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Seeds germination of different species in saline water

Germinação de sementes de diferentes espécies em água salina

Germinación de semillas de diferentes especies en agua salina

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Maximiliano Kawahata Pagliarini
ORCID: https://orcid.org/0000-0001-7408-6327
Universidade Federal da Grande Dourados, Brazil
E-mail: mpagliarini@ufgd.edu.br
Fabio da Silva Ribeiro
ORCID: https://orcid.org/0000-0003-1040-5530
Centro Universitário da Grande Dourados, Brazil
E-mail: fabioribeiro11dasilva@gmail.com
Bruno Cezar Alvaro Pontim
ORCID: https://orcid.org/0000-0002-3370-8916
Universidade Federal da Grande Dourados, Brazil
E-mail: brunopontim@ufgd.edu.br
Carla Regina Baptista Gordin
ORCID: https://orcid.org/0000-0003-1781-699X
Universidade Federal da Grande Dourados, Brazil
E-mail: carlagordin@ufgd.edu.br
Kamila de Almeida Monaco-Mello
ORCID: https://orcid.org/0000-0002-6118-2640
Universidade Federal da Grande Dourados, Brazil
E-mail: kamilamonaco@ufgd.edu.br
Patricia dos Santos Zomerfeld
ORCID: https://orcid.org/0000-0001-8590-839X
Universidade Federal da Grande Dourados, Brazil
E-mail: patricia.zomerfeld@gmail.com
Luiz Carlos Ferreira de Souza
ORCID: https://orcid.org/0000-0002-9216-5077
Universidade Federal da Grande Dourados, Brazil
E-mail: luizsouza@ufgd.edu.br

Abstract

The objective of the work was to evaluate the interference of saline water in seeds germination of several species of economic interest. The experiment was developed at the Laboratory of Support to Teaching, Research and Extension of the Experimental Farm of Agricultural Sciences, Grand Dourados Federal University, in the municipality of Dourados, Mato Grosso do Sul state, Brazil. The germination tests were performed separately for each species, thus, each one has a methodology determined by Rules for Seed Analysis. The species used were: cotton, chickpea, pea, safflower, sesame, soybeans, and vetch. The treatments were formed by sodium chloride (NaCl) dissolved in water: T1 – control (0.0 g L^{-1} – 0.065 mS cm^{-1}); T2 – 3.0 g L^{-1} (5.50 mS cm^{-1}); T3 – 6.0 g L^{-1} (10.70 mS cm^{-1}) and T4 – 9.0 g L^{-1} (15.10 mS cm^{-1}). All treatments were cultivated in B.O.D with constant light and temperatures according to the species. The characteristics evaluated were: First count; percentage of germination; germination speed index; mean germination time; mean germination speed and seedling length. The experimental design used was completely randomized with four treatments and four replications. Doses up to 6.0 g L^{-1} of NaCl had not interfered on germination of cotton, chickpea, safflower and sesame seeds. Pea, soybean and vetch have not had their germination influenced by concentrations of NaCl used. Water salinity may not harm germination, however, it affects seedlings growth, and may be a determining factor in achieving the ideal population of each crop at field level.
Keywords: Rules for seed analysis; Salinity; Percentage of germination; Germination speed index.

Resumo

O Objetivo do trabalho foi avaliar a interferência de água salina na germinação de sementes de diversas espécies de interesse econômico. O experimento foi desenvolvido no Laboratório de Apoio ao Ensino, Pesquisa e Extensão da Fazenda Experimental de Ciências Agrárias da Universidade Federal de Grande Dourados, no município de Dourados, estado de Mato Grosso do Sul, Brasil. Os testes de germinação foram realizados separadamente para cada espécie, assim, cada uma possuiu uma metodologia determinada pelas Regras para Análise de Sementes. As espécies utilizadas foram: algodão, grão-de-bico, ervilha, cártamo, gergelim, soja e ervilhaca. Os tratamentos foram formados por cloreto de sódio (NaCl) dissolvido em água: T1 – controle (0,0 g L^{-1} – 0,065 mS cm^{-1}); T2 – 3,0 g L^{-1} (5,50 mS

cm^{-1}); T3 – 6,0 g L^{-1} (10,70 mS cm^{-1}) e T4 – 9,0 g L^{-1} (15,10 mS cm^{-1}). Todos os tratamentos foram cultivados em B.O.D com luz e temperaturas constantes de acordo com a espécie. As características avaliadas foram: Primeira contagem; porcentagem de germinação; índice de velocidade de germinação; tempo médio de germinação; velocidade média de germinação e comprimento de plântulas. O delineamento experimental utilizado foi inteiramente casualizado com quatro tratamentos e quatro repetições. Doses de até 6,0 g L^{-1} de NaCl não interferiram na germinação de sementes de algodão, grão-de-bico, cártamo e gergelim. Ervilha, soja e ervilhaca não tiveram sua germinação influenciada pelas concentrações de NaCl utilizadas. A salinidade da água pode não prejudicar a germinação, porém, afeta o crescimento das mudas, podendo ser um fator determinante para atingir a população ideal de cada cultura em nível de campo.
Palavras-chave: Regras para análise de sementes; Salinidade; Porcentagem de germinação; Índice de velocidade de germinação.

Resumen

El objetivo del trabajo fue evaluar la interferencia del agua salina en la germinación de semillas de varias especies de interés económico. El experimento fue realizado en el Laboratorio de Apoyo a la Enseñanza, Investigación y Extensión de la Hacienda Experimental de Ciencias Agrícolas de la Universidad Federal de Grande Dourados, en el municipio de Dourados, estado de Mato Grosso do Sul, Brasil. Las pruebas de germinación se realizaron por separado para cada especie, por lo que cada una tuvo una metodología determinada por las Reglas para el Análisis de Semillas. Las especies utilizadas fueron: algodón, garbanzos, guisantes, cártamo, ajonjolí, soja y veza. Los tratamientos consistieron en cloruro de sodio (NaCl) disuelto en agua: T1 – controle (0,0 g L^{-1} – 0,065 mS cm^{-1}); T2 - 3,0 g L^{-1} (5,50 mS cm^{-1}); T3 – 6,0 g L^{-1} (10,70 mS cm^{-1}) y T4 – 9,0 g L^{-1} (15,10 mS cm^{-1}). Todos los tratamientos se cultivaron en B.O.D. con luz y temperaturas constantes según la especie. Las características evaluadas fueron: Primer conteo; porcentaje de germinación; índice de velocidad de germinación; tiempo medio de germinación; Velocidad media de germinación y longitud de las plántulas. El diseño experimental utilizado fue completamente al azar con cuatro tratamientos y cuatro repeticiones. Dosis de hasta 6,0 g L^{-1} de NaCl no interfirieron en la germinación de semillas de algodón, garbanzo, cártamo y ajonjolí. Los guisantes, la soja y la arveja no tuvieron su germinación influenciada por las concentraciones de NaCl utilizadas. La salinidad del agua puede no perjudicar la germinación, sin embargo, afecta el crecimiento de las plántulas, lo que puede ser un factor determinante para lograr la población ideal de cada cultivo a nivel de campo.
Palabras clave: Reglas para el análisis de semillas; Salinidad; Porcentaje de germinación; Índice de tasa de germinación.

1. Introduction

With the great expansion of agricultural production and the diversification of species, it is extremely important to obtain seeds that present a good physiological quality. To which two characteristics are fundamental to evaluate their physiological quality, viability and vigour (Marcos Filho, 2005). Viability is determined by the germination test. Mean while, vigour comprises a set of characteristics that determine the physiological potential of seeds (Vieira & Carvalho, 1994).

According to Carvalho and Nakagawa (2012), for seeds to have good germination, favourable conditions of light, temperature and water availability are necessary. However, these conditions are not always adequate (Souza et al., 2016) and the availability of water is a very limiting factor and this water availability can be affected in several ways.

The presence of high concentrations of ions in the solution is proportional to the reduction of water potential, in which the water is osmotically retained in the saline solution, becoming less available as the concentration of these salts increases, which negatively influences the absorption of water by the seed, and consequently affects the germination potential and seedlings development (Ribeiro, Marques & Amaro Filho, 2001).

Under water deficit conditions, one of the primary effects triggered in plants is cellular dehydration, which consequently causes reduction in pressure potential (turgor) and in cell volume. This condition triggers secondary effects, such as accumulation of ion concentration in the cytosol, becoming cytotoxic, as they cause denaturation of proteins and destabilization of membranes, which can culminate in cell death (Taiz, Zeiger, Møller & Murphy, 2017).

In seeds, the main effects observed in the literature are: reduction in the percentage of germination, reduction of the primary root and hypocotyl and increase in the average time for germination (Demontiêzo et al., 2016; Freire et al., 2018).

As mentioned, water deficit is one of the main causes of problems in seed germination, however, it is not always caused by the lack of water itself. Often, water is present but not available to the plant and this is what needs to be ascertained.

The excess of salts present, both in surface and underground waters, being recurrent, especially in arid and semi-arid regions due to the irregularities of the rains and the high rate of evapotranspiration (Nogueira et al., 2012; Santos, Silva, Souza, Araújo & Gonçalves, 2021), is a worrying cause in the seed germination phase that affects the entire production chain. Furthermore, salinity may also be caused by inadequate soil and water management in agricultural areas, such as insufficient drainage and incorrect use of fertilizers (Dantas, Ribeiro, Oliveira, Silva & Araújo, 2019), in addition to wrong irrigation management.

Thus, the objective of this work was to evaluate the influence of saline waters on irrigation in this species of economic interest.

2. Methodology

The experiment was developed at the Laboratory of Support to Teaching, Research and Extension of the Experimental Farm of Agricultural Sciences, Grand Dourados Federal University, located in the following geographic coordinates: latitude of 22° 13’ 52,4495’’, longitude of 54° 59’ 10,5372’’. The farm altitude is 411,75 m, in the municipality of Dourados, Mato Grosso do Sul state, Brazil.

The germination tests were performed separately for each species, thus, each one has a methodology determined in Brasil (2009) and which are summarized in Table 1. Regardless of substrate in all cases, four replications of 50 seeds each were used.

Table 1. Methodology used in germination tests for each species according to Brasil (2009).

Crop	Scientific name	Substrate	Temperature	First count (days)	Last count (days)
Cotton	*Gossypium hirsutum L.*	PR	25°C	4	12
Chickpea	*Cicer arietinum L.*	PR	20°C	5	8
Pea	*Pisum sativum L.*	PR	20°C	5	8
Safflower	*Carthamus tinctorius L.*	OP	25°C	4	14
Sesame	*Sesamum indicum L.*	OP	20-30°C	3	6
Soybean	*Glycine max (L.) Merrill*	PR	25°C	5	8
Vetch	*Vicia sativa L.*	BP	20°C	5	14

PR: Paper roll; OP: On paper; BP: Between paper. Source: Prepared by the authors themselves with data from Brazil (2009).

The treatments were formed by sodium chloride (NaCl) dissolved in water: T1 – control (0.0 g L^{-1} – 0.065 mS cm^{-1}); T2 – 3.0 g L^{-1} (5.50 mS cm^{-1}); T3 – 6.0 g L^{-1} (10.70 mS cm^{-1}) and T4 – 9.0 g L^{-1} (15.10 mS cm^{-1}). In all treatments, the substrates were moistened 2.5 times their masses. The paper rolls (PR) were placed in plastic bags to prevent moisture loss. The substrates on paper (OP) and between paper (BP) were placed in a plastic germination box (“gerbox” - 11×11×3.5 cm). All treatments were cultivated in B.O.D with constant light and temperatures according to Table 1.

The characteristics evaluated were the same used by Pagliarini et al. (2021): First count; Percentage of germination; Germination speed index (Maguire, 1962); Mean germination time (Edmond & Drapalla, 1958); Mean germination speed and Seedling length – SL.

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The experimental design used was completely randomized with four treatments, four replications and data were submitted to analysis of variance and in the case of significance at 5% of probability means were compared by Tukey test by Sisvar computer program (Ferreira, 2012).

3. Results

The first count was presented in Table 2, and it was possible to note that pea (*Pisum sativum L.*) and vetch (*Vicia sativa L.*) have not presented statistical difference among treatments.

For cotton (*Gossypium hirsutum L.*), the presence of sodium chloride (NaCl) in the irrigation water interfered the first count in the last dosage, for control and 3.0 g L^{-1} and 6.0 g L^{-1} there was no statistical difference between them. The same was evidenced for sesame (*Sesamum indicum L.*). Regarding safflower (*Carthamus tinctorius L.*) and soybean (*Glycine max (L.) Merrill*), the highest first count averages were found in the control and up to 3.0 g L^{-1} of NaCl in the irrigation water (Table 2).

Regarding chickpea (*Cicer arietinum L.*), control and the 6.0 g L^{-1} dose did not differ from each other, however, both were statistically different from 3.0 and 9.0 g L^{-1} (Table 2).

Table 2. First count (FC – %) of germination test of seven different species submitted to doses of NaCl solution in irrigation water.

First Count – FC (%)							
Crop	**Scientific name**	**Botanic Family**	**Doses of NaCl (g L^{-1})**				**CV(%)**
			Control	**3.0**	**6.0**	**9.0**	
Cotton	*Gossypium hirsutum L.*	*Malvaceae*	92.00 a	86.00 a	74.50 ab	53.00 b	13.60
Chickpea	*Cicer arietinum L.*	*Fabaceae*	97.50 a	92.00 b	97.50 a	63.00 c	2.99
Pea	*Pisum sativum L.*	*Fabaceae*	94.00 a	97.50 a	97.00 a	97.50 a	3.08
Safflower	*Carthamus tinctorius L.*	*Asteraceae*	85.00 a	76.50 ab	58.00 b	16.50 c	16.56
Sesame	*Sesamum indicum L.*	*Pedaliaceae*	58.00 a	57.50 a	56.50 a	32.50 b	17.94
Soybean	*Glycine max (L.) Merrill*	*Fabaceae*	83.00 a	79.00 ab	67.00 bc	64.50 c	8.54
Vetch	*Vicia sativa L.*	*Fabaceae*	69.50 a	69.50 a	67.50 a	64.50 a	10.26

Means followed by the same letter on the line do not differ from each other at 5% of probability level by Tukey test. Source: The authors.

At the end of the test period for each species, the percentage of germination of pea, vetch and soybean showed no statistical difference in any salt concentration (Table 3).

For cotton, chickpeas, safflower and sesame, only 9.0 g L^{-1} dose showed lower germination percentage averages, differing statistically from the other doses and control (Table 3).

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Table 3. Percentage of germination (%) test of seven different species submitted to doses of NaCl solution in irrigation water.

% of Germination							
Crop	**Scientific name**	**Botanic Family**	**Doses of NaCl (g L^{-1})**				**CV(%)**
			Control	**3.0**	**6.0**	**9.0**	
Cotton	*Gossypium hirsutum L.*	*Malvaceae*	92.50 a	87.50 a	77.00 ab	60.50 b	10.62
Chickpea	*Cicer arietinum L.*	*Fabaceae*	97.50 a	93.50 a	97.50 a	67.50 b	3.24
Pea	*Pisum sativum L.*	*Fabaceae*	95.50 a	98.00 a	98.50 a	97.50 a	2.53
Safflower	*Carthamus tinctorius L.*	*Asteraceae*	85.00 a	79.50 a	75.50 a	34.50 b	11.88
Sesame	*Sesamum indicum L.*	*Pedaliaceae*	71.50 a	72.50 a	65.00 a	40.00 b	12.60
Soybean	*Glycine max (L.) Merrill*	*Fabaceae*	87.50 a	86.50 a	86.00 a	77.00 a	8.35
Vetch	*Vicia sativa L.*	*Fabaceae*	73.50 a	75.00 a	78.50 a	77.00 a	6.42

Means followed by the same letter on the line do not differ from each other at 5% of probability level by Tukey test. Source: The authors.

The Germination Speed Index (GSI) did not present statistically different means for vetch. On the other hand, for cotton, peas and soybeans, the presence of up to 3.0 g L^{-1} of NaCl did not affect the index (Table 4). Sesame, in turn, showed more salinity tolerance, with no statistical difference up to the dose of 6.0 g L^{-1}. On the other hand, chickpeas and safflower had their GSI impaired with the lowest dose of NaCl (Table 4).

Table 4. Germination speed index of seven different species submitted to doses of NaCl solution in irrigation water.

Germination Speed Index – GSI							
Crop	**Scientific name**	**Botanic Family**	**Doses of NaCl (g L^{-1})**				**CV(%)**
			Control	**3.0**	**6.0**	**9.0**	
Cotton	*Gossypium hirsutum L.*	*Malvaceae*	96.30 a	89.71 ab	76.22 b	52.73 c	10.87
Chickpea	*Cicer arietinum L.*	*Fabaceae*	59.02 a	47.87 b	41.64 c	30.55 d	5.41
Pea	*Pisum sativum L.*	*Fabaceae*	69.68 ab	74.44 a	60.29 b	62.25 b	8.58
Safflower	*Carthamus tinctorius L.*	*Asteraceae*	77.00 a	61.18 b	47.89 b	18.75 c	13.60
Sesame	*Sesamum indicum L.*	*Pedaliaceae*	40.98 a	38.59 a	34.24 a	19.41 b	15.39
Soybean	*Glycine max (L.) Merrill*	*Fabaceae*	47.21 a	42.42 a	33.15 b	31.46 b	9.28
Vetch	*Vicia sativa L.*	*Fabaceae*	56.28 a	54.91 a	51.56 a	55.74 a	6.53

Means followed by the same letter on the line do not differ from each other at 5% of probability level by Tukey test. Source: The authors.

Germination Mean Time (GMT) was affected in all species comparing the control treatments and the highest dose of NaCl (9.0 6.0 g L^{-1}). In this case, the analysis needs to be done with the lowest averages, so the lowest time for cotton and sesame were, and which did not differ statistically from each other, in saline water up to 6.0 6.0 g L^{-1} of NaCl. For pea, safflower, soybean and vetch the lowest germination speeds were found up to the dose of 3.0 g L^{-1} of NaCl and for chickpeas, any concentration of NaCl in the irrigation water increases the germination speed.

Table 5. Germination mean time (Days) of seven different species submitted to doses of NaCl solution in irrigation water.

Germination Mean Time – GMT (Days)							
Crop	**Scientific name**	**Botanic Family**	**Doses of NaCl (g L^{-1})**				**CV(%)**
			Control	**3.0**	**6.0**	**9.0**	
Cotton	*Gossypium hirsutum L.*	*Malvaceae*	4.52 b	4.54 b	4.60 b	4.85 a	1.05
Chickpea	*Cicer arietinum L.*	*Fabaceae*	5.02 c	5.27 b	5.52 a	5.62 a	1.19
Pea	*Pisum sativum L.*	*Fabaceae*	4.77 bc	4.73 c	5.02 a	4.98 ab	2.25
Safflower	*Carthamus tinctorius L.*	*Asteraceae*	8.38 c	8.74 c	9.21 b	9.91 a	2.22
Sesame	*Sesamum indicum L.*	*Pedaliaceae*	4.41 b	4.51 ab	4.56 ab	4.69 a	1.94
Soybean	*Glycine max (L.) Merrill*	*Fabaceae*	5.16 c	5.29 c	5.63 b	5.83 a	1.38
Vetch	*Vicia sativa L.*	*Fabaceae*	5.28 c	5.39 bc	5.64 a	5.55 ab	1.76

Means followed by the same letter on the line do not differ from each other at 5% of probability level by Tukey test. Source: The authors.

The Mean Germination Speed (MGS) of studied species was shown in Table 6 and showed that the highest dose of NaCl in the irrigation water (9.0 g L^{-1}) had the lowest average velocity.

For cotton and sesame, doses of up to 6.0 g L^{-1} of NaCl presented statistically similar means in relation to control. For pea, safflower, soybean and vetch, the highest germination speed means were presented at doses of up to 3.0 g L^{-1} of NaCl and for chickpeas, salinity affected the germination speed at any concentration of NaCl (Table 6).

Table 6. Mean Germination speed ($Days^{-1}$) of seven different species submitted to doses of NaCl solution in irrigation water.

Mean Germination Speed – MGS ($Days^{-1}$)							
Crop	**Scientific name**	**Botanic Family**	**Doses of NaCl (g L^{-1})**				**CV(%)**
			Control	**3.0**	**6.0**	**9.0**	
Cotton	*Gossypium hirsutum L.*	*Malvaceae*	0.220 a	0.220 a	0.218 a	0.205 b	1.77
Chickpea	*Cicer arietinum L.*	*Fabaceae*	0.199 a	0.189 b	0.181 c	0.178 c	1.20
Pea	*Pisum sativum L.*	*Fabaceae*	0.210 a	0.210 a	0.198 b	0.200 ab	2.34
Safflower	*Carthamus tinctorius L.*	*Asteraceae*	0.120 a	0.115 ab	0.108 bc	0.100 c	3.45
Sesame	*Sesamum indicum L.*	*Pedaliaceae*	0.228 a	0.223 ab	0.220 ab	0.218 b	1.95
Soybean	*Glycine max (L.) Merrill*	*Fabaceae*	0.195 a	0.190 a	0.178 b	0.170 b	2.09
Vetch	*Vicia sativa L.*	*Fabaceae*	0.188 a	0.183 ab	0.178 b	0.180 ab	2.38

Means followed by the same letter on the line do not differ from each other at 5% of probability level by Tukey test. Source: The authors.

For seedling length (Table 7), cotton, chickpea, pea and vetch presented seedlings with statistically similar average lengths in relation to control and dose of 3.0 g L^{-1} of NaCl.

Safflower was the only species that had mean seedling length numerically greater in saline water, and at 3.0 g L^{-1} of NaCl had not differed statistically from control and at 6.0 g L^{-1} of NaCl. On the other hand, sesame and soybean had seedling length affected by salinity regardless of salt concentration Table 7).

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Table 7. Seedling length (cm) of germination test of seven different species submitted to doses of NaCl solution in irrigation water.

Seedling length – SL (cm)							
Crop	**Scientific name**	**Botanic Family**	**Doses of NaCl (g L^{-1})**				**CV(%)**
			Control	**3.0**	**6.0**	**9.0**	
Cotton	*Gossypium hirsutum L.*	*Malvaceae*	7.25 a	6.25 ab	5.80 bc	4.42 c	11.47
Chickpea	*Cicer arietinum L.*	*Fabaceae*	4.09 a	3.48 ab	2.60 b	1.18 c	16.24
Pea	*Pisum sativum L.*	*Fabaceae*	13.27 a	11.78 a	9.09 b	7.38 b	8.64
Safflower	*Carthamus tinctorius L.*	*Asteraceae*	2.98 ab	4.00 a	3.23 ab	2.18 b	23.74
Sesame	*Sesamum indicum L.*	*Pedaliaceae*	5.95 a	4.29 b	2.49 c	1.38 d	7.42
Soybean	*Glycine max (L.) Merrill*	*Fabaceae*	11.06 a	7.38 b	6.26 b	3.44 c	13.27
Vetch	*Vicia sativa L.*	*Fabaceae*	11.00 a	11.30 a	8.66 ab	6.37 b	15.57

Means followed by the same letter on the line do not differ from each other at 5% of probability level by Tukey test. Source: The authors.

4. Discussion

The first count test is important as it evaluates the speed of germination, indicating that the greater the germination of the seeds in the first count, the greater will be their vigour (Nakagawa, 1999).

Thus, pea and vetch were not affected by salinity in the first count (Table 2) or at the end of the test time, as the final germination percentage (Table 3) also did not show statistical difference for the treatments. In this case, soybean also did not show any statistical difference between treatments in terms of final germination, however, in the first count, doses of up to 9.0 g L^{-1} caused delay at germination. It may be concluded that for soybean the initial vigour was affected, however, over the days the germination managed to be uniformed.

The other species maintained the same behaviour between the first count and the final count, except for safflower, which showed reduced first count germination at dose of 6.0 g L^{-1} of NaCl, however, it managed to reach the same final percentages of germination at this concentration, not differing statistically from the control and 3.0 g L^{-1} of NaCl.

According to Rhoades & Loveday (1990), the salinity of water irrigation influences not only the germination percentage, but also the number of days to germinate, which may be easily observed in the present work, in which higher doses of NaCl in the water decreased the germination of all species, as well as increased the Germination Mean Time (GMT – Table 5).

Salinity affects germination not only hindering the kinetics of water absorption, but also facilitating the entry of ions in toxic amounts into the soaked seeds (Lima & Torres, 2009; Lovera, Ocampo, Barrios, González & Jarra, 2022). Thus, the germination of cotton, chickpea, safflower and sesame seeds was reduced (Table 3).

The water was osmotically retained in a saline solution, which with increasing salt concentration makes water less available to plant. An excess of ions, such as Na^+ and Cl^-, causes disturbances in the protoplasm, affecting enzymatic activity and inadequate energy production, as a consequence, nitrogen assimilation is limited (Larcher, 2004; Cruz et al. 2020). With the reduction of water available for absorption by the seed, there is an increase in the average time of germination, more days will be needed for germination of seeds to be completed, a fact observed in the present work in which the concentrations of NaCl delayed the germination as shown in Table 5.

The Germinations Speed Index (GSI) decreases in all species studied at some degree of NaCl concentration, some more and others less (Table 4), a fact that proves that the unavailability of water reduces the metabolism of seeds for the digestion of reserves and translocation of metabolized products (Oliveira & Gomes-Filho, 2009; Monteiro, Monteiro, Santos, Lima & Costa, 2021). Bewley & Black (1994) characterized these processes as a three-phase pattern of germination.

Regarding the decline in germination potential and GSI, it is possible to infer that high saline concentrations reduce the speed of metabolic and biochemical processes in seeds. These influences associated with salinity in the seed are directly linked to the delay or reduction of germination, interference in imbibition and cellular elongation of the embryo, as well as the difficulty of emission of the radicle (Bansal, Bhati & Sen, 1980; Guerra & Machado, 2022).

Plants have mechanisms of adaptation to salt stress in which there are morphological and anatomical transformations. One of this change is size reduction, a way for plants to reduce the rate of transpiration (Tester & Davenport, 2003). The same authors reported that changes resulted from the increase in the osmotic pressure of irrigation water, due to the osmotic potential becoming more negative, making its absorption difficult, in addition to other nutritional effects, making Na toxic to plants and/or interfering on the availability of other ions.

This application is observed in the present work, in which all evaluated species had their length reduced in some concentration of NaCl (Table 7). Sesame and soybean, for example, were completely intolerant to salinity at any concentration, with a reduction of 27.9% and 33.3% in length, respectively. For the other species, up to 3 g L^{-1} of NaCl managed to produce seedlings with lengths similar to the control, showing a certain tolerance to saline waters (Table 7).

Contrary to data presented in this work, Pinto, Santos, Zanão Junior, Daniel and Hubner (2021) reported that any concentration of NaCl interfered at crambe (*Crambe abyssinica* Hochst) seeds germination and, consequently, with the development of the plant. Likewise, Hubner, Santos, Zanão Junior, Daniel and Pinto (2021) found difficulty to grow fodder radish (*Raphanus sativus* L.) in saline environment.

Guerra and Machado (2022) working with beet cultivars subjected to saline stress reported that the process of germination have been impaired, as found in this work, mainly by the increment of germination time making it difficult for water to enter the seed, consequently causing a reduction in seedling height.

Barros et al. (2021) found that within the same species, different cultivars may present different behaviours, as in the case of bell peppers (*Capsicum annuum* L.). Under authors study conditions, they found that the cultivar 'Amarelo SF 134' showed tolerance to saline stress in the germination process, while 'Casca Dura Ikeda', in the initial seedling growth phase.

Analysing all evaluated characteristics, plants have divergent behaviours regarding the exposure of salts, being classified according to the degree of tolerance and sensitivity. Sensitivity and tolerance may be different between species and cultivars of the same species, as well as region climatic conditions, type of soil, irrigation method and crop development stage. These characteristics allow choosing the plant species with the best degree of tolerance for cultivation in areas affected by salinity. However, to ensure good production throughout the year in these areas, consideration must be given not only to the cultivar to be used, but also to the conditions of the property and the climate of the region (Guerra & Machado, 2022).

5. Conclusion

Doses up to 6.0 g L^{-1} of NaCl have not interfered on germination of cotton, chickpea, safflower and sesame seeds, and it may be concluded that these species are moderately tolerant to NaCl in irrigation water.

On the other hand, it may be inferred that pea, soybean and vetch did not have their germination influenced by concentrations of NaCl used, thus, it may be concluded that these species are tolerant to salinity (NaCl solution in irrigation) up to the dose of 9.0 g L^{-1} of the salt.

However, the mean germination time of all species was altered at doses of NaCl, therefore, there was increment in time to germinate when in contact with saline water. As much as salinity did not interfere with germination, the initial development of seedlings of all species was impaired at some concentration of NaCl.

Thus, it is concluded that water salinity may not harm germination process, however, it affects seedlings growth, and may be a determining factor in achieving the ideal population of each crop at field level.

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