). Salinity is an environmental condition which affects the physiological processes of plants and it is the most important factor which severely affects crop production. These adverse effects may be attributed to non-availability of water, disturbance in nutrient uptake causing deficiency and ion-toxicity to plants. Among abiotic stress, salinity is foremost and second most widespread problem causing reduction in growth and productivity (Munns *et al*. 2006).). Plants growing under saline condition invariably face increased concentrations of toxic ions in their tissues resulting from increased uptake of ions mainly Na and Cl under salinity. Three major hazards associated with salinity are; osmotic (water) stress arising from more negative osmotic potential (higher osmotic pressure) of the rooting medium, specific ion toxicity–excess of Na^+, Cl^-, SO_4^{-2} or other ions, and nutritional imbalance (Islam *et al*., 2011).

In most southern provinces of Iraq, salinity is a growing problem particularly in irrigated agricultural areas with rising water tables, poor water quality and/or deficient soil drainage. Soil salinity has reduced wheat yield usually when values of electrical conductivity were above 6 dS/m throughout the root zone (Munns *et al*. 2006). Salinity causes considerable reduction in crop production (Rengasamy, 2006; Katerji *et al*., 2009). EL-Hendawy *et al*. (2011) reported that salinity affected shoot growth more severely than root growth of seedlings. Importantly, height and dry weight of shoot ranked genotypes in the same order as their salt-tolerance rankings in terms of grain yield, whereas root dry weight did not. Therefore, they conclude that the measurements of shoot growth may be effective criteria for screening wheat genotypes for salt tolerance at early growth stages. El-Hendawy et al.(2005) concluded that an increase in tiller number per plant and spikelet number per spike will improve the salt tolerance of wheat genotypes in breeding programs. Islam *et al*. (2011)showed that number of tillers and panicles/plant and grain yield decreased similarly by the salinity of 6 and 10 dS/m. Number of dry leaves increased with the increase in salinity although total number of leaves were not affected by the salinity levels. Sadeghi and Emam(2011) indicated that increasing salinity from 0 to 12 dS/m, decreased growth and yield of two cultivars of wheat . Worst salinity is present in arid and semiarid regions of the world. According to Flower and Flower (2005) about three forth part of earth is occupied by saline water. Iraq presents a typical example of the problems faced by countries in such areas. In most southern provinces of Iraq, where the rainfall is low and the salt remains in the subsoil, increased salt tolerance will allow plants to extract more water. Salt tolerance may have its greatest impact on crops growing on soils with natural salinity, when all of the other agronomic constraints have been overcome (e.g. disease resistance and nutrient deficiency); subsoil salinity remains a major limitation to agriculture in all semi-arid regions as most southern provinces of Iraq. Obviously, improvement of the salt tolerance of genotypes has been proposed as the most effective way to reducing the deleterious effects of salinity on crop production (Pervaiz *et al*., 2002), because this strategy is still much less expensive for poor farmers in developing countries and is more feasible to apply on a large scale than using other management practices (e.g. leaching salt from the soil surface etc., Qureshi and Barrett-Lennard, 1998).

One of the critical issues restricting breeding efforts to enhance the salt tolerance of genotypes is the lack of effective evaluation methods and selection criteria for screening the salt-tolerance among genotypes, especially at the early stages (Zeng *et al*., 2002; Koyro and Huchzermeyer, 2004). Therefore, it is very important to develop an effective evaluation approach for screening the salt-tolerance among genotypes, which should be quick, economic and reliable. So, the possible ways are reclamation of soil and breeding new varieties suitable for saline soils, however reclamation needs more financial needs, laborious man power and not always practically feasible. The other possible strategy is breeding to enhance salinity tolerance, but it has been slow due to limited knowledge about the genetics of salt tolerance, inadequate screening techniques, low selection efficiency and poor G x E interactions. Salt tolerance of crops may vary with their growth stage (Mass and Grieve, 1994). In general, cereal plants are the most sensitive to salinity during the vegetative and early reproductive stages, and less sensitive during flowering and during the grain filling stage (Mass and Poss, 1989). However, a difference in the salt tolerance among genotypes may also occur at different growth stages**.** Differences in salt tolerance exist not only among different genera and species , but also within the different organs of the same species (Ismail , 2001). Comparing the response of cultivars of one species to salinity provides a convenient and useful tool for unveiling the basic mechanisms involved in salt tolerance ((Tammam *et al*., 2008).Therefore, in this study we attempted to test salt-tolerant genotypes of wheat and identify their characteristics of salt tolerance.

Materials and methods

Plant materials

Five genotypes of winter wheat (*Triticum aestivum* L.) were used in this study. Three genotypes (N1 , N2 and N3) were obtained from Department of Seed Technology – Ministry of Science and Technology ,Iraq. Additionally, Tumos 2 and Mexipak were obtained from Board stat of Agricultural Researches –Ministry of Agriculture.

Salinity

The genotypes were sowing in soil with salinity 28 dS m^{-1} ,and irrigated by well water with salinity 7.5 ds m^{-1}. Chemical composition of the original well water is shown in Table (1).

Site and treatment application

The experiment was carried out at Agricultural Station ,AL- Qaam region /AL-Anbar province , Iraq. The experimental plan was a randomized complete block design with four replications. The wheat crop was sown on 10 November 2010 and harvested on 30 April 2011. 120 Kg ha^{-1} of Calcium super phosphate (45 % P_20_5) was added before sowing and urea (46% N) in the rate of 250 Kg ha^{-1} was added in two equal doses, the first one was add after two weeks from sowing and the 2nd two weeks later. Irrigation with well water was started after sowing irrigation. The crop was managed according to the recommended conventional agronomical practices.

Soil Analysis

Samples of soil were taken at soil depth 0 – 30 cm for physical and chemical analysis. Result of soil analysis revealed that soil salinity at 0 -30 cm was 28 dS m^{-1}. Soil properties are shown in Table 2. Additionally , Samples of soil were taken at soil depth 0 – 30 cm after germination , tillering , elongation , flowering and maturity for determination of soil salinity .

Parameters studied

The different growth parameters were studied on the site during the growth period of the wheat: germination percentage (%) ,number of days from sowing to spikes formation , days from sowing to physiological maturity , number of spike per 6 m^2 , number of grain per spike , 1000 grain weight (g) and grain yield per 6 m^2.

. Statistical analysis

Data were analyzed by an analysis of variance (ANOVA) using G-STAT to test the significance of the main effects. Means were compared by using Duncan's multiple range test. Terms were considered significant at $P < 0.05$.

Results

Soil analysis of salt affected soil revealed marked differences in electrical conductivity. Highly significant differences among salt concentrations with plant growth stages . Salt concentration in the soil before sowing was 28 dS m^{-1} reduced with plant growth stages to 8, 7.5 and 7.6 dS m^{-1} for N1 , N2 and N3 genotypes, respectively. Whereas reached to 16 and 17 dS m^{-1} for sensitive cultivars Tumos2 and Mexipak , respectively at maturity (Table 3).

Concerning germination percentage under saline conditions (Table 4) wheat genotypes N1 , N2 and N3 showed the highest percentage 89 , 90 and 90 % , respectively which significantly different than wheat cultivars Tumos2 and Mexipak 79 and 83 % , respectively. Number of days for germination measured at 14 days from sowing, indicating there are differential responses of genotypes to salinity (Table 4). Statistical analysis of the data revealed that genotype N2 required maximum days for germination 14 days, while cultivar Tumos2 required less days for germination 12 days . For spikes formation duration growth the genotype N3 was the late 119 days with a no significant differences with the genotypes N1 and N2 , and with significant differences with the rest sensitive cultivars Tumos2 and Mexipak 105 and 103 days, respectively . For physiological maturity N1 genotype the latest 153 days with a no significant differences with the genotypes N2 and N3 , and with significant differences with the sensitive cultivars Tumos2 and Mexipak 142 and 140 days, respectively (Table 4).

Table. 1 Chemical composition of the well water.

Salinity (ds m^{-1})	7.5
pH	8.0
Elements	Concentration (mg.L^{-1})
Na	7850
Cl	13400
Mg	750
K	255
Ca	300
N	9
P	Trace
Mn	Trace
Zn	Trace
Cu	Trace

Table. 2 Some physical and chemical properties of the soil used.

Soil property	Value	Soil property	Value
Particle size distribution (g Kg^{-1})		Exchangeable macronutrient (mg.100g -1 soil)	
Sand	297.3	N	9.4
Silt	603.6	P	4.2
Clay	342.1	K	28.9
Texture	Clayloam	Mg	25.7
		Available micronutrients (mg. kg-1 soil)	
CaCO3 (%)	0.6	Fe	2.99
Organic matter (%)	0.1	Mn	4.66
pH	7.5	Zn	0.33
Ec (dSm-1), soil past extract	28	Cu	1.33

Table.3 soil salinity with plant growth stages

Genotypes	before sowing	germination	tillering	elongation	flowering	maturity
N1	28.0 a	20.0 a	15.2ab	15.0a	8.4 a	8.0a
N2	28.0 a	19.0a	14.4 a	15.0a	7.6a	7.5a
N3	28.0 a	19.8a	13.9 a	14.0a	8.0a	7.6a
Tumos2	28.0 a	22.0b	19.9b	17.2b	16.3b	15.5b
Mexipak	28.0 a	23.5b	20.3 b	19.0 b	17.8c	16.7c

Yield and yield components showed a significant differences between N1 , N2 and N3 genotypes and sensitive cultivars Tumos2 and Mexipak (Table 5) .

Number of spikes per 6 m^2 reduced significantly to 157 and 117 spike in sensitive cultivars Tumos2 and Mexipak , respectively. While ranged from 469 to 540 spike in other genotypes . Grains $spike^{-1}$ also reduced significantly to 33

and 34 compared to 45-55 for other genotypes . . At N1 ,N2 and N3 1000 grains weight ranged from 33 to 35 g , whereas Tumos2 and Mexipak gave the less weight 22 and 20 g , respectively. Reduction in grain spike^{-1} and 1000

Table .4 germination percentage (%) , days number of germination, spikes formation, and physiological maturity

Genotypes	germination (%)	germination (day)	spikes formation (day)	physiol.maturity (day)
N1	89.3 a	13.0 ab	118.7a	153.7a
N2	90.3a	14.0b	117.7ab	152.0a
N3	90.0a	13.7ab	119.0a	152.0a
Tumos2	79.7b	12.0a	105.2b	142.0b
Mexipak	83.6b	13.0ab	103.0b	140.0b

grain weight also causes reduction in yield 6 m^{-2}. Concerning grain yield per 6 m^2 Table 5 showed higher grain yield with N2 genotype 2739.43 g with a no significant differences with the genotypes N1 and N2 , and with significant differences with the rest sensitive cultivars Tumos2 and Mexipak 346.61 and 242.98 g, respectively.

Table.5 effect of salinity on some yield components and grain yield (ton ha $^{-1}$)

Genotypes	number of spike Per 6 m^2	number of grain per spike	1000 grain weight (g)	grain yield (g per 6 m^2)
N1	521a	48 ab	35.20a	2640.84a
N2	469a	55a	35.40a	2739.43a
N3	540a	45b	33.78a	2462.56a
Tumos2	157b	33c	22.30b	346.61b
Mexipak	117b	34c	20.36b	242.98b

Discusion

The comparison of soil salinities at germination , tillering , elongation , spike formation and maturity (Table 3) indicated that the salinity decreases with plant growth stages . This was in agreement with the finding of Feizi *et al*.(2007).The main cause of reduced plant growth in the presence of salt can be impairment of water regime. Increasing the salt concentration in the soil increases the osmotic pressure of the soil solution and plants cannot uptake the water as easily as in the case of relatively non-saline soils. Therefore, as the concentration of salt i.e. soil EC increases, water becomes less accessible to plants**.** The spikes formation and physiological maturity periods are shortened for sensitive cultivars (Table 4) , water regime of plants is disrupted and the uptake and distribution of essential elements in both semi-controlled and field conditions is altered . In the more sensitive genotypes salts accumulate more rapidly and because cells are not able to isolate the salt ions in vacuoles to the same extent as more tolerant genotypes, the leaves of more sensitive genotypes usually die faster (Munns, 2002). Neumann (1997) suggests that growth inhibition due to excessive salt concentration in the leaves reduces the volume of new leaf tissue in which excess salts can accumulate and therefore, in combination with the continuous accumulation of salts, it can lead to an increase in salt concentration in the tissue. There are significant differences in salt tolerance between plant species and genotypes and similar goes for the ability to tolerate water deficiency (Munns, 2002).

Germination is a suitable stage in the life of plants to evaluate differences in gene expression induced by salinity. When the usual hydration of wheat seeds is interrupted due to salinity stress, the radical emergence is blocked and the biochemical mechanisms involved can be impaired (Dell' and Spada, 1992). Sabir and Ashraf (2007); Khan and Gul (2006)also reported reduction in germination under salinity stress. Generally, it was obvious that salinity concentrations affected the final germination percentage (Table 4). The genotypes N2 and N3 attained 90% final germination percentage even with higher level of salt concentration except two salt sensitive cultivars (Tumos2 and Mexipak), which achieved 79 and 83% of the final germination percentage **.** Seed germination is critical steps in life cycle of wheat crop. The loss of plant stand causes a reduction in yield sink capacity by a decrease in plant density. Thus, screening of genotypes for salt tolerance at this early stage may important for screening salt tolerance as a considerable saving in time. The duration of plant development is also affected by

salinity (Table 4). Most of the literature indicates that wheat plants are particularly susceptible to salinity during the seedling and early vegetative growth stage as compared to germination. (Maas and Poss, 1989). Salinity stress at different phenological stages inhibits photosynthetic activities of the plant because it had a direct inhibitory effect on the Calvin cycle enzymes (Ottender and Oquist, 1991). Tiller plant^{-1} is most salinity sensitive trait in wheat (El-Hendawy *et al*., 2005). Thus to increase yield under stress condition it is necessary to maintain high plant density. Spikelets spike^{-1} and fertile tillers were found most salt susceptible yield components in wheat. At heading salinity suppresses reproductive development, spikelet formation and ultimately spikelets number (Mans and Rawson, 2004). Due to their response to salinity and significant positive correlation with yield these two traits could be used to evaluate wheat genotypes under saline field conditions.(Ahmad , 2011**).** A similar salt tolerance was observed in N1, N2 and N3 genotypes The characteristics of these genotypes are more germination percentage , longer duration for growth compared with other sensitive cultivars, less effect of salinity on final grain yield and the yield components (Table 5). Differences in salt tolerance exist not only among different genera and species , but also within the different organs of the same species (Ismail , 2001).

Conclusion

Overall, it can be concluded that substantial variation in salt tolerance among wheat genotypes at the germination stage was found in this study. Most importantly, This parameters can be considered for screening wheat genotypes at high salinity concentrations . Because N1 , N2 and N3 genotypes were identified as the most salt tolerant genotypes in this study , they can be utilized through appropriate selection and breeding programs for further improvement in salt tolerance of Iraqi wheat genotypes. Because Tumos2 and Mexipak were more sensitive to salinity at early growth stage , their salt tolerance can be improved by developing strategies for agronomic management according to the different growth stages, indicating that the degree of salt tolerance of wheat genotypes to salinity must be evaluated according to different growth stages.

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