Germinative performance of wheat cultivars under salt stress

Desempenho germinativo de cultivares de trigo sob estresse salino

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ABSTRACT

It is estimated that over 20% of all cultivated land in the world has high salt levels and one of the least costly ways to mitigate this problem is to identify species that are tolerant to such conditions. In this context, this work aimed to evaluate the germination performance of two wheat cultivars (*Triticum aestivum* L.) at different levels of simulated saline stress. The cultivars used were BRS Reponte and TbioSinuelo, sown on a paper substrate moistened with solutions of different NaCl saline concentrations (0.0; -0.2; -0.4; -0.6 and -0.8 MPa). The experimental factorial design consisted of 5 osmotic potentials x 2 cultivars with 4 replications for each cultivar. There is no significant difference between the germination performance of BRS Reponte and TbioSinuelo wheat seeds in response to salinity. Both cultivars had germination performances negatively affected by any potential higher than -0.2 MPa.

Key Words: germination, osmotic potential, seeds

RESUMO

Estima-se que mais de 20% de todas as terras cultivadas no mundo apresentam elevados níveis de sais e um dos meios menos onerosos para mitigar essa problemática é buscar identificar espécies tolerantes a essas condições. Nesse contexto, este trabalho objetivou avaliar o desempenho germinativo de duas cultivares de trigo (*Triticum aestivum* L.) em diferentes níveis de estresse salino simulado. As cultivares utilizadas foram BRS Reponte e a TbioSinuelo, semeadas em substrato de papel umedecido com soluções de diferentes concentrações salinas de NaCl (0,0; -0,2; -0,4; -0,6 e -0,8 MPa). O desenho experimental fatorial consistiu de 5 potenciais osmóticos x 2 cultivares com 4 repetições para cada cultivar. Não há diferença significativa entre o desempenho germinativo de sementes de trigo das cultivares BRS Reponte e TbioSinuelo em resposta a salinidade, tendo ambas as cultivares, desempenho germinativo afetado negativamente pelo potencial superior a -0,2 MPa.

Palavras-Chave: germinação, potencial osmótico, sementes

1 INTRODUCTION

Salinity is a growing negative environmental condition in the world which limits soil fertility, crop development and consequently productivity (ZAHEDI et al., 2011). Such problem may derive from natural phenomena, as well as anthropic actions such as extensive use of fertilizers, irrigated areas, elevated water table and high level of evapotranspiration (SARMUGAM; WORSLEY, 2014).

Considering salinization as a harmful factor, it is estimated that over 20% of all cultivated land in the world has high salt levels (SHRIVASTAVA et al. 2015) and according to Begum et al. (2013), salinity stress affects around 930 million hectares in the world. Said environmental issue background has been observed throughout Brazilian territory, however it is more intense in the
northeastern semiarid regions (GHEYI, 2000), where it is estimated that about 25% of irrigated areas are affected by salinity.

Harmful effects of substrate salinity directly affect crop growth and development, causing alteration even at a cellular level. Plant response to the increase of soil salinity may be manifested in the interruption or reduction of species growth and development (LÄUCHLI; GRATTAN, 2007). The deleterious effects in growth can be related to changes in ionic balance, water status, membrane disorganization of seeds, among others (TAVAKKOLI et al., 2010).

Salinity may affect negatively in the germination and growth of cultivated plants non-tolerant to such stress condition, which may result in a low germination percentage, lower dry mass accumulation, longer period to achieve root germination and atrophy of the root portion, according to Jovović et al. (2018), Shahi et al. (2015), Vibhuti et al. (2015) and Datta et al. (2009). In this context, to know the response variation of seeds and seedlings to salinity represents outstanding value from an environmental and economic point of view. Understanding the salinity effects in the initial stages of development, such as the germination performance of different crops in stressful environments may serve as foundation to improve production efficiency.

In studies of the initial establishment of the species, the knowledge of how salinity stress influences the germination process holds great importance also in the ecophysiology scope, aimed at assessing tolerance limits and the species acclimatization capacity, since abiotic factors interfere in seed germination (LARCHER, 2006).

Based on the considerations above, this research aimed to evaluate the germination performance of two wheat cultivars (Triticum aestivum L.) in different simulated salt stress levels.

2 MATERIALS AND METHODS

The experiment was performed in the Educational Laboratory of Seed Analysis of the Seeds Science and Technology Post-Graduation Program at the Federal University of Pelotas (UFPeI), RS, Brazil.

The experimental design used was completely randomized in a factorial scheme 2 x 5 (cultivars x salinity osmotic potentials) with four replications of 50 seed, each. BRS Reponte and TbioSinuelo cultivars were used. The seeds were sown in paper substrate moistened with different concentrations of NaCl salt solution (0.0; -0.2; -0.4; -0.6 and -0.8 MPa). The NaCl solution was prepared following Van’t Hoff equation (SALISBURY; ROSS, 1992).

For the germination tests, the seeds were placed in a substrate of germitest paper® type moistened with double the dry paper mass in different NaCl concentrations, and the paper rolls were
conditioned in a Biochemical Oxygen Demand (B.O.D) germination chamber, at a temperature of 25ºC and a photoperiod of 12 hours.

The following analysis processes were executed:

a) Seed moisture content – Prior to the germination, test water content was determined through four replications with 6g of seed dried in a forced-ventilation oven at 105±3°C for 24h, according to the recommendations from the Seed Analysis Rules (BRASIL, 2009).

b) First germination count (FGC) and germination (G%) - The FGC was accomplished on the fourth day after sowing and carried out simultaneously with the germination test. The G% was expressed by the total number of germinated seeds at the end of the experiment, as recommended by the Seed Analysis Rules (BRASIL, 2009).

c) Mean germination time (MGT) - The MGT was calculated through the equation \( t = \frac{\sum n_i t_i}{\sum n_i} \), in which “\( n_i \)” represents the number of seeds germinated in a certain time interval “\( t_i \)” (BORGHETTI; FERREIRA, 2004).

d) Germination speed index (GSI) – The GSI was determined by the Maguire (1962) equation, being the \( GSI = \frac{G_1/N_1 + G_2/N_2 + G_n/N_n}{N_1 + N_2 + N_n} \), in which \( GSI = \) germination speed index. \( G_1, G, G_n \) represent the number of seeds germinated at the first, second and last count and \( N_1, N_2, N_n \) correspond to the number of the days after sowing, equivalent to first, second and last count.

e) Length of shoot, root and total – was determined at the end of the experiment, when 20 seedlings of each repetition were randomly selected. Shoot and root length were measured by using a centimeter ruler, and total length was obtained from the summation of the shoot and root part.

Data were submitted to variance analysis. The results were submitted to normality analysis through the Shapiro-Wilk test and data homogeneity was evaluated through the Levene’s test at 5% of significance, using InfoStat software (DI RIENZO et al., 2014). The interaction between seed cultivars and osmotic potential levels were compared using the Tukey’s test at a 5% confidence level, as well as through regression analysis.

3 RESULTS AND DISCUSSION

Water content in wheat seed, cultivar BRS Reponte and TbioSinuelo were 11.6% and 11% respectively, which falls within the ideal range for orthodox seeds. According to the analysis of variance (Table 1), there was no significant interaction between cultivars and levels of osmotic potential at germination (G%), germination speed index (GSI) and the root length (RL). However, all of the varieties were significantly affected after saline treatments. The first count, mean
germination time (MGT), shoot length (SL) and total length (TC) showed significant interaction between the studied factors.

Table 1. Summary of variance analysis for germination performance characteristics of wheat, BRS Reponte and TbioSinuelocultivars at different levels of saline stress induced by NaCl solution, Pelotas, RS, Brazil, 2019

| Variation | Source | DF | FGC  | G%  | GSI  | MGT  | SL  | RL  | TC  |
|-----------|--------|----|------|-----|------|------|-----|-----|-----|
| Cultivar  | 1      | 57.6 ns | 16.9 ns | 0.0039 ns | 2.03** | 2.25 ns | 3.2 ns | 2.25 ns |
| PotentialLevels | 4 | 9883** | 8893.1** | 156.44** | 4.86** | 250.6** | 164.3** | 250.6** |
| Cultivar*PotentialLevels | 4 | 317.6** | 124.15 ns | 6.03 ns | 0.88** | 5.44** | 1.54 ns | 5.44** |
| Residual  | 30     | 31.47 | 109.3 | 1.19 | 0.02 | 0.4 | 0.84 | 0.4 |
| CV%       |       | 9.88 | 13.5 | 5.7 | 6.09 | 10.7 | 18.28 | 10.7 |

Note: ** Significant at a 1% probability level according to the F test, ns: not significant. CV%: coefficient of variation. G%: germination, GSI: germination speed index, MGT: mean germination time, SL: shoot length, RL: root length, TC: total length of seedlings.

Study results demonstrate a negative effect on germination performance (Table 2). In general, the first count of germination in BRS Reponte and TbioSinuelo cultivars were negatively affected at an intermediate osmotic potential (-0.4 MPa) with a reduction of 33 and 21 p.p (percentage points), respectively, regarding treatment without the influence of salinity (0.0 MPa). Osmotic stress in the initial stage of germination and development of plants causes physiological changes, such as membrane disruption and nutritional unbalance (RAHNAMA et al., 2010).

Table 2. The first count, mean germination time (MGT), shoot length (SL) and total length of wheat seedlings (TC), BRS Reponte e TbioSinuelo cultivars at different levels of saline stress induced by NaCl solution, Pelotas, RS, Brazil, 2019

| Cultivar    | PotentialLevels (MPa) | Firstcount (%) | Meangermination time (days) | Seedlingshootlength (cm) | Total length of seedlings (cm) |
|-------------|------------------------|----------------|-----------------------------|--------------------------|--------------------------------|
|             | 0.0                    | -0.2           | -0.4                        | -0.6                     | -0.8                           |
| BRS Reponte | 84 aA                  | 87 aA          | 56 bB                       | 35 aC                    | 17 aD                          |
| TbioSinuelo | 94 aA                  | 92 aA          | 74 aB                       | 24 aC                    | 7 aD                           |
| BRS Reponte | 2.0 aA                 | 2.0 aA         | 2.1 aA                      | 2.4 aB                   | 3.0 bC                         |
| TbioSinuelo | 2.0 aA                 | 2.0 aA         | 2.2 aA                      | 2.8 aB                   | 4.7 aC                         |
| BRS Reponte | 12.3 bA                | 10.5 aB        | 5.0 aC                      | 2.4 aD                   | 0.3 aE                         |
| TbioSinuelo | 14.5 aA                | 9.3 aB         | 3.3 bC                      | 0.8 bD                   | 0.2 aD                         |
| BRS Reponte | 12.3 bA                | 10.5 aB        | 5.0 aC                      | 2.5 aD                   | 0.3 aE                         |
| TbioSinuelo | 14.5 aA                | 9.3 aB         | 3.3 bC                      | 0.8 bD                   | 0.3 aE                         |

Note: Mean values appear followed by the same letter, uppercase in the row for concentration and lowercase in the column for cultivar, which do not differ according to the Tukey test (≤5%).
It was observed that the first count of the TbiosaSinuelo cultivar, although affected by salinity levels, expressed the greater performance when submitted to the concentration of -0.4 MPa and a germination of 35 p.p. - greater than BRS Reponte. The germination first count of both cultivars presented low response under potentials of -0.6 and -0.8 MPa.

The mean germination time presented a similar performance between the cultivars, differing only in the most drastic level of salt stress. The MGT showed a short period up to -0.6 MPa in both cultivars (Table 2, Figure 1B). However, when analyzing this variable combined with the first and the last germination count in the same osmotic potential, it is possible to verify there is a significant reduction regarding the initial process of plant growth, which ratifies that, under such circumstances, MGT may not serve as a good indication of the establishment and development of cultivars under stress conditions.

Figure 1. Graphic representation of the first count (A), mean germination time (B), shoot length (C) and the total length of wheat seedlings (D), BRS Reponte e TbiosaSinuelo cultivars at different levels of saline stress induced by NaCl solution.

The shoot length and the total length of TbiosaSinuelo cultivar in 0.0 MPa potential presented the best growth performance, but also showed sensitivity to salinity, as well as the BRS Reponte cultivar, having declined sharply from -0.2 MPa (Figure 1C and 1D, respectively). Singh et al. (2000), Khatun et al. (2013) and Moud and Maghsoudi (2008) also found differential sensitivity in
wheat cultivars based on seedling growth, and in their studies exposed that such feature is one of most important to be considered for salinity tolerance testing during the early stage of growth.

High salt concentration causes various modifications in plant metabolism, inhibiting its growth and interfering in production and the quality of grain (CUARTERO; FERNÁNDEZ-MUÑOZ, 1999).

Datta et al. (2009) worked with five wheat varieties in laboratory conditions and observed that different salinity levels (with potassium chloride) significantly affected growth attributes, reducing the root length and shoot length at levels below -0.3 MPa.

The effects of salinity levels on germination, germination speed index, and root length resulted in a negative linear behavior of the variables as the NaCl concentration increased in both cultivars of wheat (Figure 2), where in the more negative osmotic potential (-0.8 MPa) the G%, GSI and RL decreased in 70, 48 and 90% when compared to control treatment, respectively.

Figure 2. Germination (A), germination speed index (B) and root length (C) of wheat (BRS Reponte and TbioSinuelo cultivars at different levels of saline stress induced by NaCl solution.

Jovović et al. (2018), when studying the selection of winter wheat varieties tolerant to salinity, also observed high sensitivity of root and shoot growth of genotypes as from -0.3 MPa. Those damaging effects caused by salinity on seeds germination process are already expected, since the presence of salt may interfere with the substrate water potential, delay the soaking process and
cause several biochemical and physiological changes in the germination of seeds (JOVOVIĆ et al., 2018)

Salinization may delay or prevent the seed germination through several factors, such as reducing water availability, changes in the mobilization of stored reservations as well as affecting structural organization of proteins. Delay and decrease of wheat germination in a salt environment also were found by Rahman et al. (2000).

In this context, however, there are some species which have greater tolerance to stress conditions due to genetic and physical attributes of seeds, which favor the establishment of the crop even in an unfavorable environment. SalomómandSamudio (2015), for example, observed good germinative performance of Panicum maximum Jacq, Tanzania cultivar under salt stress.

In general, it was verified that the behavior of the BRS Reponte and TbioSinuelo wheat cultivars presented similar germination performances to other wheat varieties, as mentioned, presenting high sensibility during germination in salt stress conditions.

Even though germination may be negatively affected by salinity, under field conditions it is possible that plants perform differently from each other, since there are several adverts factors acting together which can reduce or upgrade the stress caused by salt.

4 CONCLUSION

Based on the results of this study, it can be inferred that there is no difference in the germination performance of BRS Reponte and TbioSinuelo wheat seeds in response to salinity.

Both cultivars present low germination performance negatively affected as from -0.2 MPa.

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