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Assessment of Salt Tolerance in Wheat Accessions: Growth and Yield Components under Saline Conditions

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Abstract - **Iraq is one of two regions (along with Africa) heavily impacted by soil salinity. A significant portion of land in Iraq, Pakistan, India, and Egypt is unsuitable for agriculture due to this issue. Breeding and hybridization programs may utilize parameters exhibiting high genotypic variation and linked to salt tolerance as quick and affordable screening criteria. The goal of this study was to assess the growth and yield components of wheat accessions for their salt tolerance. Five accessions of winter wheat (*Triticum aestivum* L.) with varying salt tolerances were employed in this work. The plants were grown in saline-affected soil with a salinity of 28 dS m^{-1} and were irrigated with well water having a salinity of 7.5 dS m^{-1}. The findings demonstrated that as plants progressed through different growth stages, the soil's salt concentration decreased. For the A1, A2, and N3 accessions, this decrease was from 28 dS m^{-1} before sowing to 8, 7.5, and 7.6 dS m^{-1}, respectively. At the mature stage, the Tamoz2 and Maxipak cultivars showed salinity levels of approximately 16 and 17 dS m^{-1}, respectively. Wheat accessions A1, A2, and N3 displayed the highest germination rates under salinized conditions, at 89%, 90%, and 90%, respectively, which differed considerably from those of the Tamoz2 and Maxipak cultivars, at 79% and 83%, respectively. A statistical analysis of the data revealed that the Tamoz2 cultivar required fewer days for germination (12 days) than genotype A2, which required a maximum of 14 days. Accession A3 was the latest for spike formation and growth, at 119 days, while accession A1 required the most time for physiological maturity, at 153 days. Significant reductions were observed in the number of spikes per 6 m^2, grain weight, and grains per spike in the sensitive cultivars Tamoz2 and Maxipak. The A2 accession achieved an increased grain yield of 2739.43 g, with no significant differences compared to the A1 accession. However, substantial differences were observed when compared to the remaining sensitive cultivars Maxipak and Tamoz2, which yielded 242.98 g and 346.61 g, respectively. In conclusion, metrics for measuring growth and yield components may serve as useful standards for determining the salt tolerance of wheat accessions. Furthermore, as the A1, A2, and A3 accessions were found to be the most salt-tolerant in this study, breeding programs and appropriate selection strategies can be employed to further enhance the salt tolerance of Iraqi wheat accessions.**
Keywords: **Soil Salinity, Wheat Accessions, Salt Tolerance, Breeding Programs, Grain Yield**

I. INTRODUCTION

One of the main food crops grown worldwide is wheat, which is also recognized as one of Iraq's staple cereal foods. It provides essential carbohydrates, protein, minerals, and other vital vitamins. In the irrigated regions of the world's dry and semi-arid areas, including Iraq, soil salinity is a prevalent issue [34]. Salt-affected soils presently cover 6.74 million hectares in various agro-ecological zones, and this figure is projected to rise to 16.2 million hectares by 2050 [1]. Soil salinity poses a serious challenge to agriculture, evidenced by reduced productivity in salt-affected soils. Sodium chloride (NaCl) is the most harmful and common salt compound in these soils [2], [36]. The adverse effects of salinity on plants include ion toxicity, poor growth, and decreased productivity due to water and nutrient deficiencies [3], [35].

Salinity also causes physiological effects such as leaf cracking, malnutrition symptoms, premature leaf senescence, reduced root growth, halted root elongation, and impaired nutrient absorption [4]. Studies have indicated that *Puccinia striiformis f. sp. tritici* (Pst), which causes wheat stripe rust (WSR), is a major disease affecting wheat globally. Fungicides and highly resistant gene breeding have been utilized; however, Pst can develop new strains resistant to these fungicides, diminishing the effectiveness of resistance genes. Consequently, alternative and effective strategies for disease control are necessary. Biological control is a promising approach for managing crop diseases. This study examined the efficacy of three *Trichoderma* species - *Trichoderma asperellum* T34, *Trichoderma harzianum* (TH), and *Trichoderma viride* (TV) - at the seedling stage on a set of 34 wheat accessions. Assessments were conducted using two temperature ranges with four treatments in each experiment: TV, TH, T34, and a control group.

All accessions displayed high genetic diversity during *Trichoderma* treatment trials. Temperature influenced WSR symptoms across all treatments; however, T34 exhibited stable performance in both tests. Among the 34 durum and bread wheat accessions analyzed, significant genetic diversity was noted, originating from ten countries. Among the three *Trichoderma* species, T34 consistently improved WSR resistance in all examined accessions, demonstrating its effectiveness in fostering resistance across various wheat genetic backgrounds.

A related study conducted by [6] in southeast Ethiopia's Kolomsa and Meraro zone during the primary growing season of 2021 focused on identifying bread wheat accessions resistant to stripe rust using grid designs under natural epidemiological conditions. Slow rust resistance was evaluated using yield-related criteria. With the exception of accession 231237 (yielding 62.013 q/ha), highly significant differences ($P < 0.01$) were observed among the 100 accessions.

In another investigation, [7] used simple sequence repeats (SSRs) genetic markers to assess the genetic backgrounds of germplasm for elite lines with diverse accessions to enhance rust resistance in wheat. Principal component analysis (PCA) revealed an 85.3% variance in genetic variation among samples. High connections were found in markers like XWMC170/XGWM608, while CSLV34b and CSLV34a had weaker associations.

Cluster analysis identified three primary clusters, with cluster A differing substantially from clusters B and C. This indicated significant genetic diversity. Forty single-stranded repeat markers (SSRs) were used to identify genetic distances and differences among wheat germ lines. The study confirmed that disease-associated SSR markers could provide overall genetic diversity data, aiding in efficient breeding and disease resistance strategies.

Research on *Puccinia striiformis f. sp. tritici* focused on its impact on Ethiopian bread wheat yield. Experiments conducted during the 2018 season used two fungicides (Nativo SC 300 and Tlet 250 EC) on four wheat cultivars (Degalu, Hidasi, Danda, and Honkolo) under natural epidemic conditions, employing a completely randomized factorial design. Nativo SC 300 significantly ($p < 0.01$) increased hectoliter weight and wet gluten content, although grain protein content showed no significant change ($p > 0.01$). High yellow rust severity correlated with increased values of disease progress curves and physical quality loss.

Salinity remains a major challenge in Iraq's southern provinces, primarily due to poor soil drainage and irrigated agriculture. Wheat and barley accessions respond to salinity in two stages: growth rate reduction due to surrounding salts and further reduction from toxic salt levels [9]. Wheat yields decrease when soil electrical conductivity exceeds 6 dS/m in the root zone [3]. High salinity impacts germination, tiller numbers, and other growth metrics, as noted in [10], [11].

To mitigate salinity's impact, selecting salt-tolerant accessions through simple and reliable criteria is a proven strategy. Crops are most sensitive to salinity during vegetative and early reproductive stages, while sensitivity decreases during blooming and grain filling [17]. Wheat rusts, caused by *Puccinia* fungi, are significant global threats to wheat productivity [18], with environmental conditions and cultivar resistance levels influencing disease severity [22].

II. MATERIALS AND METHOD

A. Plant Materials

Three wheat accessions (A1, A2, and A3) were obtained from the Department of Seed Technology at the Ministry of Science and Technology, Iraq. Additionally, the Board of Agricultural Research - Ministry of Agriculture provided the two cultivars used in this study, Tamoz 2 and Maxipak.

B. Salinity

The accessions and varieties were irrigated with well water having a salinity of 7.5 dS m^{-1}, while the soil salinity was 28 dS m^{-1}. Table I shows the chemical composition of the original well water.

TABLE I CHEMICAL COMPOSITION OF THE WELL WATER

Parameter	Value
Salinity (dS m^{-1})	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

C. Site and Treatment Application

The experiment was conducted in the Iraqi provinces of Al-Anbar and the Al-Qaim district using a randomized complete block design (RCBD) with four replications. The wheat crop was planted on November 10, 2010, and harvested on April 30, 2011. Before seeding, 120 kg ha^{-1} of 46% P_2O_5 was applied, and 250 kg ha^{-1} of 46% N was supplied in two equal doses - the first two weeks after seeding and the second two weeks later. Irrigation with well water commenced after sowing irrigation. The crop was managed according to conventional agronomic guidelines.

Weekly records of disease incidence and severity were maintained, starting from the flowering stage. For each variety, 100 plant samples were examined for disease severity and incidence. The following formula was used to determine disease incidence. Disease severity was determined using the modified Cobb's disease scale [29] (Roelfs *et al.,* 1992).

Immunity (O) = 0, resistant (R) = 0.1, moderately resistant (MR) = 0.2, intermediate (M) = 0.4, moderately susceptible (MS) = 0.6, and susceptible (S) = 1.

D. Soil Analysis

Soil samples were collected for physical and chemical analysis at a depth of 0 to 30 cm. The results indicated a salinity of 28 dS m^{-1}. The soil parameters after germination, tillering, elongation, flowering, and maturity stages for the tested soil salinity are shown in Table II.

TABLE II PYSICAL AND CHEMICAL PROPERTIES OF THE SOIL USED

Value	Soil Property	Value	Soil Property
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	Clay loam	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

E. Parameters Studied

The growth parameters examined during the growth stage included germination percentage (%), 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.

F. Statistical Analysis

Data were analyzed using analysis of variance (ANOVA) with G-STAT. Means were compared using Duncan's multiple range test at P<0.05.

III. RESULTS OF THE STUDY

Variations in electrical conductivity were observed through soil analysis. Significant relationships were found between plant growth phases and salt concentrations. Before seeding, the salt concentration was 28 dS m^{-1}.

As the plants developed, it decreased to 8, 7.5, 7.6, 15.5, and 16.7 dS m^{-1} for A1, A2, A3, Tamoz2, and Maxipak, respectively, at the maturity stage (Table III).

The highest number of days needed for germination was 14 for accession A2, while the Tamoz2 cultivar required 12 days. Spike formation time analysis indicated that accession A3 required 119 days, while accessions A1 and A2 did not differ significantly. However, the sensitive cultivars Tamoz2 and Maxipak required 105 and 103 days, respectively, while accession A3 required 119 days. While accessions A1, A2, and A3 did not differ significantly in physiological maturity (153.7, 152, and 152 days, respectively), Tamoz2 and Maxipak cultivars differed significantly (142 and 140 days, respectively) (Table IV).

TABLE III SOIL SALINITY WITH PLANT GROWTH STAGES

Maturity	Flowering	Elongation	Tillering	Germination	Before Sowing	Accessions
A1	28.0 a	20.0 a	15.2ab	15.0a	8.4 a	8.0a
A2	28.0 a	19.0a	14.4 a	15.0a	7.6a	7.5a
A3	28.0 a	22.0b	13.9 a	14.0a	8.0a	7.6a
Tamoz2	28.0 a	22.0b	19.9b	17.2b	16.3b	15.5b
Maxipak	28.0 a	23.5b	20.3 b	19.0 b	17.8c	16.7c

TABLE IV GERMENATION PERCENTAGE (%) DAYS NUMBER OF GERMENATION, SPILES FORMATION AND PHYSILOGICAL MATURITY

Accessions	Germination (%)	Germination (Day)	Spikes Formation (Day)	Physiol. Maturity (Day)
A1	89.3a	13.0ab	118.7a	153.7a
A2	90.3a	14.0b	117.7ab	152.0a
A3	90.0a	13.7ab	119.0a	152.0a
Tamoz2	79.7b	12.0a	105.2b	142.0b
Maxipak	83.6b	13.0ab	103.0b	140.0b

Table V displays notable variations in yield and yield components among A1, A2, and A3 accessions, as well as Tamoz2 and Maxipak cultivars. For the sensitive cultivars Tamoz2 and Maxipak, the number of spikes per 6 m^2 dropped significantly to 157 and 117, respectively. In contrast, the surge in other accessions ranged from 469 to 540. Additionally, the number of grains per spike significantly decreased to 33 and 34 for Tamoz2 and Maxipak, compared to 45–55 for other accessions. The 1000-grain weight for A1, A2, and A3 ranged from 33 to 35 g, while Tamoz2 and Maxipak produced grains weighing 22 and 20 g, respectively. A decrease in grains per spike and 1000-grain weight also results in a yield loss per 6 m^2. Table V, which presents grain yield per 6 m^2, indicates that the A2 accession yielded a greater amount of 2739.43 g. No significant differences were observed between accessions A1 and A2; however, substantial disparities were found between the sensitive cultivars Tamoz2 and Maxipak, which yielded 346.61 g and 242.98 g, respectively.

TABLE V EFFECT OF SALINITY ON SOME YIELD COMONENTS AND GRAIN (ton ha -1)

Accessions	Number of Spike Per 6 m^2	Number of Grain Per Spike	1000 Grain Weight (g)	Grain Yield (g per 6 m^2)
A1	521a	48 ab	35.20a	2640.84a
A2	469a	55a	35.40a	2739.43a
A3	540a	45b	33.78a	2462.56a
Tamoz2	157b	33c	22.30a	346.61b
Maxipak	117b	34c	20.36a	242.98b

Table VI shows that the incidence and severity of leaf rust varied from 8% to 18% and from 2% to 23%, respectively. Low disease incidence and severity were observed in the A2 variety, recording 8% and 2%, respectively, while high disease incidence and severity were observed in the Maxipak variety, recording 18% and 23%, respectively. The reduced disease incidence and severity of leaf rust in the A2 variety may be attributed to the presence of a resistant gene in this accession.

TABLE VI LEAF RUST INCIDENCE AND SEVERITY

Accessions	Disease Incidence %	Disease Severity %
A1	12	3
A2	8	2
A3	11	4
Tamoz2	15	18
Maxipak	18	23

IV. DISCUSSION OF THE STUDY

Salinity decreases with plant growth phases, according to a comparison of soil salinities at germination, tillering, elongation, spike production, and maturity (Table III). This is consistent with the findings of [19], which reported reduced growth in the presence of salt, primarily caused by changes to the water regime. As the amount of salt in the soil increases, the osmotic pressure of the soil solution also rises, making it more difficult for plants to absorb water compared to non-saline soils. As a result, when soil electrical conductivity (EC) increases, plants find it more difficult to obtain water. For sensitive cultivars, the spike formation and physiological maturity durations are shortened (Table IV). Plant water regulation is disrupted, and essential element intake and distribution are altered in semi-controlled and outdoor conditions. Salts accumulate more quickly in more sensitive accessions, and because these accessions' cells are less able to isolate salt ions in vacuoles, their leaves frequently wither more quickly [24]. The amount of new leaf tissue where excess salts can accumulate may be reduced due to growth restrictions caused by excessive salt concentrations in the leaves. This, combined with continuous salt accumulation, may lead to an increase in the salt concentration in the tissue [25]. As with the ability to withstand water shortages, tolerance to salt varies considerably among plant species and accessions [24]. Germination is the best time to study how salinity affects a plant's gene expression. Wheat seeds under salinity stress are unable to hydrate properly, which delays radicle development and may cause problems for associated metabolic systems [26]. Reduction in germination under salinity stress was also observed by [27], [28]. Overall, it was clear that the final germination percentage was influenced by salinity concentrations (Table IV). With the exception of two salt-sensitive cultivars (Tamoz2 and Maxipak), which attained final germination percentages of 79% and 83%, respectively, accessions A2 and A3 achieved a 90% final germination percentage even at higher salinity concentrations. Germination is a critical stage in the life cycle of a wheat crop. The loss of plant stand reduces the yield sink's capability by decreasing plant density. Thus, genotyping for salt tolerance at this early stage may be crucial as a time-efficient method for assessing salt tolerance. Salinity also impacts plant development duration (Table IV). Most research suggests that, in contrast to germination, wheat plants are more sensitive to salinity during the seedling and early vegetative growth stages [17]. Salt stress decreased plant photosynthetic activity at several phenological stages due to its direct inhibitory effect on the Calvin cycle enzymes [29], [30]. The wheat characteristic most vulnerable to salinity is tiller plant-1 [6]. Thus, maintaining high plant density is essential to increasing output under stress conditions. The components of wheat yield most susceptible to salt stress were viable tillers and spikelet spike-1. Spikelet formation, reproductive development, and ultimately spikelet number are inhibited by salinity at heading [31]. These two variables could be used to assess wheat accessions in salinized fields due to their responsiveness to salt and strong positive correlation with yield [32]. The A1, A2, and A3 accessions showed comparable salt tolerance, characterized by higher germination percentages and longer growth durations. Salinity had less of an impact on the final grain yield and yield components of these accessions than on other sensitive cultivars (Table V). Variations in salt tolerance exist within the same species' organs, as well as between genera and species [8].

V. CONCLUSION

The experiment was conducted in the Iraqi provinces of Al-Anbar and the Al-Qaim district. A randomized complete block design (RCBD) with four replications was used to conduct the experiment. Overall, the findings of this study indicate significant variance in salt tolerance between wheat accessions during the germination stage. Above all, these characteristics should be considered when screening wheat accessions at high salinity levels. Given that the A1, A2, and A3 accessions were shown to be the most salt-tolerant in this study, breeding programs and appropriate selection can be employed to further enhance the salt tolerance of Iraqi wheat accessions. The degree of salt tolerance of wheat accessions to salinity must be evaluated across different growth stages, as Tamoz2 and Maxipak were more sensitive to salinity at early growth stages. This suggests that their salt tolerance can be improved by developing agronomic management strategies tailored to the different growth stages.

REFERENCES

[1] S. S. Smrutishree, B. Bhagawati, and N. Nitesh, "Salinity tolerance in wheat," *Marumegh*, vol. 3, no. 1, pp. 61–65, 2018. ISSN: 2456-2904.

[2] T. Yamaguchi and E. Blumwald, "Developing salt-tolerant crop plants: challenges and opportunities," *Trends Plant Sci.*, vol. 10, pp. 615–620, 2005.

[3] R. Munns, R. A. J. Richard, and A. Lauchli, "Approaches to increasing the salt tolerance of wheat and other cereals," *J. Exp. Bot.*, vol. 57, no. 5, pp. 1025–1043, 2006.

[4] G. A. Ghulam, M. S. Muhammad, R. Qaisir, R. Atiq ur, A. Javaid, A. Anwar ul H, and Nasim, "Effect of salinity on grain yield and grain quality of wheat (Triticum aestivum L.)," 2013.

[5] A. M. I. Mourad, A. Börner, and S. M. Esmail, "Alleviation of stripe rust disease in wheat seedlings using three different species of *Trichoderma* spp.," *Agriculture*, vol. 13, no. 9, p. 1755, 2023, doi: 10.3390/agriculture13091755.

[6] R. Shumi, L. Ararsa, and N. Gudeta, "Evaluation of bread wheat (Triticum aestivum L.) genotypes for stripe rust (*Puccinia striiformis* f.sp. *tritici*) resistance, yield, and yield attributes at Arsi Highlands, southeastern Ethiopia," *Global Research in Environment and Sustainability*, vol. 1, no. 5, pp. 46–54, July 2023.

[7] H. Sahir, A. Sajid, B. Khan, K. Imdad, B. Sania, N. Saima, M. Ghulam, H. Aqsa, A. Baber, N. Muhammad, A. Alevcan, I. Majid, U. Riaz, Z. Akhtar, U. Rehman, and A. Fathia, "Diversity analysis for wheat genotypes against rust resistant genes," *Pol. J. Environ. Stud.*, vol. 33, no. 3, pp. 2129–2140, 2024.

[8] K. Metiku, S. Elfinesh, and H. Fikre, "Impact of managing yellow rust (*Puccinia striiformis* f.sp. *tritici*) by the use of fungicide sprays and resistant varieties on the physiochemical qualities of bread wheat," *Food and Energy Security*, 2023, published by John Wiley & Sons Ltd.

[9] O. J. Omid, A. E. Alireza, R. A. Reza, E. Asa, and A. P. Alireza, "Physiological and molecular responses of barley genotypes to salinity stress using multiple parameters," *Eur. J. Agron.*, vol. 22, pp. 243–253, 2022.

[10] S. E. El-Hendawy, Y. Hu, G. M. Yakout, A. M. Awad, S. E. Hafiz, and U. Schmidhalter, "Evaluating salt tolerance of wheat genotypes," 2005.

[11] S. E. El-Hendawy, Y. Hub, J. I. Sakagamic, and U. Schmidhalter, "Screening Egyptian wheat genotypes for salt tolerance at early growth stages," *Int. J. Plant Prod.*, vol. 5, no. 3, pp. 283–298, 2011.

[12] M. S. Islam, "Water stress tolerance of *Phaseolus vulgaris* L. as affected by potassium," M.S. thesis, Dept. of Agronomy, Bangabandhu Sheikh Mujibur Rahman Agric. Univ., Salna, Gazipur-1703, 2001.

[13] H. Sadeghi and Y. Emam, "Chemical composition, yield, and yield components of two wheat cultivars in response to salt stress," *J. Plant Physiol. and Breeding*, vol. 1, no. 1, pp. 39–47, 2011.

[14] T. J. Flowers and S. A. Flowers, "Why does salinity pose such a difficult problem for plant breeders?" *Agric. Water Manag.*, vol. 78, pp. 15–24, 2005.

[15] Z. Pervaiz, M. Afzal, S. Xi, Y. Xiaoe, and L. Ancheng, "Physiological parameters of salt tolerance in wheat," *Asian J. Plant. Sci.*, vol. 1, pp. 478–481, 2002.

[16] E. V. Mass and C. M. Grieve, "Tiller development in salt-stressed wheat," *Crop Sci.*, vol. 34, pp. 1594–1603, 1994.

[17] E. V. Mass and J. A. Poss, "Salt sensitivity of cowpea at various growth stages," *Irri. Sci.*, vol. 10, pp. 313–320, 1989.

[18] S. Singh, G. S. Sethi, and H. K. Chaudhary, "Differential responsiveness of winter and spring wheat genotypes to maize-mediated production of haploids," *Cereal Res. Commun.*, vol. 32, no. 2, pp. 201–207, 2004.

[19] G. N. Agrios, "Disease caused by Basidiomycetes: Cereal rusts," in *Plant Pathology*, 5th ed., pp. 565–571, Florida, USA: Elsevier Academic Press, 2005.

[20] B. Getie, "Identification, genetic studies, and molecular characterization of resistance to rust pathogens in wheat," Ph.D. thesis, Plant Breeding Institute, Univ. of Sydney, Cobbitty, Australia, 2015.

[21] J. A. Kolmer, "Tracking wheat rust on a continental scale," *Curr. Opin. Plant Biol.*, vol. 8, pp. 441–449, 2005.

[22] G. S. Brar, "Population structure of *Puccinia striiformis* f.sp. *tritici*, the cause of wheat stripe rust, in western Canada," M.Sc. thesis, Plant Sci., Univ. of Saskatchewan, Saskatoon, Canada, 2015.

[23] M. Feizi, A. Aghakhan, B. Mostafazadeh-Fard, and M. Heidarpour, "Salt tolerance of wheat according to soil and drainage water salinity," *Pak. J. Biol. Sci.*, vol. 10, no. 17, pp. 2824–2830, 2007.

[24] R. Munns, "Comparative physiology of salt and water stress," *Plant Cell Environ.*, vol. 25, pp. 239–250, 2002.

[25] P. Neumann, "Salinity resistance and plant growth revisited," *Plant Cell Environ.*, vol. 20, pp. 1193–1198, 1997.

[26] A. A. Dell and P. Spada, "Regulation of protein synthesis in germinating wheat embryos under polyethylene glycol and salt stress," *Seed Sci. Res.*, vol. 2, pp. 75–80, 1992.

[27] P. Sabir and M. Ashraf, "Screening of local accessions of *Panicum miliaceum* L. for salt tolerance at the seedling stage using biomass production and ion accumulation as selection criteria," *Pak. J. Bot.*, vol. 39, no. 5, pp. 1655–1661, 2007.

[28] M. A. Khan and B. Gul, "Halophytic seed germination," in *Eco-physiology of High Salinity Tolerant Plants*, M. A. Khan and D. J. Weber, Eds., Springer, Netherlands, pp. 11–30, 2006.

[29] A. Roelfs, R. Singh, and E. Saari, *Rust Disease of Wheat: Concepts and Methods of Disease Management*, Mexico D.F.: CIMMYT, 1992, 81 pp.

[30] C. Ottander and G. Oquist, "Recovery of photosynthesis in winter stressed Scots pine," in *Current Research in Photosynthesis*, *Plant Cell Environ.*, vol. 14, pp. 345–349, 1991.

[31] R. Mans and H. M. Rawson, "Effect of salinity on salt accumulation and reproductive development in the apical meristem of wheat and barley," *Aust. J. Plant Physiol.*, vol. 6, pp. 345–350, 1985.