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Seeds Germination of Poaceae Family Species in Saline Water

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Abstract **– Salt stress may cause serious problems in the plant, such as reduced photosynthesis, cell death and mainly interfere with seed germination. Thus, the aim of the work was to evaluate the influence of saline water in the germination of seven species of Poaceae family. The experiment was developed at the Laboratory of Research, Teaching and Extension Support at Experimental Farm of Agrarian Sciences of Grand Dourados Federal University (UFGD) using seeds of barley, oat, rice, rye, ryegrass, triticale and wheat. The experimental design used was completely randomized with four treatments and four replications. The treatments were formed by doses of NaCl dissolved in water: T1 – 0.0 g L^{-1} (control – 0.065 mS); T2 – 3.0 g L^{-1} (5.50 mS); T3 – 6.0 g L^{-1} (10.70 mS) and T4 – 9.0 g L^{-1} (15.10 mS). In all cases, the substrates were moistened with treatments 2.5 times their masses. All germination tests were performed in B.O.D. with constant light. The temperature and the duration of test changed according to the species. It was analysed: first count, percentage of germination, germination speed index, mean germination time, mean germination speed, seedling length and synchronization index. 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. The use of water with the maximum concentration of sodium chloride (NaCl – 9.0 g L^{-1}) did not affect the final percentage of germination of barley, oats, rice, triticale and wheat. However, for rye and ryegrass, the maximum dose of NaCl, that did not interfere with the final germination percentage was 6 g L^{-1}. Barley may be considered the most tolerant to salinity. Even under conditions of higher saline concentrations, the species showed uniform seed germination. The other species may be considered moderately tolerant to salinity, according to research data. Salinity affected the initial development of all species, decreasing seedling length in the first NaCl dosage (3 g L^{-1}) in the irrigation water.**

Keywords **– Saline Strees, NaCl, Germination Speed Index, Mean Germination Time.**

I. Introduction

It is true that one of the challenges facing humanity today is the production of food that follows the increase in world population. Cobb et al. [1] in 2013 has already warned that the FAO (Food and Agriculture Organization) estimated a drastic increase the necessity for food until 2050, which was reinforced by Landi et al. [2] in 2017, four years later nothing has changed.

The world agriculture has struggled to maintain this growth; however, some situations may get out of control because they are considered physiological problems that are intensified by abiotic stress, often caused by humanity itself. It is true that the rainfall regime has changed annually, in which regions where rainfall was constant nowadays occur very long droughts or the opposite is true.

These abiotic factors cause physiological and biochemical changes in plants causing reduced production and economic damage [3]. One of these factors is related to the soil salinity, which may be caused both by the source material and by the water stress that causes the salt concentration due to moisture loss. In the first case, the salts originate from the weathering of primary minerals found in soils and rocks. These salts are transported by water and stored in the soil, accumulating as the water is evaporated in regions of low disconnection, when the water table is close to the surface or consumed by crops, causing the salinization process. Soil salinization due to this phenomenon is called primary salinization [4]. On the other hand, secondary salinization, mentioned by the same authors, has also been associated with water used in irrigation, poor drainage and the presence of subsurface waters rich in soluble salts at shallow depths, in this case, an exclusively anthropic action.

Salt stress may cause serious problems in the plant, such as reduced photosynthesis, cell death and mainly interfere with seed germination, as it causes dehydration and damage to proteins, DNA and membranes [5, 6, 7].

Taking this into account, one of the most important families for food production in the world, the species of the *Poaceae* family has its critical production and sees the need for increment. Rice (*Oryza sativa*) is the most important food for more than half of the world population, wheat (*Triticum aestivum*) is a source of carbohydrate for more than 55% of the world, barley (*Hordeum vulgare*) is the fourth largest cereal in planted area in the world, mainly used in the brewery and forage industries [8, 9, 10]. In addition, in Brazil, oats, ryegrass are used as forage in the off-season and rye an alternative for baking.

With such a large family, having several species, it is notorious that each one presents different characteristic in face of the adversities of climate, soil, biotic and abiotic stress. In case of salinity, this will affect each species differently at different stages of development and will also depend on the type of salt involved.

Among the species mentioned above, some authors claim that rice is one of the most susceptible cereals to salinity, wheat is moderately sensitive, while barley is the most tolerant [10]. In this sense, this study aimed to evaluate the influence of sodium chloride doses dissolved in irrigation water on seed germination of seven *Poacea* family species of economic interest for Brazil.

II. Material and Methods

The experiment analyses were performed at the Laboratory of Research, Teaching and Extension Support at Experimental Farm of Agrarian Sciences of Grand Dourados Federal University (UFGD), located at latitude of 22° 13’ 52,4495’’, longitude of 54° 59’ 10,5372’’, altitude of 411,75 m, in the municipality of Dourados, Mato Grosso do Sul state, Brazil.

The seeds were received through donations from partner companies (wheat, triticale), acquired through the local trade (ryegrass, rye) or as a result of the current crop harvest (oats, rice, barley).

The methodology used for the germination tests for each species was based on Brasil [11] and are shown in table 1.

Table 1. Methodology used in germination tests for each species of *Poaceae* family according to Brasil [11].

Crop	Cultivar	Scientific Name	Substrate	Temperature	First Count (Days)	Last Count (Days)
Barley	BRS Demeter	*Hordeum vulgare*	Roll Paper	20°C	4	7
Oat	Common	*Avena sativa*	Between Paper	20°C	5	10
Rice	Common	*Oryza sativa*	On Paper	25°C	5	14

Rye	Serrano	*Secale cereale*	On Paper	20°C	4	7
Ryegrass	Inia Titan	*Lolium multiflorum*	On Paper	20°C	5	14
Triticale	IPR Caiapo	×*Triticosecale*	Between Paper	20°C	4	8
Wheat	TBIO Ponteiro	*Triticum aestivum*	Between Paper	20°C	4	8

The experimental design used was completely randomized with four treatments and four replications. The treatments were formed by doses of NaCl dissolved in water: T1 – 0.0 g L^{-1} (control – 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 cases, the substrates were moistened with treatments 2.5 times their masses.

When the substrate was roll paper, they were packed in plastic bags to prevent moisture loss. When the substrate was between paper or on paper, they were placed in a plastic germination box ("gerbox" - 11×11×3.5 cm), needing substrate rehydration every two days. In both cases they were placed to germinate in B.O.D with constant light and temperature according to the table mentioned above.

The evaluated characteristics were similar to the work performed by Pagliarini et al. [12]: First count – the number of germinated seeds in the first count was performed according the days after sowing mentioned in Table 1, transforming the value in percentage.

Percentage of germination – the amount of germinated seeds at the end of test period was performed according the days after sowing mentioned in Table 1, transforming the value in percentage.

Germination speed index [13] – GSI, in which the number of normal seeds or seedlings was counted during the days of the test duration for each species, according to the equation 1:

$$GSI = G1/N1 + G2/N2 + \dots Gn/Nn \quad (1)$$

Where: G1, G2, ... Gn = number of germinated seeds at the day of observation and N1, N2, ... Nn = number of days after sowing.

Mean germination time [14] – MGT, which is the maximum time to germinate the seeds and was calculated by the equation 2:

$$MGT = (N1\,G1 + N2\,G2 + \dots + Nn.Gn) / (G1 + G2 + \dots + Gn) \quad (2)$$

Where: G1, G2, ... Gn = number of germinated seeds at the day of observation and N1, N2, ... Nn = number of days after sowing. The results were expressed in days.

Mean germination speed – MGS, calculated using the equation 3:

$$MGS = 1 / MGT \quad (3)$$

Where: MGT is mean germination time calculated previously. The results were expressed in $days^{-1}$.

Seedling length – SL, determined using the mean of 10 plants per plot. They were measured from the apex of the largest primary root to the end of the primary leaves. The results were expressed in centimeters. Synchronization index [15] – SI, calculated according to equation 4:

$$E = - \Sigma fi.\ \log_2 fi \quad (4)$$

Where: fi = relative germination frequency (RGF) and log_2 = base 2 logarithm. The results were expressed in bits.

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 [16].

III. Results and Discussion

The germination speed index (GSI) was not significant only for barley at any dose of NaCl (Table 2). In relation to oats and wheat, both showed statistical differences between the means, and the control, without the presence of NaCl, had the highest means (109.13 and 94.89, respectively for oats and wheat) (Table 2). For rice, rye, ryegrass and triticale, doses of up to 3 g L^{-1} of NaCl did not interfere in the GSI as the means did not differ statistically from the control (Table 2).

Table 2. Germination speed index (GSI) of seven species of *Poaceae* family in different doses of NaCl in irrigation water.

Germination Speed Index – GSI							
Crop	**Scientific name**	**Doses of NaCl (g L^{-1})**				**Overall Mean**	**CV(%)**
		0.0	**3.0**	**6.0**	**9.0**		
Barley	*Hordeum vulgare*	83.76 a	81.73 a	79.12 a	77.18 a	80.45	6.31
Oat	*Avena sativa*	109.13 a	67.61 b	38.51 c	28.48 c	60.93	8.51
Rice	*Oryza sativa*	74.05 a	67.07 ab	59.01 b	61.34 b	65.37	7.97
Rye	*Secale cereale*	71.84 a	63.63 ab	56.26 b	35.61 c	56.84	9.65
Ryegrass	*Lolium multiflorum*	45.45 a	39.87 a	31.21 b	4.25 c	30.20	12.77
Triticale	×*Triticosecale*	106.62 a	99.94 ab	88.25 b	70.16 b	91.24	8.06
Wheat	*Triticum aestivum*	94.89 a	65.92 b	48.45 c	42.98 c	63.06	11.92

Means followed by the same letter in the line do not differ from each other at the 5% probability level by Tukey test.

Barley also behaved similarly in relation to the mean germination time (MGT) as well as the GSI, with no statistical difference between the mean doses of NaCl and the control (Table 3). In the tests performed on oats and wheat, the control obtained the lowest means of MGT, gradually increasing as the salt concentration increased, the lowest average for oat was 5.74 days and for wheat 4.88 days (Table 3).

In relation to rice, ryegrass and triticale saline waters containing up to 3 g L^{-1} of NaCl did not interfere in the MGT as they did not differ statistically from the control without the addition of salt (Table 3). In addition, rice did not show any significant difference between any NaCl dose evaluated (Table 3), while triticale showed the mean MGT mediators at the highest NaCl dose (Table 3).

Table 3. Germination mean time (GSI – days) of seven species of *Poacea* family in different doses of NaCl in irrigation water.

Mean Germination Time – MGT (Days)							
Crop	**Scientific name**	**Doses of NaCl (g L^{-1})**				**Overall Mean**	**CV(%)**
		0.0	**3.0**	**6.0**	**9.0**		
Barley	*Hordeum vulgare*	4.45 a	4.79 a	4.53 a	4.56 a	4.50	1.39

Mean Germination Time – MGT (Days)							
Crop	**Scientific name**	**Doses of NaCl (g L^{-1})**				**Overall Mean**	**CV(%)**
		0.0	**3.0**	**6.0**	**9.0**		
Oat	*Avena sativa*	5.74 d	6.46 c	7.29 b	7.83 a	6.83	1.27
Rice	*Oryza sativa*	8.63 b	8.85 ab	9.18 a	9.20 a	8.96	2.08
Rye	*Secale cereale*	4.54 b	4.65 b	4.76 b	5.28 a	4.81	2.43
Ryegrass	*Lolium multiflorum*	9.08 c	9.46 c	10.08 b	11.67 a	10.07	2.76
Triticale	×*Triticosecale*	4.78 c	4.85 bc	5.02 b	5.26 a	4.97	1.93
Wheat	*Triticum aestivum*	4.88 c	5.39 b	5.76 a	5.98 a	5.50	1.90

Means followed by the same letter in the line do not differ from each other at the 5% probability level by Tukey test.

It is possible to observe in Table 4 that for barley and rice there was no statistical difference for the mean germination speed (MGS). Oat was the only species that showed statistical difference between all treatments and the control showed the highest speed (0.17), decreasing as the dose of NaCl increased (Table 4). In relation to rye, the control treatments, 3 g L^{-1} and 6 g L^{-1} did not differ from each other, however, the three differed from the highest dose of sodium chloride. The germination speed of ryegrass and triticale was statistically different compared to the control and the highest dose of NaCl, while wheat germinated faster in the control treatment than in the saline water treatments (Table 4).

Table 4. Mean germination speed (MGS – $Days^{-1}$) of seven species of *Poacea* family in different doses of NaCl in irrigation water.

Mean Germination Speed – MGS ($Days^{-1}$)							
Crop	**Scientific name**	**Doses of NaCl (g L^{-1})**				**Overall Mean**	**CV(%)**
		0.0	**3.0**	**6.0**	**9.0**		
Barley	*Hordeum vulgare*	0.23 a	0.22 a	0.22 a	0.22 a	0.22	1.30
Oat	*Avena sativa*	0.17 a	0.16 b	0.14 c	0.13 d	0.14	2.56
Rice	*Oryza sativa*	0.12 a	0.11 a	0.11 a	0.11 a	0.11	3.41
Rye	*Secale cereale*	0.22 a	0.22 a	0.21 a	0.19 b	0.21	2.40
Ryegrass	*Lolium multiflorum*	0.11 a	0.11 ab	0.10 b	0.09 b	0.10	3.80
Triticale	×*Triticosecale*	0.21 a	0.21 a	0.20 ab	0.19 b	0.20	2.37
Wheat	*Triticum aestivum*	0.21 a	0.19 b	0.17 c	0.17 c	0.18	2.61

Means followed by the same letter in the line do not differ from each other at the 5% probability level by Tukey test.

The first count showed no significant difference for barley, rye and triticale (Table 5). For oat, the first count had lower percentage of germinated seeds and statistically differing only in relation to the highest dose of the other doses and the control, in this case 9 g L^{-1} of NaCl presented 34% of germinated seeds compared to 86%, 85.5% and 77 %, respectively for control, 3 g L^{-1} and 6 g L^{-1} of NaCl (Table 5).

Rice presented an interesting behaviour, as it did not present statistical difference between control, 3 g L^{-1} and 9 g L^{-1} of NaCl, while the intermediate dose (6 g L^{-1}) had less mean germination in the first count (Table 5).

Among the species evaluated and that obtained results with statistical differences, wheat was the one with the highest percentage of germinated seeds in the first count and there was no statistical difference up to dosage of 3 g L^{-1} of NaCl (91.5% and 81.5%, respectively for control and 3 g L^{-1}) (Table 5). On the other hand, ryegrass was the species that had the lowest average number of germinated seeds in the first count. As with wheat, there was no statistical difference between the control (51%) and 3 g L^{-1} (40.5%) (Table 5), but it was the only one that did not have any germinated seeds when the seeds were subjected to the highest concentration of NaCl (Table 5).

Table 5. First count (FC – %) of germination test of seven species of *Poacea* family in different doses of NaCl in irrigation water.

First Count – FC (%)							
Crop	**Scientific Name**	**Doses of NaCl (g L^{-1})**				**Overall Mean**	**CV(%)**
		0.0	**3.0**	**6.0**	**9.0**		
Barley	*Hordeum vulgare*	98.0 a	100.0 a	96.0 a	95.0 a	97.3	3.08
Oat	*Avena sativa*	86.0 a	85.5 a	77.0 a	34.0 b	70.6	7.92
Rice	*Oryza sativa*	89.0 a	78.0 ab	59.5 b	68.5 ab	73.8	18.43
Rye	*Secale cereale*	91.0 a	89.0 a	86.0 a	65.0 a	82.8	15.83
Ryegrass	*Lolium multiflorum*	51.0 a	40.5 a	26.0 b	0.0 c	29.4	18.62
Triticale	×*Triticosecale*	99.0 a	96.0 a	95.0 a	95.5 a	96.4	2.73
Wheat	*Triticum aestivum*	91.5 a	81.5 ab	65.0 c	72.5 bc	77.6	7.26

Means followed by the same letter in the line do not differ from each other at the 5% probability level by Tukey test.

The germination percentage at the end of each test showed no statistical difference for barley, oats, rice, triticale and wheat (Table 5). In relation to rye, there was an effective statistical difference only between the control (93%) and the highest dosage of NaCl – 9 g L^{-1} (82%) (Table 6) and for ryegrass it is possible to observe that doses up to 6 g L^{-1} of NaCl did not differ statistically from the control without addition of salt (Table 6).

Table 6. Percentage of germination (%G) of seven species of *Poacea* family in different doses of NaCl in irrigation water.

% of Germination - %G							
Crop	**Scientific Name**	**Doses of NaCl (g L^{-1})**				**Overall Mean**	**CV(%)**
		0.0	**3.0**	**6.0**	**9.0**		
Barley	*Hordeum vulgare*	98.0 a	100.0 a	98.5 a	97.0 a	98.4	2.18
Oat	*Avena sativa*	86.5 a	88.5 a	82.5 a	76.0 a	83.4	8.43
Rice	*Oryza sativa*	90.0 a	89.5 a	90.5 a	92.5 a	90.6	5.78
Rye	*Secale cereale*	93.0 a	89.5 ab	86.0 ab	82.0 b	87.6	5.73
Ryegrass	*Lolium multiflorum*	68.5 a	70.0 a	73.0 a	19.5 b	57.8	11.24
Triticale	×*Triticosecale*	99.0 a	97.0 a	100.0 a	97.0 a	98.3	2.12
Wheat	*Triticum aestivum*	95.5 a	96.5 a	94.5 a	93.0 a	94.9	2.38

Means followed by the same letter in the line do not differ from each other at the 5% probability level by Tukey test.

Seedling length was almost unanimous, barley, oats, rye, ryegrass, triticale and wheat had the highest means and also statistical differences for the control, without addition of NaCl in relation to treatments with doses of salt (Table 7). On the other hand, only rice showed no statistical difference between the control and the first dose of NaCl (Table 7).

Table 7. Seedling length (SL – cm) of seven species of *Poacea* family in different doses of NaCl in irrigation water.

Seedling Length – SL (cm)							
Crop	Scientific Name	Doses of NaCl (g L^{-1})				Overall Mean	CV(%)
		0.0	3.0	6.0	9.0		
Barley	*Hordeum vulgare*	17.72 a	11.91 b	6.81 c	4.51 d	10.24	10.55
Oat	*Avena sativa*	16.45 a	10.29 b	4.29 c	3.09 c	8.53	8.80
Rice	*Oryza sativa*	13.39 a	11.69 ab	7.90 bc	5.91 c	9.72	18.56
Rye	*Secale cereale*	15.69 a	11.31 b	7.67 c	3.73 d	9.60	10.25
Ryegrass	*Lolium multiflorum*	20.99 a	17.39 b	15.58 b	7.00 c	15.24	6.90
Triticale	×*Triticosecale*	21.99 a	15.91 b	9.97 c	3.24 d	12.78	9.58
Wheat	*Triticum aestivum*	13.97 a	10.66 b	7.92 c	5.54 d	9.52	7.89

Means followed by the same letter in the line do not differ from each other at the 5% probability level by Tukey test.

The rice synchronization index (Table 8) was not statistically different for any treatment. In all other species, despite different behaviors, the control showed numerically lower values than the other treatments with the presence of NaCl (Table 8).

Table 8. Synchronization index (SI – Bites) of seven species of *Poacea* family in different doses of NaCl in irrigation water.

Synchronization Index – SI (Bits)							
Crop	Scientific Name	Doses of NaCl (g L^{-1})				Overall Mean	CV(%)
		0.0	3.0	6.0	9.0		
Barley	*Hordeum vulgare*	0.54 c	0.47 c	0.84 b	1.07 a	0.73	14.71
Oat	*Avena sativa*	0.47 c	1.17 ab	0.80 b	1.61 a	1.01	27.68
Rice	*Oryza sativa*	1.17 a	1.49 a	1.69 a	1.51 a	1.46	19.77
Rye	*Secale cereale*	0.17 b	0.42 b	0.55 ab	1.20 a	0.58	58.85
Ryegrass	*Lolium multiflorum*	1.76 b	2.15 ab	2.69 a	2.47 ab	2.26	15.98
Triticale	×*Triticosecale*	0.65 b	0.80 ab	1.05 a	0.79 ab	0.82	18.81
Wheat	*Triticum aestivum*	0.82 b	1.41 a	1.12 ab	0.90 b	1.06	14.37

Means followed by the same letter in the line do not differ from each other at the 5% probability level by Tukey test.

Analysing each characteristic evaluated in isolation, it is difficult to reach a conclusion about the influence of saline water on seed germination and seedling development of *Poaceae* family species, therefore, the analysis needs to be joint.

The germination speed index, first count, mean germination time and mean germination speed are important characteristics that show the initial plant development, which in the soil is extremely important. The first days after sowing, when pests and diseases may attack seeds that remain for a long time without germinating, they may suffer physical, chemical and even biological damage.

There was great reduction in the germination speed index for the studied species, except for barley (Table 2). This may be related to the fact that the increase in the concentration of salt in the growing medium causes a reduction in the water potential, resulting in lower water absorption capacity by the seeds, which generally negatively influences the germination capacity [17]. The authors also reported that there is possibility of causing the disruption of the integumentary layers and causing damage to the embryo, which may lead to the death of the seeds. In this case, this did not occur as the germination percentage of the species was relatively high (Table 6).

In relation to the mean germination time, the shorter the time presented the better it was, as it means that shorter was the time presented by the species to germinate all viable seeds under the conditions in which they were found. Again, barley was not harmed by saline water, as seeds germinated at the same time with or without NaCl (Table 3). In the other species, there was an increase in the mean germination time as there was an increase in the concentration of sodium chloride, that is, the saline water somehow interfered in the initial germination process, but not enough to stop the whole process, as the germination occurred as shown in Table 6.

The first count is an ideal characteristic to identify the initial vigour of the lot being studied, it is evaluated according to each species according to the Rules for Seed Analysis, with the exception of ryegrass, all had high percentage of germinated seeds in the first days after sowing for the control and also for the minimum dosage of NaCl (Table 5). The ryegrass, in turn, presented a low germination percentage even for the control, which may be due to problems of the studied seed lot.

When we analyse the final percentage of germinated seeds, the situation changes and all species, with exception of rye and ryegrass, showed no statistical difference between any treatments, which means that seed germinated even with saline water occurred in satisfactory way (Table 6).

Lewandoski et al. [18] and Almeida et al. [19] found a decrease in the percentage of germination and first count and an increase in the mean germination time of radish seeds as the saline concentration in the irrigation water increased. In the same way, Ferreira et al. [20] and Soares et al. [21], studying different melon hybrids under salinity, found a reduction in seedling emergence speed as saline levels increased.

Brunes et al. [22] observed that the increase in saline concentration caused a decrease in the germination rate and in the germination speed index in different varieties of white oat, from the concentration of 75 mM NaCl, partially agreeing with the data presented in the present work in that there was a decrease in the germination speed index (Table 2), but there was no statistical difference for the final germination percentage (Table 6).

By presenting all these data from researches performed, it is observed that salinity affects germination in different ways in relation to the species. Salinity affects the osmotic potential of the soil, making the water unavailable to be absorbed, however, according to the results, the seeds of the species evaluated were tolerant to salinity in relation to germination, since in general, with the exception of rye and ryegrass was not affected [23].

The authors also affirmed that the reduction in water availability similarly affects all species, however, not all crops are affected by the same level of salinity, and some of them, being more tolerant than others, may extract water more easily and germinate satisfactorily.

Analysing the plants development, it was possible to observe that the salinity of irrigation water interfered with the growth of seedlings for all species, except for rice, which in the first level of salinity still presented an average without statistical difference from the treatment without NaCl. Thus, salinity did not significantly affect the germinal part, only delaying in some cases, however, in the development of plants there was great interference (Table 7).

The study of the tolerance of plants to salinity is of great importance, as salt is a limiting factor for agricultural production, causing two different types of stress: osmotic stress, which was mentioned previously when there is interruption of water absorption by plants, and ionic stress due to specific phytotoxicity. This last type of phytotoxicity causes decreased nutrient absorption, causing disturbances in metabolic activities in general affecting growth [24, 25, 26], probably what occurred in all species.

Even rice being the only one that showed non-significant means between the control and the first dose of NaCL, numerically the seedlings length in the control were higher and this occurred in all species in decreasing levels as the dose of NaCl increased. The greatest reduction in length was observed in oats with a drop of 59.9% compared to the first level of salinity, while the smallest drop was observed in ryegrass with a 20.7% reduction (Table 7).

Although salinity is harmful in all stages of plants, sensitive and moderately sensitive, there are species with greater sensitivity and others with greater tolerance to salts during the germination process [27]. This situation indicates [28] that species from the same family may respond differently, in the same exposure phase, as verified in this research. Among the species studied, some authors claim that rice is one of the most susceptible cereals to salinity, wheat is moderately sensitive, while barley is the most tolerant [10].

Last but not least, a feature that is undervalued is the synchronization index. This index demonstrates the level of organization or disorder of chemical reactions in the germination process [29, 30]. In its interpretation, the lower its value, the more synchronized will be the germination, regardless of the total number of germinated seeds [30].

In the present work, the only species that did not show statistical difference between any treatment (with or without NaCl) was rice, which means that there was synchrony in the germination of viable seeds in all treatments (Table 8) which corroborates the mean germination speed (Table 4) in which rice did not show statistical difference.

For the other species, oat was the only one that presented the lowest synchronization index in the control and that differed statistically from the treatment with some dosage of NaCl, which means the germination proceeded in a more orderly way in the control treatment compared to the saline treatments, reaffirming that salinity interfered with the absorption of water by the seeds, but not to the point of preventing germination and initial development as seedlings grew. This also occurred in barley, but the species tolerated a little more salinity up to the level of 3 g L^{-1} of NaCl, as well as ryegrass and triticale. In contrast, rye showed germination synchrony up to the level of 6 g L^{-1} of NaCl (Table 8).

The study of the effects of salinity on crops is extremely important nowadays, especially when we analyse why soils become saline, except for those that are due to their origin material. The use of uncontrolled irrigation without correct sizing may affect the amount of salts in the soil, mainly depending on the quality of the water used. Saline water tends to salinize the soil, as these elements do not evaporate like water and are not absorbed by the plants, resulting in their contamination. It is also important to study these effects on plants as even within the same family there are differences in the metabolism of salts, some being more sensitive than others.

Despite the considerable number of Poaceae family species studied in this research and of great economic interest for Brazil and the world, there are still thousands of species of this same family that need to be evaluated, so the conclusions of this research may not be extrapolated to the other species. Salt stress is a much more complex abiotic factor than we may imagine and should be investigated by further research to provide more scientific data needed for more sustainable and productive agriculture.

IV. Conclusion

The present work aimed to study the effects of saline water only from germination to the initial development of seedlings of seven species of the Poaceae family.

The use of water with the maximum concentration of sodium chloride (NaCl – 9.0 g L^{-1}) did not affect the final percentage of germination of barley, oats, rice, triticale and wheat. However, for rye and ryegrass, the maximum dose of NaCl not to interfere with the final germination percentage was 6 g L^{-1}.

Regarding the characteristics that demonstrate seeds vigour, only barley may be considered the most tolerant to salinity. Even under conditions of higher saline concentrations, the species showed uniform seed germination. The other species may be considered moderately tolerant to salinity, according to research data.

Salinity affected the initial development of all species, decreasing seedling length in the first NaCl dosage (3 g L^{-1}) in the irrigation water.

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