المؤتمر العلمي الدولي الأول للهندسة و العلوم
The First Scientific International Conference in Engineering & Science

http://bwu.edu.ly/icse2022
Received 30/07/2022 Revised 30/12/2022 Published 05/01/2023
icse@bwu.edu.ly ترسل الورقات كاملة علي*

Effect of salinity on seed germination and seedling growth of bread wheat

Amar Omran Alshmam
Crops Department, College of Agriculture / University of Tripoli, Libya
a.alshmam@uot.edu.ly

Abstract: At the Crop Physiology Lab, Faculty of Agriculture, University of Tripoli, Libya. (February 2022), Salinity effects were evaluated on seed germination and seedling growth bread wheat (Triticum aestivum L.) variety Utique. The seeds were grown in Petri dishes to five levels of electrical conductivity (Ec) 0, 2.5, 5, 7.5, and 10 ds/m, with three replicates. The data for the water uptake percentage, germination percentage, shoot length (cm), root length (cm), dry weight of root (g) and dry weight of shoot (g) was measured eight days after germination. The experimental statistical analysis was performed using one-way ANOVA ($P<0.05$). Based on the ANOVA results, a DUNCAN test was performed to compare means.
The results show that the water uptake by seeds has a direct relationship with increases in NaCl levels. Where the highest water uptake level was recorded at low concentrations of NaCl. By increasing NaCl concentration, seed germination is delayed and decreased. Increasing NaCl concentrations adversely affected shoot length and root length and also, adversely affected shoot dry weight and root dry weight. Probably, it was the delay in germination was mainly due to higher Na^+ accumulation in the seeds rather than osmotic stress in bread wheat.

Keywords: Salinity, NaCl, Germination, water uptake, Bread wheat.

Introduction

The Food and Agriculture Organization (FAO, 2009) indicated that the world population is envisaged to increase by 34 % in 2050 reaching about 9.1 billion, thus necessitating 70 % more food production. Meeting the nutritional requirements of the growing population remains a challenging task as climate changes threaten the sustainability and productivity of agricultural production systems (Hussain et al., 2014). Plants experience various abiotic stresses in the field. Modern agriculture also faces several abiotic stresses, such as sub-optimal levels of salinity, drought, chilling and temperature, as major constraints affecting crop yields (Saud et al. 2013). According to Wang et al., (2001), more than a 50 % reduction in the average yield of major crops has been attributed to abiotic stresses.

Plants use many strategies in response to abiotic stress, which ultimately improves plant growth and productivity in stressful environments. These phenomena include changes in morphological and developmental patterns (growth plasticity), also, physiological and biochemical processes against several stresses (Saud et al. 2014). The plant can try to escape or survive under stressful conditions that can reduce its growth so that the plant can concentrate its resources on stress resistance (Skirycz and Inze´ 2010).

In the world, soil salinity has adversely affected about 30 % of the irrigated, this represents about 6 % of the total land area (Chaves et al. 2009), which leads to a resultant monetary loss of 12 billion dollars (USD) in agricultural production (Shabala, 2013). According to FAO (2005), soil salinity is one of the major stressors affecting more than 831 million hectares of agricultural land worldwide.

Salinity is one of the most important abiotic stresses limiting crop production in dry and semi-dry regions, where soil salt content is naturally high and precipitation can be insufficient for leaching (Saboora and Kiarostami., 2006).

Increased incidence of salinity on arable lands suggests the need for a better understanding of the plant tolerance mechanisms in order to sustain crop productivity by modulating growth conditions to the best possible extent. Where under soil salinity, the plants have been inhibition of growth and development, and reduction in photosynthesis, respiration and protein synthesis in sensitive species (Mustafa et al. 2014; Hussain et al. 2013).

Wheat (Triticum aestivum L.) is the staple food for more than 35% of the world's population (Jing and Chang., 2003). Wheat grain yield is depressed, by environmental stresses such as drought, heat, low temperatures, low fertility (especially nitrogen) and soil salinity (Mehmet et al., 2006). As with other crops, seed germination and wheat seedling growth have been negatively affected by drought (Passioura, 1988) and salinity stresses (Hampson and Simpson, 1990). According to Mehmet et al., (2006), any effect that drought might have should be most considerable under salt-stressed conditions because salinity can affect germination and seedling growth either by creating an osmotic pressure (OP) that prevents water uptake or by toxic effects of sodium and chloride ions on the germinating seed. The salt accumulation in soils affects plant growth to different degrees (Bernstein, 1975). However, in the same saline environment, different plant species mayexhibit different growth responses (Mehmet et al., 2006).

Many studies are reported that several plants are sensitive to high salinity during germination and the seedling stage (Ghoulam and Fares., 2001). The source of the sensitivity to salinityis not fully understood. Where some researchers have indicated that the main reason for germination failure was the inhibition of seed water uptake due to a high salt concentration (Mehmet et al., 2006), whereas others have suggested that germination was affected by salt toxicity (Mehmet et al., 2006; Khajeh-Hosseini et al., 2003).

Wheat is cultivated over a wide range of environments, because of wide adaptation to diverse environmental conditions. It is a moderately salt-tolerant crop (Moud and Maghsoudi 2008; Saboora and Kiarostami., 2006).

The main goal of this study was to determine the effects of salinity on water uptake, seed germination, and seedling growth by seeds of bread wheat during germination at various concentrations of NaCl.

1. Materials and Methods

1.1. Seed Source

Seeds of bread wheat (*Triticum aestivum* L.) variety Utique was used for this study. The seeds were obtained from the Ministry of Agriculture. Before cultivation, seeds were sterilized in 1% sodium hypochlorite solution for 3 min, and then were rinsed with sterilized water and air-dried.

1.2. Preparation of NaCl solutions

The solutions were prepared based on methods by (Rhoades, et. al., 1992) with electrical conductivity (Ec) of 0 (as control), 2.5, 5, 7.5 and 10 ds/m.

1.3. Water uptake

Water uptake was recorded at 12 hours after planting. The water uptake percentage was calculated by the formula given below (Rahman et. al., 2008).

Water uptake % = $(W2 - W1/W1)100$

Where:

$W1$ = Initial weight of seed

$W2$ = Weight of seed after absorbing water in a particular time.

1.4. Germination test

The experiment was carried out in three replicates where 10 seeds were separately germinated on two sheets of Whatman No.1 filter paper placed in 9-cm diameter Petri dishes. Priority, 10 ml of the respective test solution was poured into every dish. The papers were altered once every 2 days to prevent salt accumulation (Rehman et al., 1996). The plates were incubated at 25 ± 2°C in darkness for 8 days (Rhoades, et. al., 1992). Germination percentages were recorded every 24 h for 4 days. Mean germination was calculated to assess the germination rate (Ellis and Roberts, 1980).
The data for the shoot length (cm), root length (cm), dry weight of root (g) and dry weight of shoot (g) was measured eight days after germination. Dry weights were measured after drying at 70°C for 48 h in an oven.

1.5.Data analysis

Statistical analysis was performed using one-way ANOVA (for $P<0.05$). Based on the ANOVA results, a DUNCAN test to compare the averages, and test for significant differences among treatments by the GenStat program (Release; 19.3.0.9425; VSN International, Nottingham, UK). In the figures, different letters (a,b,c,…) between the columns express significant differences.

2. Results

2.1. Water uptake

A direct relationship was observed between water uptake by seeds and an increase in NaCl concentration ($P = 0.002$)(Figure 1). When NaCl concentration increases the water uptake ability decrease in comparison to the control. Maximum water uptake was recorded in (0, 2.5) NaCl concentration, where no significant effect between these concentrations.

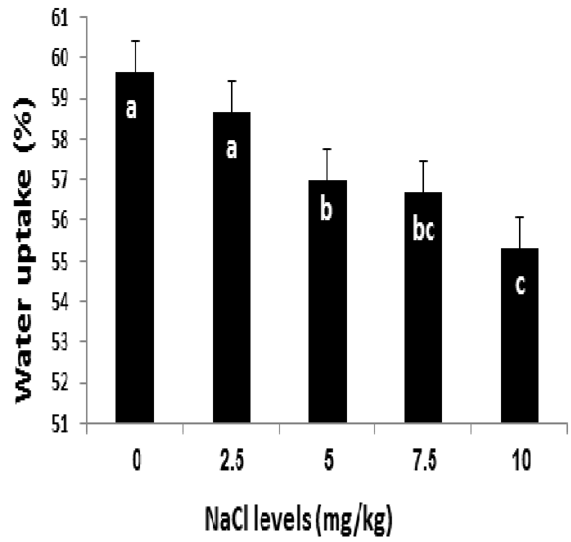

Figure 1: The effect of the different levels of NaCl concentration on water uptake by wheat seeds

2.2. Seeds germination (%)

The effect of increasing NaCl levels on germination percentage after 96 hours (final germination) is shown in (Figure 2). Results showed by increasing NaCl concentration, germination is delayed and decreased germination ($P<.001$). The maximum germination percentage was observed in the control compared with other levels of NaCl concentrations.

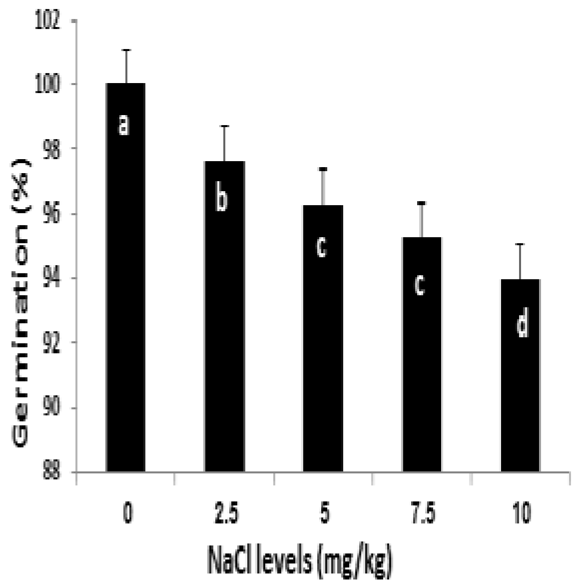

Figure 2: The effect of the different levels of NaCl concentration on seeds of wheat germination (%)

2.3. Shoot length (cm)

The mean of shoot length varied between 11.87 and 15.74 cm at various NaCl concentrations. The longest shoot length was observed in the control. Also, by increasing NaCl concentrations, the shoot length decreased. Results showed that the shoot growth was more affected by NaCl levels (P<.001)(Figure 3).

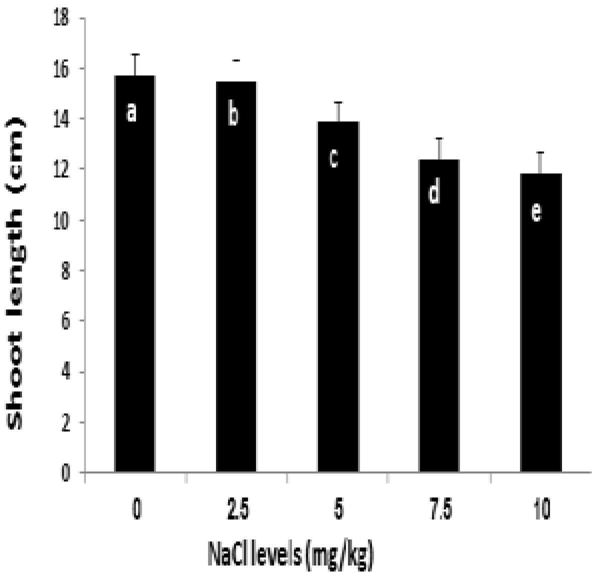

Figure 3: The effect of the different levels of NaCl concentration on shoot length (cm) of wheat

2.4. Root length (cm)

The mean root length varied between 9.39 and 12.31 cm in different NaCl concentrations. As was expected, the control (0 ds/m) and the highest (10 ds/m) NaCl concentration had the longest and shortest root length (12.31 cm & 9.39 cm) respectively. Generally, root length decreased as NaCl concentration increased significantly (P<.001)(Figure 4).

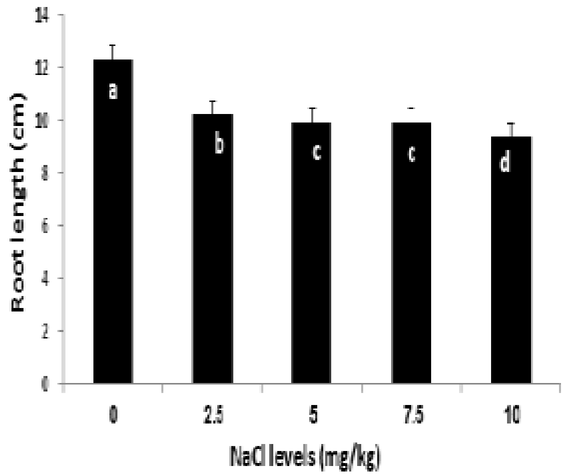

Figure 4: The effect of the different levels of NaCl concentration on root length (cm) of wheat

2.5. Shoot dry weight (mg/plant)

Increasing NaCl concentrations adversely affected significantly (P<.001)(Figure 5), shoot dry weight (mg/plant). Where the weight decreased with the increase in NaCl concentration. The control and the highest NaCl concentration had the longest and shortest shoot dry weight (0.128 mg/plant & 0.101 mg/plant) respectively.

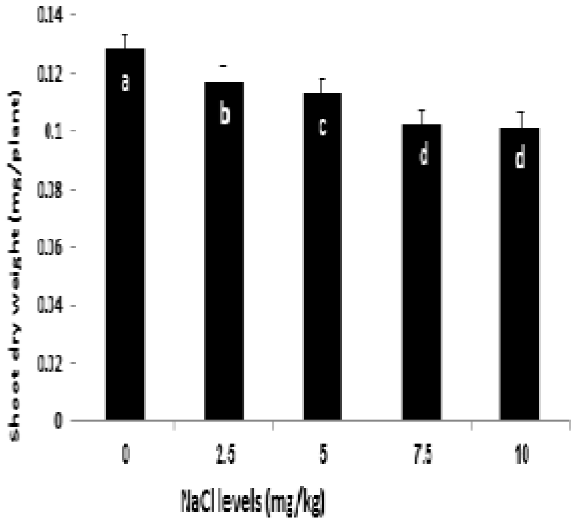

Figure 5: The effect of the different levels of NaCl concentration on shoot dry weight (mg/plant) of wheat

2.6. Root dry weight (mg/plant)

Higher NaCl concentrations resulted in a significant reduction in root dry weight (P<.001)(Figure 6). The results showed that the control and the highest NaCl concentration had the longest and shortest root dry weight (0.121 & 0.092 mg/plant) respectively.

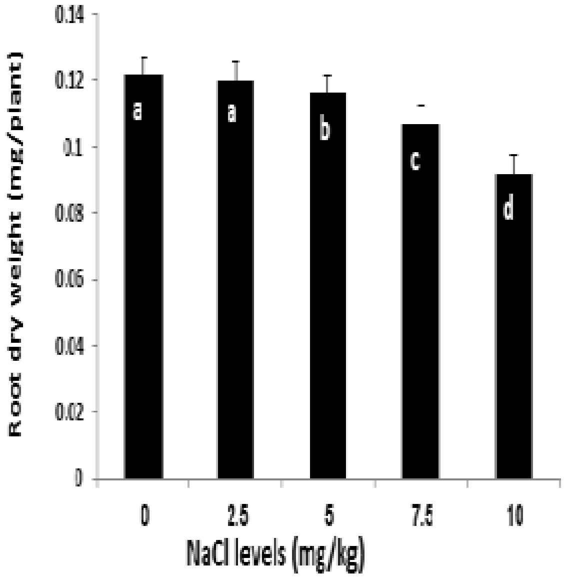

Figure 6: The effect of the different levels of NaCl concentration on root dry weight (mg/plant) of wheat

3. Discussion

This research was carried out to observe the effects of salinity on the germination and seedling growth of bread wheat. The maximum germination percentages were 100 % with control (0 sd/m). The results showed that by increasing NaCl concentrations, germination the delayed and decreased. Increasing salinity concentrations often cause osmotic and/or specific toxicity which may reduce germination percentage (Saboora and Kiarostami., 2006). A slight decrease in water uptake was observed by increasing NaCl levels. The osmotic barrier due to NaCl level affected water uptake and mean germination time but not final germination, this result was similar to the result of (Mehmet et al., 2006). Also, NaCl affected seed germination by creating an external osmotic potential preventing water uptake. However, a number of studies have demonstrated that water uptake in plants is significantly reduced under salt or water stress conditions (Mehmet et al., 2006; Moud and Maghsoudi, 2008; Saboora and Kiarostami., 2006).

Root and shoot length decreased by increasing NaCl concentration. This result is similar to those reported by (Saboora and Kiarostami., 2006). As NaCl concentration increased, it antagonistically affected shoot and root dry weight. The reduction of dry weights relatively depended on the shoot or root lengths. Also, the wheat shoots were more severely affected by increasing NaCl concentrations than the roots. In conclusion, it seems that the delay in seed germination was related more to Na+ accumulation in seeds rather than lower water uptake in wheat. Therefore, it is necessary to know the NaCl concentration in the shoots and roots in order to estimate the reasons for the delay in germination.

4. References

Bernstein, L., (1975). Effects of salinity and sodicity on plant growth. Annual Review of Phytopathology, 13(1), pp. 295–312.

Chaves, MM, Flexas J, Pinheiro C, (2009). Photosynthesis under drought and salt stress: regulation mechanisms from whole plant to cell. Ann Bot 103:551–560.

Ellis, R.H., Roberts, E.H., (1980). Towards a rational basis for testing seed quality. In: Hebblethwaite, P.D. (Ed.), Seed Production. Butterworths, London, pp. 605–635.

FAO (Food and Agricultural Organization), (2009). Land and plant nutrition management service. www.fao.org/wsfs/forum2050/.

FAO (Food and Agriculture Organization of the United Nations), (2005). Global network on integrated soil management for sustainable use of salt-affected soils. Rome, Italy: FAO Land and

Plant Nutrition Management Service. http://www.fao.org/ag/AGL/agll/spush.

Ghoulam, C. and K. Fares., (2001). Effect of salinity on seed germination and early seedling growth of sugar beet (Beta vulgaris L.). Seed Sci. & Technol, 29: 357-364.

Hampson, C. and Simpson, G., (1990). Effects of temperature, salt, and osmotic potential on early growth of wheat (Triticum aestivum). I. Germination. Canadian Journal of Botany, 68(3), pp.524-528.

Hussain, S, Khaliq A, Matloob A, Wahid MA, Afzal I. (2013). Germination and growth response of three wheat cultivars to NaCl salinity. Soil Environ 32:36–43.

Hussain, S, Peng S, Fahad S, Khaliq A, Huang J, Cui K, Nie L, (2014). Rice management interventions to mitigate greenhouse gas emissions: a review. Environ Sci Pollut Res.

Jing, R.L. and X.P. Chang., (2003). Genetic diversity in wheat (Triticum aestivum L.) germplasm resources with drought resistance, Acta Botanica Boreal-Occident Sinica 23: 410-416.

Khajeh-Hosseini, M., Powell, A.A. and Bingham, I.J., (2003). The interaction between salinity stress and seed vigour during germination of soyabean seeds.*Seed Science and Technology*, 31(3), pp. 715–725.

Mehmet, A., M.D. Kaya and G. Kaya. (2006). Effects of NaCl on the germination, seedling growth and water uptake of triticale. Turkish Journal of Agriculture and Forestry 30: 39-47.

Moud, AM, Maghsoudi K., (2008). Salt stress effects on respiration and growth of germinated seeds of different Journal of Plant Interactions 95 wheat (Triticum aestivum L.) cultivars. World J Agric Sci. 4:351-358.

Mustafa, Z, Pervez MA, Ayyub CM, Matloob A, Khaliq A, Hussain S, Ihsan MZ, Butt M, (2014). Morpho-physiological characterization of chilli genotypes under NaCl salinity. Soil Environ 33:133–141.

Passioura, J., (1988). Root Signals Control Leaf Expansion in Wheat Seedlings Growing in Drying Soil. Functional Plant Biology, 15(5), p.687.

Rahman, M., U.A. Soomro, M.Z. Haq and S. Gul. (2008). Effects of NaCl salinity on wheat (Triticum aestivum L.) cultivars. World Journal of Agricultural Sciences 4: 398-403.

Rehman, S., Harris, P.J.C., Bourne, W.F., Wilkin, J., (1996). The effect of sodium chloride on germination and the potassium and calcium content of Acacia seeds. Seed Sci. Technol. 25, 45–57.

Rhoades, J.D., Kandiah, A. and Mashali, A.M., (1992). The Use of saline waters for Crop production. FAO Irr. And Drain. Paper no: 48, p: 1 133, Rome, available at: https://www.ars.usda.gov/arsuserfiles/20361500/pdf_pubs/P1313.pdf (Accessed: February 7, 2022).

Saboora, A., and Kiarostami, S., (2006). Salinity (NaCl) Tolerance of Wheat Genotypes at Germination and Early Seedling Growth. Pakistan Journal of Biological Sciences, 9(11), pp.2009-2021.

Saud, S, Chen Y, Baowen L, Fahad S, Arooj S, (2013). The different impact on the growth of cool season turf grass under the various conditions on salinity and drought stress. Int J Agric Sci Res 3(4):77–84.

Saud, S, Li, X, Chen Y, Zhang L, Fahad S, Hussain S, Sadiq A, Chen Y, (2014). Silicon application increases drought tolerance of Kentucky bluegrass by improving plant water relations and morphophysi- ological functions. Sci World J.

Shabala, S, (2013). Learning from halophytes: physiological basis and strategies to improve abiotic stress tolerance in crops. Ann Bot 112:1209–1221.

Skirycz, A, Inze´ D, (2010). More from less: plant growth under limited water. Curr Opin Biotechnol 21:197–203.

Wang, Y, Mopper S, Hasentein KH, (2001). Effects of salinity on endogenous ABA, IAA, JA, and SA in Iris hexagona. J Chem Ecol 27:327–342.