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Research Article

Physiological Quality of Wheat Seeds in Saline Stress Conditions

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Abstract

Wheat is one of the most consumed and produced cereals in the world, accounting for about 35% of world grain production. Due to genetic improvement, it is a cereal that has great capacity of adaptation to diverse edaphoclimatic conditions and resistance to abiotic factors. Among these, one of the factors of greatest concern in agriculture is soil salinity, which causes the reduction of plant development, and consequently impairs its production. In this context, the objective of this work was to study the influence of salinity on germination and initial growth of wheat seedlings. Throughout the simulation of saline stress, wheat seeds from cultivar IPR Catuara TM were used, and tested the following concentrations of NaCl: 0; 15; 30; 45; 100 e 200 mmol L^{-1}. The following determinations were analyzed: germination, length and dry mass of seedlings. For the statistical analysis, the statistical design was applied in a completely randomized design, with four replicates of 50 seeds, submitting the data to regression analysis. From the obtained results it can be concluded that: Up to the dose 100 mmol L^{-1} of NaCl, the germinative power of the seeds is above 80%; The seedling length is affected from 30 mmol L^{-1} and the seedling dry mass from 100 mmol L^{-1}, the dose 200 mmol L^{-1} of NaCl was considered extremely harmful for the initial growth of the culture.

Keywords: *Triticum aestivum*; Wheat; Saline Soils; NaCl; Germination; Seedling Length; Seedling Dry Matter

Introduction

Wheat is one of the most produced cereals in the world, having great capacity of edaphoclimatic adaptation due to genetic improvement. Consequently, it is grown in various regions of the world, from those with desert climate, as is the case in some Middle Eastern countries, to regions with high rainfall, such as China and India [1].

Considering cereals used in animal feed, feed composition, and human consumption, wheat crop accounts for about 35% of world grain production [2]. Food consumption is part of the Brazilian economy and society on a daily basis, which is why the wheat production chain has a fundamental role, constituting in its final product bread, pasta, cookies and flour [3].

Agriculture faces problems worldwide due to population growth and food demand pressure, which significantly contribute to the expansion of areas with degraded or unsuitable soils such as saline soils [4].

Saline soils are the result of a series of factors combining human action with natural ones, such as: climatic (low rainfall and high evapotranspiration rate), edaphic (low salt leaching capacity and presence of impermeable layers) and soil management (irrigation with saline water, excess irrigation water, excessive use of agrochemicals) [5].

Salinization is a very complex process, therefore, for a recovery of saline soils, a study of viable techniques and possibilities should be done first, for each case. Such techniques are listed as irrigation, leaching, correction, plastering, fallow, use of salt-resistant plants, all associated appropriate drainage practices [6,7].

As a result of salinization, the plant encounters difficulties with water absorption, specific ion toxicity and interference with physiological processes, reducing its growth and development. The seeds also suffer negative effects of soil salinity condition. Excess salts may inhibit germination resulting from decreased osmotic potential, causing damage to other stages of the development process [4]. In addition to the osmotic potential that affects the plant's physiology, but also the adverse effects of sodium (Na+) and chloride (Cl-) ions on cellular homeostasis, which directly impact water absorption [8,9].

The salinity present in the soil, stimulates a sequence of reactions in the metabolism of the plant, such as differentiated genetic expression and change in the synthesis profile of phytohormones and organic compounds [10].

In the literature, studies on saline stress in wheat crop are relevant, as studies by Silva., *et al.* (2008) [11] and Oyiga., *et al.* (2016) [12], but do not address specific tolerance doses, or even lethal doses for culture. Additionally, they do not study how salinity affects germination and initial seedling growth.

Given the relevance of the theme, the present work aimed to evaluate the influence of salinity on germination and initial growth of wheat seedlings by testing different doses of NaCl.

Material and Methods

The research was conducted at the Seed Analysis Laboratory of the Department of Plant Protection and Plant Health, Federal University of Parana, Curitiba, from March to June 2017. Wheat seeds of the cultivar IPR Catuara TM were used.

Saline stress simulation was performed with sodium chloride (NaCl) weighing, performed on an analytical balance, to obtain the concentrations of: zero (distilled water without salt, making up the control); 15; 30; 45; 100 and 200 mmol L-1 NaCl. After that, the paper towel substrate was moistened with the salt solution.

For the germination test, four replicates of 50 seeds were placed to germinate on a paper towel moistened with saline in an amount equivalent to 2.5 times the dry substrate mass (Figure 1). The substrates were placed in a Mangelsdorf germinator at 20ºC.

Figure 1: Wheat seeds placed to germinize in towel paper roll.

On the seventh day after the test installation, the percentage of normal seedlings was computed, following the criteria established in the Rules for Seed Analysis [13].

The determination of the total seedling length, as well as the dry mass, was performed together with the germination test, of which using 10 normal seedlings per repetition for each treatment.

Total seedling length measurements were obtained with the aid of a millimeter ruler. For the determination of the dry mass, the remaining seeds were extracted and then the seedlings were placed in a paper bag, carried in an air circulation oven at 65 ºC until constant mass was obtained. Subsequently, they were removed from the paper bags and weighed on an analytical balance with four decimal places.

Data were subjected to analysis of variance by the F test ($p < 0.01$) and regression, and the models were chosen based on the coefficient of determination and its significance; ASSISTAT® microcomputer analysis system [14] was used.

Results and Discussion

Germination

The relationship of wheat seed germination as a function of the NaCl concentrations tested is shown in figure 2. The linear regression with the determination coefficient (R2) of approximately 0.83 makes it possible to verify the germination drop according to the different doses of salt used in the substrate.

Control germination (0 mmol L^{-1} NaCl) was 92%. As NaCl concentrations increased, no significant differences were detected at the 15, 30, 45 and 100 mmol L^{-1} NaCl doses, except for the 200 mmol L^{-1} NaCl dose, where there was a significant decrease, obtaining a germination of only 65%, which resulted in a 29% reduction compared to the control. Thus, for IPR Catuara TM cultivar, seed germination was negatively influenced by the concentration of 200 mmol L^{-1} NaCl.

Figure 2: Germination of cultivar IPR Catuara TM wheat seeds as a result of substrate salinity.

The fact that the control presented a germination rate above 90% can be explained by Lima., *et al.* (2006) [15] who reports the germination test is conducted under very favorable conditions of temperature and humidity, allowing to obtain the maximum expression of germination potential.

Oyiga., *et al.* (2016) [12] used 150 wheat genotypes to evaluate seed germination capacity under salt stress. Compared to the control (0 mmol L^{-1} NaCl), all treatments with different salt concentrations significantly reduced seed germination. Reductions reached 7, 19 and 33% at doses of 100, 150 and 200 mmol L^{-1} NaCl, respectively. Among the genotypes analyzed in the study, Atlay2000, 14IWWYTIR-19 and UZ-11CWA-8 were tolerant to salt stress, while the Bobur genotype was sensitive. After observing the results of Oyiga., *et al*. (2016) [9], it can be said that the IPR Catuara TM wheat cultivar is more tolerant to salt stress than the Bobur cultivar.

Olivo (2013) [10], working with 14 wheat genotypes under saline stress, analyzed seed germination in relation to concentrations of 44.83, 89.66 and 134.49 mmol L^{-1} of substrate NaCl. Wheat seeds presented germination of 75% control dose, against 10% in the

Seedling length

Figure 3 shows the wheat seedling length data in relation to the NaCl doses tested.

Regarding the vigor evaluated by the seedling length test, it is possible to observe, considering the trend line, a linear decrease in seedling length according to the increase in NaCl concentration in the substrate. The control (0 mmol L-1) and the 15 mmol L^{-1} dose of NaCl expressed a statistically similar seedling length, with values of 279 and 280 mm, respectively. From the 30 mmol L^{-1} dose of NaCl, there was a significant decrease in length, and at the 100 mmol L^{-1} dose of NaCl the seedling measured 153 mm in length and, at the dose of 200 mmol L^{-1}, the size reduction was so drastic that the seedlings reached only 85 millimeters. Figure 4 shows the difference in the average seedling length caused by the salt effect, between 0 and 200 mmol L^{-1} NaCl concentrations.

Figure 3: Length of wheat seedling of CULTIVAR IPR CATUARA TM as a function of substrate salinity. **Significant at 1% probability by F test.

Freitas and Camargo (1988) [16], studying the saline effect on root length of four wheat cultivars, revealed lower mean lengths as salt doses (NaCl) increased. For concentrations of 0; 100; 200; 300; 400; and 800 mmol L^{-1}, the average root lengths were 154, 127, 66, 34, 20 and 20 mm, respectively.

The results can be explained by Levitt (1972) [17], who reported in his work that the primary response to any stress of the plant will be reflected in its slow growth. This is supported by the fact that stress causes the plant to increase growth inhibitor hormone production.

The reduction in seedling length is also explained by Pedrotti., *et al.* (2015) [18] who reports in their work that salt affects plant development in two ways: by increasing the osmotic potential of the soil, in which the vegetable increases its energy. necessary to absorb water and with it the other vital elements; and by the toxicity of elements that in high concentration causes physiological disturbances in the plant.

For seedling length, which is a vigor test, the behavior of seeds subjected to saline stress was more intense when compared to germination. Thus, the answers obtained from the tests are in agreement with the statement by Coelho., *et al.* (2010) [19] that, in seedling vigor, the effects are always more intense than in germination.

Figure 4: Germination of cultivar IPR CATUARA TM wheat seeds submitted to doses of 0 MMOL L^{-1} NACL (A) and 200 MMOL L^{-1} NACL (B).

Seedling dry mass

Data of dry mass of wheat seedlings in relation to the tested doses of NaCl can be found in figure 5.

The control dose of 0 mmol L^{-1} NaCl had an average dry mass of 146 mg $seedling^{-1}$. Up to the 45 mmol L^{-1} dose there was no significant reduction in seedling dry mass in relation to the control, characterizing the limit for this cultivar. For dry mass of seedlings, the wheat cultivar was more susceptible to salt stress at doses of 100 and, especially, at 200 mmol L^{-1} NaCl, where with the latter presented a value of 81 mg $seedling^{-1}$, in other words 45% reduction over the witness.

Figure 5: Cultivar IPR Catuara TM wheat seedling dry mass due to substrate salinity. ** Significant at 1% probability by F test.

Freitas and Camargo (1988) [16], working with four wheat cultivars IAC-5, IAS-55, Siete Cerros and Paraguay-281, analyzed the average weight of dry mass of seedlings, in relation to concentrations of 0; 100; 200; 300; 400 and 800 mmol L^{-1} NaCl in the substrate. At the 100 mmol L^{-1} dose of NaCl, the average dry weight increased for IAC-5, IAS-55 and Siete Cerros cultivars, and decreased for Paraguay-281. However, at the concentration of 200 mmol L^{-1}, IAS-55, Siete Cerros cultivars increased the average dry matter weight, reducing this parameter for IAC-5 and Paraguay-281, compared to the control dose (0 mmol L^{-1} NaCl). For the remaining concentrations, all cultivars had reduced average dry weight.

Conclusions

From the results obtained in this experiment, for wheat seeds of cultivar IPR Catuara TM, it can be concluded that:

- Up to 100 mmol L^{-1} dose of NaCl, seed germination power is above 80%
- Seedling length is affected from 30 mmol L^{-1} and seedling dry weight from 100 mmol L^{-1}, with 200 mmol L^{-1} NaCl being considered extremely detrimental to early crop growth.

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