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Research Article

# TESTING OF WHEAT GENOTYPES FOR SALT TOLERANCE AND LEAF RUST DISEASE CAUSED BY *PUCCINIA*

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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, which were grown in 28 dS/m saline soil, and irrigated by well water with a salinity 7.5 dS/m. The results showed that salt concentration in the soil was reduced with plant growth stages from 28 dS/m before sowing to 8, 7.5, and 7.6 dS/m for N1, N2, and N3 genotypes, respectively. Whereas approached 16 and 17 dS/m for Tumos2 and Mexipak, cultivars, respectively, at the maturity stage. Concerning germination percentage under saline conditions, wheat genotypes N1, N2, and N3 showed the highest percentages of 89, 90, and 90%, respectively, which was significantly different than wheat cultivars Tumos2 and Mexipak 79 and 83%, respectively. Statistical analysis of the data revealed that genotype N2 required a maximum days for germination 14 days, whereas cultivar Tumos2 required less days for germination 12 days. For spikes formation duration growth the genotype N3 was the late 119 days, whereas for physiological maturity N1 genotype was the latest 153 days. The 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 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. Moreover, 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.

**Keywords:** salt tolerance, 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 common phenomenon in the irrigator area of the dry and semi-dry areas of the world including Iraq. Salt-affected soils currently constitute 6.74 million ha in different agroecological regions, and the area is likely to increase to 16.2 million ha by 2050 (Smrutishree *et al*., 2016). Soil salinity is a severe problem in agriculture which is reflected in the reduced productivity of sewage-cultivated soils. NaCl is the most harmful and prevalent in soil (Yamaguchi and Blumwald, 2005). The negative effects of salt by not the availability of water and nutrient availability cause insufficiency in growth, productivity, and ion toxicity to plants (Munns *et al*., 2006). Three risks are associated with salinity. The salinity leads to the premature aging of the leaf (senescence), slow root growth, stopped elongation of sub root, and/or decrease in the absorption of elements as well as physiological effects, leaving cracking and symptoms of deficiency of nutrition (Ghulam *et al*., 2013). In most provinces of Iraq especially southern provinces, salinity is a big growing problem, especially in irrigated agriculture, use of well and trocar water, and/or poor soil drainage. The mechanism of response to the growth of the genotype of wheat and barley to the salinity is in two stages: The first a decrease in the growth rate occurs due to the presence of salt around the roots.

The second: An additional decrease occurs due to the toxic levels of salts (Omid *et al*., 2022(. 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). EL-Hendawy *et al*. (2005, 2011) reported that high salinity affects and delays the germination, rot weight, tiller number per plant, spikelet number per spike, and biological yield. The number of tillers and panicles/plant and grain yield decreased by the salinity of 6 and 10 dS/m, where dry leaves increased with high salinity and the total number of leaves was not affected with salinity levels (Islam *et al*., 2011). Increasing salinity from 0 to 12 dS/m decreased plant growth and yield of two wheat cultivars (Sadeghi and Emam, 2011). According to Flowers and Flowers (2005), about 75% of the earth is occupied by saline water. Salinity is still a great limitation to agriculture in all southern provinces of Iraq. Eliciting salinity tolerance genotypes is the most effective way to reduce the adverse effects of salinity on crop production (Pervaiz *et al*., 2002).

One of the most effective methods is to select salt-tolerance among genotypes, which should be quick, not expensive, and trusted. Therefore, breeding new varieties is suitable for saline soils. Crops vary in salt tolerance according to growth stage (Mass and Grieve, 1994). Crops are the most sensitive to salinity during their vegetative and early reproductive stages, and less sensitive during the flowering and grain-filling stage (Mass and Poss, 1989).

Wheat rusts are one of the most important diseases that limit wheat production worldwide (Singh *et al*., 2004). Wheat rust diseases are caused by fungi belonging to the class Basidiomycetes and order *Pucciniales* (Agrios, 2005). The three rust diseases of wheat are stem rust or black rust caused by *Puccinia graminis* Pers. *f.* spp. *tritici* Eriks.; stripe rust or yellow rust caused by *Puccinia striiformis* Westend. *f.* spp. *tritici* Eriks., and leaf rust or brown rust caused by *Puccinia triticina* Eriks. Rust pathogens differ in morphology, life cycle, and environmental preferences for growth and development. *P. graminis f.* spp. *tritici* develops well under hot and humid climatic conditions, whereas *P. striiformis f.* spp. *tritici* prefers a cooler climate. In contrast, *P. triticina*

is adapted to a relatively broader range of conditions, making it the most widespread of the three rust diseases (Getie, 2015). The three species of rust pathogens in wheat cause the most destructive diseases affecting cereals (Kolmer, 2005). The yield loss is usually high when the disease becomes severe before grain formation. Disease severity, however, depends on the resistance level of the cultivar grown, environmental conditions, and the time of onset of the disease (Brar, 2015).

Therefore, in this study, we attempted to test salt and leaf rust disease-tolerant genotypes of wheat and identify their characteristics of salt tolerance.

## METHODS

### Plant materials

Three genotypes of wheat (N1, N2, and N3) were obtained from the Department of Seed Technology – Ministry of Science and Technology, Iraq. And tow varieties Tumos2 and Mexipak were obtained from the Board stat of Agricultural Researches – Ministry of Agriculture and were used in this study.

### Salinity

The genotypes and varieties were sowed in soil with a salinity of 28 dS/m, and irrigated by well water with a salinity of 7.5 dS/m. The chemical composition of the original well water is shown in (Table 1).

### Site and treatment application

The experiment was carried out at AL-Qaam region/AL-Anbar province, Iraq. The experiment was carried out according to a randomized complete block design with four replications. The wheat crop was sown on November 10, 2010, and harvested on April 30, 2011. 120 kg/ha of 45% $P_20_5$, was added before sowing and 250 kg/ha of 46% N was added in two equal doses, the first dose was added after 2 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.

Disease incidence and severity were weekly recorded starting from the flowering stage. Samples of 100 plants from each variety were tested for both disease incidence and severity. Disease incidence was determined using the following formula.

$$\text{Disease incidence} = \frac{\text{Number of diseased plants}}{\text{Total plants assessed}} \times 100$$

While disease severity was determined using the modified Cobb's disease scale (Roelfs *et al*., 1992). Immunity (O) = 0, resistant (R) =0.1, moderately resistant = 0.2, intermediate (M) = 0.4, moderately susceptible = 0.6, and susceptible (S) = 1.

### Soil analysis

Soil samples were taken at depths 0–30 cm for physical and chemical analysis. Results revealed that salinity was 28 dS/m. Soil properties are shown in Table 2. After germination, tillering, elongation, flowering, and maturity for tested soil salinity.

### Parameters studied

Growth parameters were studied during the growth stage: Germination percentage (%), number of days from sowing to spike formation, days from sowing to physiological maturity, number of spikes per 6 $m^2$, number of grains per spike, 1000 grain weight (g), and grain yield per 6 $m^2$.

### Statistical analysis

Data were analyzed by analysis of variance using G-STAT. Means were compared using Duncan's multiple range tests at $p<0.05$.

## RESULTS

Soil analysis revealed differences in electrical conductivity. Highly significant differences in salt concentrations were determined according to plant growth stages. Salt concentration before sowing was 28 dS/m and reduced with plant growth stages to 8, 7.5, 7.6, 15.5, and 16.7 dS/m for N1, N2, N3, Tumos2, and Mexipak, respectively, at maturity stage (Table 3).

**Table 1: Chemical composition of the well water**

| Parameter | Value |
|---|---|
| Salinity (dS/m) | 7.5 |
| pH | 7.9 |
| Na (ppm) | 7850 |
| Cl (ppm) | 13400 |
| Mg (ppm) | 750 |
| K (ppm) | 255 |
| Ca (ppm) | 300 |
| N (ppm) | 9 |
| P (ppm) | Trace |
| Mn (ppm) | Trace |
| Zn (ppm) | Trace |
| Cu (ppm) | Trace |

**Table 2: Physical and chemical properties of the soil used**

| Soil property | Value | Soil property | Value |
|---|---|---|---|
| **Particle size distribution (g/kg)** | | **Exchangeable macronutrient (mg.100/g soil)** | |
| Sand | 297.3 | N | 9.4 |
| Silt | 603.6 | P | 4.2 |
| Clay | 342.1 | K | 28.9 |
| Texture | Clay loam | Mg | 25.7 |
| | | **Available micronutrients (mg/kg soil)** | |
| $CaCO_3$ (%) | 0.6 | Fe | 99 |
| Organic matter (%) | 0.1 | Mn | 4.66 |
| pH | 7.5 | Zn | 0.33 |
| Ec (dS/m), soil past extract | 28 | Cu | 1.33 |

The highest percentage of germination under saline conditions was 89, 90, and 90% in genotypes N1, N2, and N3, respectively, with significant differences than Tumos2 and Mexipak cultivars 79 and 83%, respectively (Table 4). The number of days for germination after 14 days from sowing indicated a differential response of genotypes to salinity (Table 4). Genotype N2 required a maximum days for germination of 14 days, whereas Tumos2 cultivar required 12 days. The formation period of spikes revealed that genotype N3 required 119 days with no significant differences with genotypes N1 and N2, with significant differences with the sensitive cultivars Tumos2 and Mexipak which required 105 and 103 days, respectively. While no significant differences between genotypes N1, N2, and N3. The physiological maturity was 153.7, 152, and 152 days, with significant differences for Tumos2 and Mexipak cultivars 142 and 140 days, respectively (Table 4). Yield and yield components showed significant differences between N1, N2, and N3 genotypes and Tumos2 and Mexipak cultivars (Table 5). The number of spikes per 6 $m^2$ reduced significantly to 157 and 117 spikes in sensitive cultivars Tumos2 and Mexipak, respectively, while ranging from 469 to 540 spikes 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 grain weight also causes a 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 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 3: Soil salinity with plant growth stages**

| Maturity | Flowering | Elongation | Tillering | Germination | Before sowing | Genotypes |
|---|---|---|---|---|---|---|
| N1 | 28.0[a] | 20.0[a] | 15.2[ab] | 15.0[a] | 8.4[a] | 8.0[a] |
| N2 | 28.0[a] | 19.0[a] | 14.4[a] | 15.0[a] | 7.6[a] | 7.5[a] |
| N3 | 28.0[a] | 22.0[b] | 13.9[a] | 14.0[a] | 8.0[a] | 7.6[a] |
| Tumos2 | 28.0[a] | 22.0[b] | 19.9[b] | 17.2[b] | 16.3[b] | 15.5[b] |
| Mexipak | 28.0[a] | 23.5[b] | 20.3[b] | 19.0[b] | 17.8[c] | 16.7[c] |

**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] | 118.7[a] | 153.7[a] |
| N2 | 90.3[a] | 14.0[b] | 117.7[ab] | 152.0[a] |
| N3 | 90.0[a] | 13.7[ab] | 119.0[a] | 152.0[a] |
| Tumos2 | 79.7[b] | 12.0[a] | 105.2[b] | 142.0[b] |
| Mexipak | 83.6[b] | 13.0[ab] | 103.0[b] | 140.0[b] |

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

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

The leaf rust incidence ranged from 8% to 18%, where's severity ranged from 2% to 23% (Table 6). Among these varieties, low disease incidence and severity were observed in N2 varieties which recorded 8.2, respectively, whereas high disease incidence and severity were observed in Mexipak which recorded 18.23%, respectively. The low disease incidence and severity of leaf rust at the N2 variety could be due to containing this genotype of the resistance gene.

**Table 6: Leaf rust incidence and severity**

| Genotypes | Disease incidence% | Disease severity% |
|---|---|---|
| N1 | 12 | 3 |
| N2 | 8 | 2 |
| N3 | 11 | 4 |
| Tumos2 | 15 | 18 |
| Mexipak | 18 | 23 |

## DISCUSSION

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 findings of Feizi *et al.* (2007). Alterations to the water regime may be the primary reason for reduced growth when salt is present. The osmotic pressure of the soil solution increases as the salt content in the soil rises, making it harder for plants to absorb water than they would in comparably non-saline soils. Therefore, plants have a harder time accessing water as soil EC (salt content) rises. For sensitive cultivars, the spike formation and physiological maturation times are shortened. (Table 4), in semi-controlled and outdoor environments, the water regulation of plants is disturbed, and the intake and distribution of critical elements are changed. The leaves of more sensitive genotypes often wither more quickly because salts accumulate more quickly in more sensitive genotypes and because cells in more sensitive genotypes are less able to isolate the salt ions in vacuoles (Munns, 2002). It is possible that growth inhibition caused by an excessive salt concentration in the leaves lowers the amount of new leaf tissue in which extra salts can build and, as a result, combined with the ongoing salt accumulation, it can result in an increase in salt concentration in the tissue Neumann (1997). The capacity of different plant species and genotypes to tolerate salt is significantly different, and the same is true for the ability to tolerate a lack of water (Munns, 2002).

When examining changes in gene expression brought on by salinity in plants, germination is an ideal time. Salinity stress prevents wheat seeds from hydrating normally, which slows radicle emergence and may disrupt related biochemical systems (Dell' and Spada, 1992; Sabir and Ashraf, 2007; Khan and Gul, 2006) also reported a reduction in germination under salinity stress. In general, 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 a higher level of salt concentration except for two salt-sensitive cultivars (Tumos2 and Mexipak), which achieved 79 and 83% final germination percentages. A crucial stage in the life cycle of a wheat crop is seed germination. By reducing plant density, the loss of plant stand lowers the capacity of the yield sink. Therefore, testing genotypes for salt tolerance at this early stage may be important as a significant time saver for testing salt tolerance. 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). Because salinity stress had a direct inhibitory effect on the Calvin cycle enzymes, it inhibited the plant's photosynthetic activity at several phonological stages (Ottander and Oquist, 1991). Tiller plant$^{-1}$ is the most salinity-sensitive trait in wheat (El-Hendawy *et al*., 2005). Thus to increase yield under stress conditions, it is necessary to maintain high plant density. The wheat yield components that were most salt-vulnerable were spikelet spike-1 and viable tillers. Salinity at the heading inhibits spikelet formation, reproductive development, and eventually spikelet quantity. (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, a 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 (Islam, 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, these 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 the salt tolerance of Iraqian wheat genotypes. Because Tumos2 and Mexipak were more sensitive to salinity at the 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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