International Journal Semiarid

IRRIGATION WITH SALINE WATER AND USE OF ORGANIC MATTER CHANGE *Gliricidia sepium* SEEDS QUALITY

IRRIGAÇÃO COM ÁGUA SALINA E USO DE MATÉRIA ORGÂNICA AFETA A QUALIDADE DE SEMENTES DE *Gliricidia sepium*

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ABSTRACT:

The aim of this study was to evaluate effects of irrigation with saline water on the germination of *Gliricidia sepium* seeds linked to the effect of organic matter supplementation to mitigate recurrent effects of high salt content in water. The experiment was conducted under a completely randomized statistical design in a 5 x 2 factorial treatment design, with five different irrigation water electric conductivities ECw (0.5, 1.0, 2.0, 3.0 and 4.0 dS m^{-1}) and two organic matter supplementations (no-organic matter and organic matter supplementation), using five replicates. The experiment was carried out under tape knitted shade cloth, shading rate of 50%. Variables of average germination time (days), relative germination frequency (%) and informational entropy (bits) were analyzed. The increase in the irrigation water salinity caused a longer time needed for the *Gliricidia sepium* seeds to germinate, however, the use of organic matter performed as a mitigating factor for the effects caused by the high salt content in the irrigation water when a high frequency of germination was observed in shorter times.

KEYWORDS: germination, forage crop, semi-arid

RESUMO:

O objetivo com esse trabalho foi de avaliar os efeitos da irrigação com água salina na germinação de plantas de gliricídia (*Gliricidia sepium*) atrelado ao efeito da suplementação de matéria orgânica para mitigar os efeitos recorrentes do alto teor de sais na água. O experimento foi conduzido sob delineamento estatístico inteiramente casualizado em delineamento de tratamento fatorial 5 x 2, com cinco níveis de condutividade elétrica da água de irrigação (0,5; 1,0; 2,0; 3,0 e 4,0 dS m^{-1}) e dois níveis de suplementação de matéria orgânica (sem e com suplementação de matéria orgânica), utilizando cinco repetições. O cultivo experimental ocorreu em telado fechado em todas as faces e revestido com sombrite 50%. Foram analisadas as variáveis de tempo médio de germinação (dias), frequência relativa de germinação (%) e entropia informacional (bits). O aumento da salinidade na água de irrigação acarretou um maior tempo necessário para que ocorresse a germinação das sementes de gliricídia, porém o uso da matéria orgânica agiu como agente atenuante dos efeitos causados pelo alto teor de sais na água quando observado uma maior frequência de germinação em tempos mais curtos.

PALAVRAS-CHAVE: germinação, forragem, semiárido

INTRODUCTION

The search for effective food options, with reduced costs and that gather animal requirements in the Semiarid region, has represented one of the main challenges in animal production. This occurs because in semi-arid regions precipitation is irregular spatially and temporally, in addition in these regions evapotranspiration rates exceed precipitation rates. So, the use of preserved forage crop appears as a strategy to guarantee nutrition and stability in different ruminant production systems during periods of forage scarcity (Fluck *et al*., 2018).

Gliricidia or *Gliricidia sepium* is a perennial leguminous that is cultivated mainly for its multiple benefits. Gliricidia is often used for agroforestry, agroecological and soil improvement purposes, as well as being a source of forage for animals. This crop is known for growing quickly and for having allelopathic properties that involve the ability to release chemicals into the environment around it, affecting the growth of other plants (Ramamoorthy & Paliwal, 1993).

Gliricidia presents itself as one of alternatives to overcome obstacles of obtaining a source of good quality silage in semi-arid conditions. Sá *et al*. (2021) pointed out that the use of gliricidia crop associated with cactus silage is adequate to gather ruminant nutritional requirements, even when it is used as a complete feed.

Due to the high evapotranspiration rates in relation to precipitation rates, a major problem in semi-arid regions is both water and soil salinity. Water and soil salinity can be understood as a situation of excess soluble salts and these salts interfere with plant growth and development processes, impacting from germination to productivity. Salinity problem creates unfavorable conditions, such as osmotic stress, ion toxicity and nutritional imbalance, impairing the absorption of water and nutrients by plants and, consequently, reducing their adequate development (Farias, 2008).

Given the impasses caused by salinity, it is necessary to adopt a careful management approach when using lower quality water in agriculture. This involves implementing economically sustainable alternatives, ensuring that the crop gets its expected productivity, maintains product quality, and minimizes the risks associated with soil salinization (Medeiros *et al*., 2007).

The relevance of adding and preserving organic matter in highly weathered soils, such as those found in the semi-arid region, derives from its reduced content. This scarcity is generally associated with low soil pH, caused by the presence of aluminum oxides, as an example in the Brazilian semi-arid region. In addition, in agricultural systems where there is no input of nutrients from external sources, soil organic matter performs a crucial role as the main nutrient source (Primo *et al*., 2011).

Organic matter added into the soil stimulates the carbon mineralization process from various organic sources, resulting in the release of essential nutrients such as nitrogen, phosphorus, sulfur, and micronutrients even at high salinity levels, reducing the harmfulness of salts to soil biota, stimulating germination and plant development (Júnior *et al*., 2009).

Given the premises presented, the aim of this study was to evaluate the effects of irrigation with saline water on the germination of gliricidia (*Gliricidia sepium*) seeds linked to the effect of organic matter supplementation to mitigate the recurring effects of high salt content in the water.

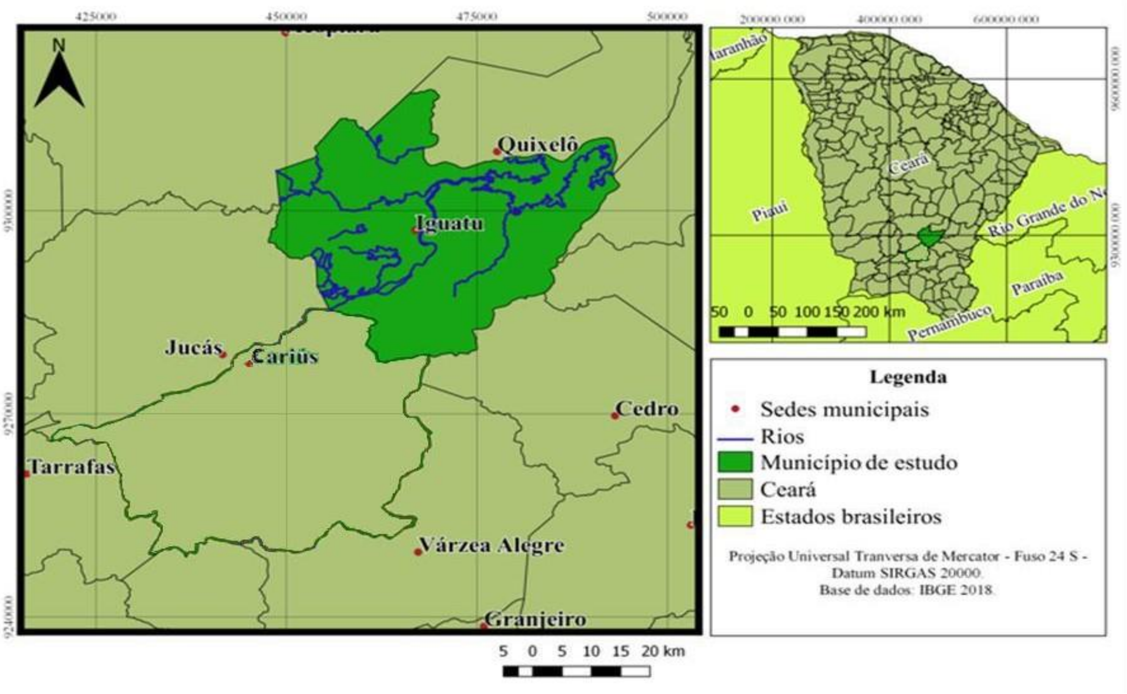
MATERIAL AND METHODS

The experiment was carried out over a period of 21 days, at the Instituto Federal de Educação, Ciência e Tecnologia do Ceará (IFCE), Iguatu City, Ceará State, Brazil (Figure 1), coordinates 6°23'3” S and 39º15 '59” W, altitude of 220 m, with a climatic characterization of the BSw'h' type according to Koppen's classification, which presents itself as a hot semi-arid. The average potential evapotranspiration, in the experimental area, is 1,988 mm a year, and the historical average precipitation is 864 ± 304 mm a year (average from 1932 to 2013). The temporal distribution of rainfall presents a concentration of 85% in the period January-May, of which around 30% is recorded in the month of March, according to Santos (2015).

The experimental cultivation was carried out under tape knitted shade cloth, shading rate of 50%, thus allowing 50% of solar radiation to pass through, with structure was made of wood, measuring 2.0 m in height, 24.0 m wide and 20.0 m long. A completely randomized statistical design and a 5 x 2 factorial treatment design were adopted, so that the main factor was composed of five different irrigation water electric conductivities ECw (S1= 0.5 dS m^{-1}, S2= 1.0 dS m^{-1}, S3= 2.0 dS m^{-1} and S4= 4.0 dS m^{-1}) and two organic matter supplementations (no-organic matter: N-OM, and organic matter: OM, supplementation) as secondary factor. Five replications were used and in each replication 12 gliricidia seeds were sown in 8L pots, totaling 60 seeds per treatment.

In the main factor, which was of a quantitative order and consisted of different irrigation water electric conductivities levels, to obtain levels from S2 to S4, water from level S1 (0.5 dS m^{-1}) was used with the addition of sodium chloride (NaCl), considering 10 mM NaCl to obtain 1 dS m^{-1} and it was monitored with a conductivity meter.

Figure 1 - Geographic location of the Iguatu city at the Ceará State, where the experiment was carried out.



Source: by author

Irrigation management was based on climatic conditions, based on the daily estimate of crop evapotranspiration – ETc, with a volume equivalent to 100% of ETc being replaced daily in the pots, according to the reference evapotranspiration – ETo made available by the Instituto Nacional de Meteorologia – INMET. ETc was estimated from the multiplication of reference evapotranspiration (ETo) by the crop coefficient (Kc = 1,0), ETo was obtained according to the Penman-Monteith methodology proposed by FAO (Allen et al., 1998) presented in Equation 1.

$$ETo = \frac{0{,}408.\Delta.(Rn - G) + \gamma.\frac{900}{T+273}.U_2(e_s - e_a)}{\Delta.\gamma.(1 + 0{,}34.U_2)} \qquad (1)$$

Where:

ETo – reference evapotranspiration (mm.dia^{-1});

Δ – slope vapor pressure curve (kPa.^{o}C^{-1});

Rn – net radiation at the crop surface (MJ.m^{-2}.dia^{-1});

G – soil heat flux density (MJ.m^{-2}.dia^{-1}),

ϒ – psychrometric constant (Kpa.^{o}C^{-1});

T – mean daily air temperature (^{o}C);

U2 – wind speed at 2m height (m.s^{-1});

(ea-ed) – saturation vapor pressure deficit (kPa).

However, as it is a cultivation in a protected environment, the ETo values used in the estimates of the applied water depths were multiplied by the factor 0.70, with a view to correcting ETo depending on the cultivation environment, considering that, in general, evapotranspiration inside the protected environment is around 70% of that verified externally (Viana, 2000).

The soil used as substrate, in the secondary factor, which was of a qualitative order, belongs to the Neossolos class. For this characterization, soil sampling was carried out in the 0.00 - 0.20 m layer, which were extracted using an auger. The soil samples were crushed, homogenized, and passed through a sieve with a 4 mm opening. Aiming to constitute a representative composite sample, for the purposes of characterizing the physical and chemical attributes of the soil, the initial subsamples were homogenized and from these a composite sample was taken and sent to the Laboratório de Solos, Água e Tecidos Vegetais (LABSAT), Limoeiro do Norte city, and the results are presented in Table 1.

Table 1. Physical and chemical attributes of the soil used as substrate.

Granulometric composition				Textural class	Density		Total porosity
Coarse sand	Thin sand	Silt	Clay		Soil	Solids	
(---------------- g kg^{-1}			---------------)	(-)	(-- g cm^{-3}	--)	(- cm^{3} cm^{-3} -)
363	426	151	59	Sandy loam	1.45	2.69	0.46

C	O.M.	P	K	Ca	Mg	Na	Al	H + Al
(---- g kg^{-1}	----)	(mg dm^{-3})	(----------------------		mmol$_c$ dm^{-3}			----------------------)
16.78	28.92	156	4.72	70.4	22.6	1.54	N.D.	N.D.
SB	CEC	V	m	ESP	pH	EC	Classification	
(mmol$_c$ dm^{-3})		(------------	%	-----------)	(-)	(dS m^{-1})		
99.3	99.3	100	2	0	7.2	1.17	Normal	

[1] N.D. – not detectable by the method; pH – hydrogen potential, EC – electrical conductivity of soil saturation extract; SB – sum of bases; CEC – cation exchange capacity; V – percentage of base saturation; ESP –exchangeable sodium percentage; C - organic carbon; O.M – organic matter; Classification - Richards (1954 *apud* Ribeiro, 2010).

In the secondary factor of the experimental design, regarding the organic matter supplementation, cattle manure from the experimental farm was used as a source of organic matter. In the treatment with application of organic matter, a volume ratio of 1:1 (soil:organic matter) was used, incorporating the organic matter into the soil and homogenizing it before filling pots.

Gliricidia seeds went through a dormancy breaking process, in which their dormancy was broken by immersion in water for a period of 12 hours before sowing. Observations regarding germination were carried out daily over a period of 21 days from sowing. The response variables to evaluate seed quality through the germination process were average germination time (t) in days (Equation 2), relative frequency of germination (Fr) in % (Equation 3) and informational entropy (E) in bits (Equation 4). Theses equations follow the methodology described by Laborial & Valadares (1976).

$$t = \frac{(\sum_{i=1}^{k} ni \cdot ti)}{\sum_{i=1}^{k} ni} \qquad (2)$$

Where:

t = average germination time in days;

ni = number of seeds germinated per day;

ti = incubation time in days.

$$F_r = \frac{ni}{\sum_{i=1}^{k} n_i} \qquad (3)$$

Where:

Fr = relative germination frequency %;

ni = number of seeds germinated per day;

∑ni = total number of germinated seeds.

$$E = \sum_{i=1}^{k} fi \cdot log\, 2 \cdot fi \qquad (4)$$

Where:

E = informational entropy in bits;

Fi = relative frequency of germination;

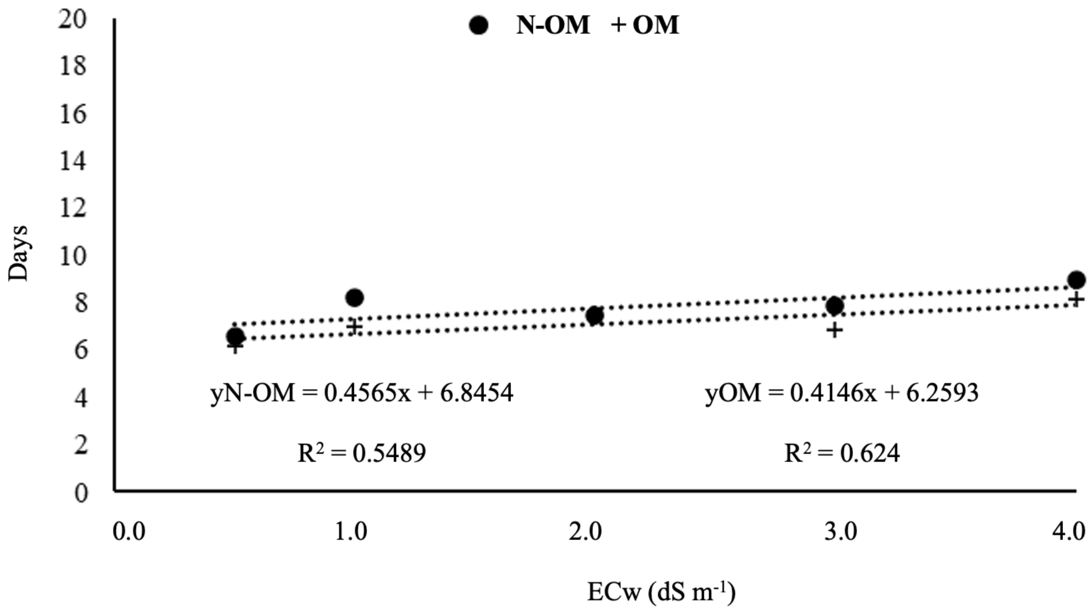
log 2 = logarithm in base 2.

The data from variables were subjected to analysis of variance (ANAVA) using the *F* test at 1% and 5% probability. Due to the significant effect in the analysis of variance, the quantitative treatments were subjected to regression analysis, with the objective of finding the equation that best represented the relationship between variables and treatments, and the qualitative treatments were subjected to the test Tukey test at the 5% significance level. Statistical analyzes were performed with the by SISVAR ® statistical software (Ferreira, 2000).

RESULTS AND DISCUSSIONS

Analyzing the average germination time, it can be seen in figure 2 that the increase in the ECw level resulted in an increase in the time needed for seed germination to occur, going from 6.57 to 8.94 days when considering the lowest and highest level of ECw analyzed, respectively, without supplementation of organic matter in the soil. Analyzing treatments that received organic matter, the values increase from 6.13 (S1) to 8.14 days (S5). In other words, an increase of 2.37 days when ECw was increased and do not have organic matter supplementation, and an increase of 2.01 days when ECw was increased and had organic matter supplementation. This result can be justified by the fact that an increase in salt concentration causes a decrease in osmotic potential, leading to a reduction in the seed ability to absorb water and influencing germination capacity (Rebouças *et al.*, 1989).

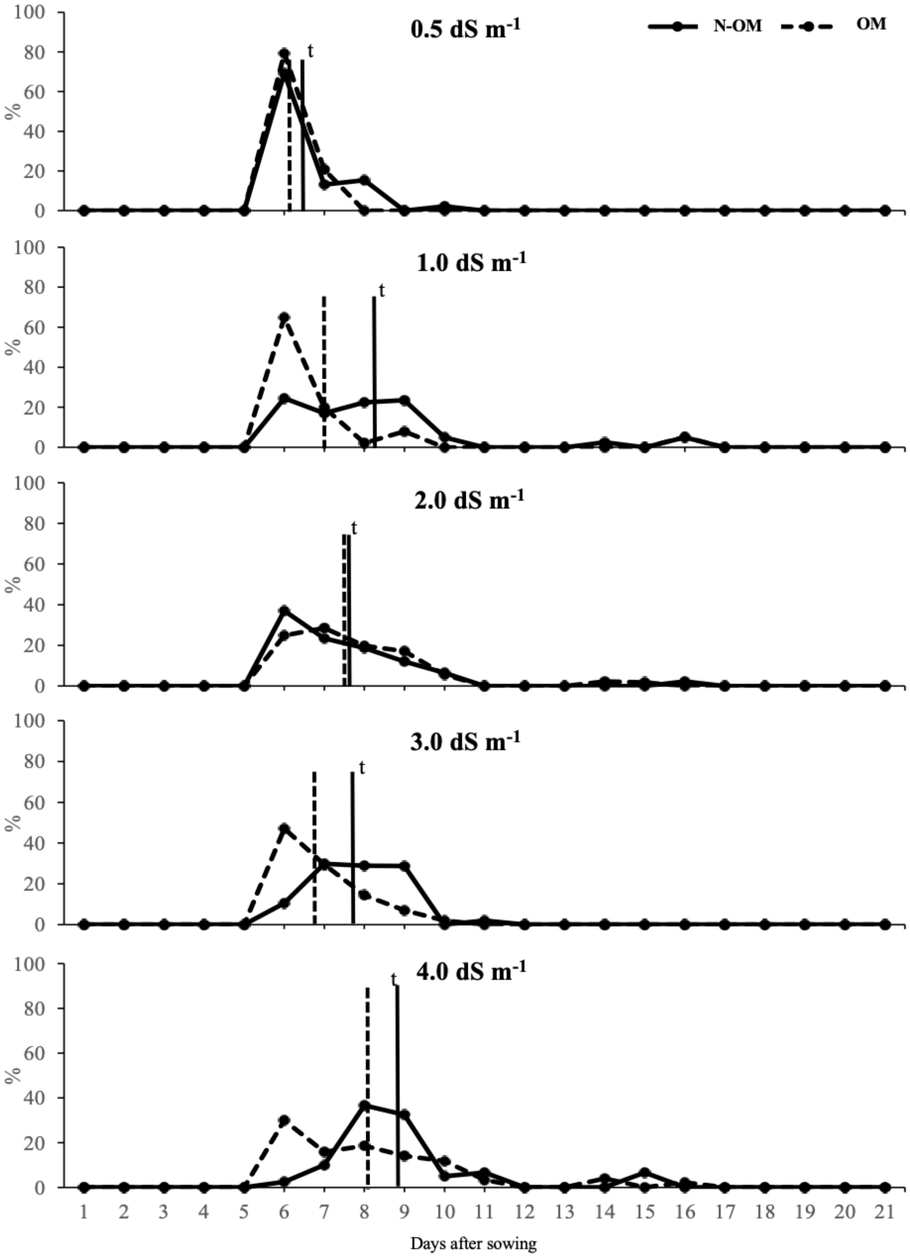
Figure 2 - Average germination time (t) of *Gliricidia sepium* seeds submitted to different ECw levels (0.5; 1.0; 2.0; 3.0 and 4.0 dS m^{-1}) associated with organic matter (OM) or no-organic matter (N-OM) added in the soil. Iguatu, Ceará 2023[1].



Average germination times were similar between treatments with and without OM supplementation, however, the soil with organic matter showed a faster germination process than without organic matter. The increase in ECw up to the value of 1 dS m^{-1} caused a higher distance from the average germination time values, and it can be observed that the soil containing organic matter provided most germination agility for the seeds (Figure 3).

Highest levels of ECw (3.0 and 4.0 dS m^{-1}) maintained the tendency of differentiation between average time values, always presenting organic matter as influencing and mitigating effects caused by irrigation water salinity on the gliricidia seeds germination (Figure 3). Study of different crops submitted to salinity stress in germination process is due to germination being the most sensitive stage of development to salinity, regardless of the tolerance of the mother plant to salt (Mayer & Poljakoff-Mayber, 1989).

Figure 3 - Relative germination frequency (Fr) of *Gliricidia sepium* seeds submitted to different ECw levels (0.5; 1.0; 2.0; 3.0 and 4.0 dS m^{-1}) associated with organic matter (OM) or no-organic matter (N-OM) added in the soil. t = vertical bars of average germination time. Iguatu, Ceará 2023[1].



The supplementation of organic matter in the soil resulted in a reduction in germination time across different ECw levels, showing that organic matter offers potential as a source to mitigate effects caused by the high salt content in irrigation waters (Figure 3). These results were also illustrated by Júnior et al. (2009), when they say that organic matter can reduce osmotic stress, providing nutrients even in conditions of high electrical conductivity, improving soil structure for seed germination, in addition to favoring microbial activity, which is responsible for improving soil quality.

Pacheco *et al.* (2020), studying effects of high salinity levels in irrigation water on the sunflower germination, found that substrate choice directly influences salinity effects, with the substrate with the highest organic matter content being ideal for mitigating the salinity deleterious effects.

The relative germination frequency (Figure 3) represents a tool for studying the distribution over time of germination. Through frequencies it is possible to observe over time whether the seeds germinate until reaching a maximum value and then decline, or if germination reaches a maximum, declines, and then increases again (Barros *et al.*, 2016).

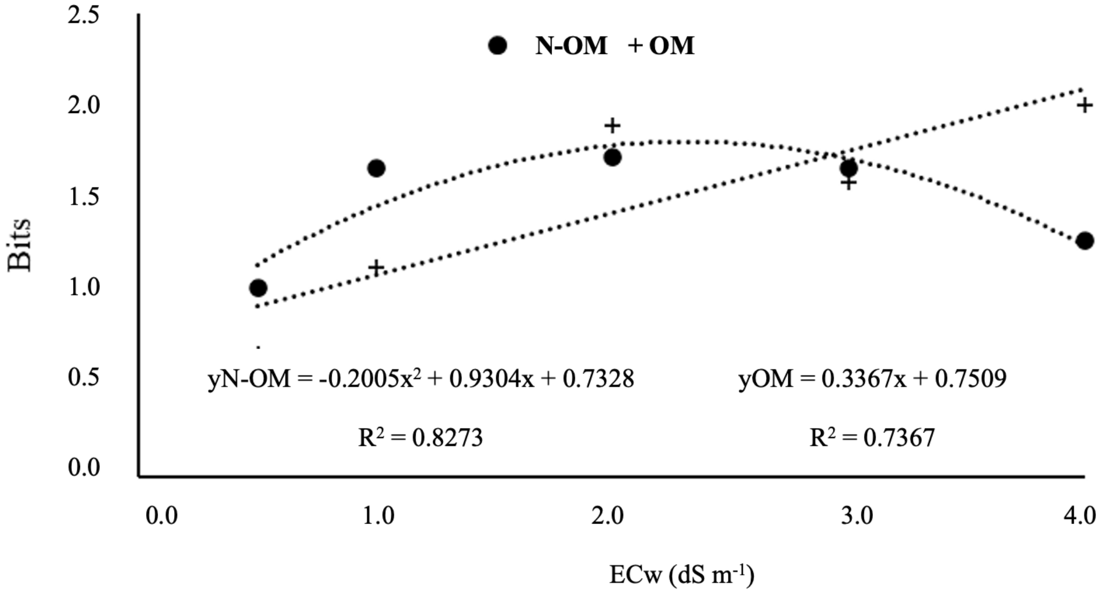
With the relative germination frequency values (Figure 3), it was evident that the salinity levels of the irrigation water interfered with the daily germination rate of gliricidia seeds. Evaluating seed germination at ECw 0.5 dS m^{-1}, it is possible to observe that the germination frequency peaks in 6 days, regardless of the application or not of organic materials, and with unimodal characteristics. However, when analyzing the treatment with the highest ECw (4.0 dS m^{-1}) and with organic matter supplementation, it is possible to observe a germination frequency peak maintained over 6 days, with a less pronounced unimodal characteristic, however, when organic matter is not supplemented in the soil, the peak germination frequency increases to 8 days, and with a polymodal characteristic (Figure 3).

When analyzed both frequency and average germination time (Figure 3), a deviation of the germination time to the right of the main frequency distribution mode is observed. This same analysis was observed by Barros et al. (2016), when studying germination under adverse temperature conditions in *Pereskia aculeata*, and authors report that the asymmetry of distribution shows that heterogeneity is due either to a majority of seeds that take a long time to germinate or to a minority of seeds that germinate very quickly (or both), depending on the temperature. Possibly the adverse effect of the salinity of the irrigation water caused the same action.

As seed germination is generally not perfectly synchronized, it is still possible to quantify the variation in germination over time through another parameter for evaluating the germination process called germination synchrony (Santana & Ranal, 2004). Speed and timing are very important because they reduce the degree of exposure of seeds and seedlings to adverse factors (Marcos Filho, 2005).

From the results of informational entropy values obtained in the present study (Figure 4), it could be observed that there was a significant interaction for ECw levels associated with supplementation (or not) of organic matter, generating different responses in relation to germination homogeneity. The informational entropy values (Bits) showed an increasing linear trend when organic matter was added to the soil, the absence showed a polynomial function of the second degree (Figure 4).

Figure 4 - Informational entropy (E) in germination of *Gliricidia sepium* seeds submitted to different ECw levels (0.5; 1.0; 2.0; 3.0 and 4.0 dS m^{-1}) associated with organic matter (OM) or no-organic matter (N-OM) added in the soil. Iguatu, Ceará 2023[1].



Informational entropy calculations demonstrated that the increase in salinity in soil with the presence of organic matter is inversely proportional to the homogeneity of gliricidia seeds germination (Figure 4). According to Nassif and Perez (2000), this fact occurs due to the fact that lower entropy values represent greater homogeneity and synchronization in a germination process.

Checking the entropy trend line, considering the ECw and the soil without organic matter supplementation, it is possible to observe that the entropy value reaches its peak at the value of 1.812 bits at 2.32 dS m^{-1}. Therefore, it is plausible to state that until reaching the maximum value (2.32 dS m^{-1}) the increase in the salt content in the irrigation water causes greater unevenness in germination (Figure 4).

Analyzing the interaction between different substrate types (N-OM and OM), it is clear that the intersection between the equations occurred at CEa = 2.96 dS m-^{1} and Bits = 1.75. Therefore, it is identified that in ECw up to 2.96 dS m^{-1}, organic matter provided, relatively, a greater uniformity of germination, from this value onwards, the soil with no incorporation of organic fertilizer demonstrated a lower entropy value.

The results of the present study are in line with those found by Jeller & Perez (2001), who, when evaluating the informational entropy variable in the germination of *Senna spectabilis* seeds submitted to water saline stress, concluded that there is a decrease in the synchronization of the germination process as the osmotic potentials of saline solutions are reduced.

CONCLUSIONS

Increase in salt concentration in irrigation water causes delays and disturbances in gliricidia seeds germination, reducing their quality. However, organic matter supplementation in the soil provides to gliricidia seeds a better condition for germination, reducing the average germination time and concentrating the germination frequency earlier days, thus making the application of organic matter effective in mitigating adverse effects caused by the high concentration of salts in irrigation water during germination.

REFERENCES

ALLEN, R. G.; PEREIRA, L. S.; RAES, D.; SMITH, M. **Crop Evapotranspiration: guidelines for Computing Crop Water Requirements**, vol. 56. Rome: FAO, 1998. 15p.

FARIAS, S. G. G. **Estresse osmótico na germinação, crescimento e nutrição mineral de gliricídia (*Gliricidia sepium* (Jacq.)**. 61f. (Dissertation – Master degree) UFCG. Brazil, 2008.

FERREIRA, D. F. **Análises estatísticas por meio do Sisvar para Windows versão 4.0**. In. Reunião anual da região brasileira da sociedade internacional de biometria, 45, 2000. São Carlos, SP: SIB, p. 255-258, 2000.

FLUCK, A.C., SCHAFHÄUSER JÚNIOR, J., ALFAYA JÚNIOR, H., COSTA, O.A.D., FARIAS, G. D., SCHEIBLER, R. B., RIZZO, F. A., MANFRON, J. A. S., FIOREZE, V. I., RÖSLER, D. C. Composição química da forragem e do ensilado de azevém anual em função de diferentes tempos de secagem e estádios fenológicos. **Arquivo Brasileiro de Medicina Veterinária e Zootecnia**, 70(6), p.1979-1987, 2018.

JELLER, H; PEREZ, S. C. J. G. Efeitos dos estresses hídrico e salino e da ação de giberelina em sementes de *Senna spectabilis*. **Ciência Florestal**, v. 11, p. 93-104, 2001.

JÚNIOR, J. M.; TAVARES, R. D. C.; MENDES FILHO, P. F.; GOMES, V. F. Efeitos de níveis de salinidade sobre a atividade microbiana de um Argissolo Amarelo incubado com diferentes adubos orgânicos. **Revista Brasileira de Ciências Agrárias**, Recife, v. 4, n. 4, p. 378-382, 2009.

LABOURIAU, L.G., VALADARES, M.E.B. **On the germination of seeds Calotropisprocera (AIT.) AIT.f.** An. Acad. Bras. Cienc. 48, 263–284, 1976.

MARCOS FILHO, J. **Fisiologia de sementes de plantas cultivadas**. Piracicaba: Fealq, 2005. 465 p.

MAYER, A.M.; POLJAKOFF-MAYBER, A. **The germination of seeds**. 4.ed. Great Britain: Pergamon Press, 270p, 1989.

MEDEIROS, J. F. de; SILVA, M. C. C.; SARMENTO, D. H. A.; BARROS, A. D. de. Crescimento do meloeiro cultivado sob diferentes níveis de salinidade, com e sem cobertura do solo. **Revista Brasileira de Engenharia Agrícola e Ambiental**, v.11, p.248-255, 2007.

NASSIF, S. M. L.; PEREZ, S. C. J. G. Efeito da temperatura na germinação de sementes de amendoim-do-campo (*Pterogyne nitens Tul.*). **Revista Brasileira de Sementes**, v.22, n.1, p.1-6, 2000. DOI: 10.17801/0101-3122/rbs.v22n1p1-6.

PACHECO, A. G.; ALMEIDA, C. A. C.; DIAS, M. S., REIS, L. S.; ELIAS, J. J.; PINTO, A. D. V. F.; SILVA, T. S. S. Germinação e crescimento inicial de girassol (*Helianthus annuus L.*) sob diferentes substratos submetidos a estresse salino. **Brazilian Journal of Development**, 6(9), 71281-71296, 2020.

PRIMO, D. C.; MENEZES, R. C.; SILVA, T. O. Substâncias húmicas da matéria orgânica do solo: uma revisão de técnicas analíticas e estudos no nordeste brasileiro. **Scientia Plena**, [*S. l.*], v. 7, n. 5, 2011.

RAMAMOORTHY, M.; PALIWAL, K. Allelopathic compounds of Gliricidia sepium (Jacq) Kunth ex Walp. And its effect on *Sorghum vulgare L*. **J. Chem. Ecol**., v. 19, n. 8, p. 1691-1701, 1993.

REBOUÇAS, M.A.; FAÇANHA, J.G.V.; FERREIRA, L.G.R.; PRISCO, J.T. Crescimento e conteúdo de N, P, K e Na em três cultivares de algodão sob condições de estresse salino. **Revista Brasileira de Fisiologia Vegetal**, v.1, n.1, p.79-85, 1989.

SÁ, F. P.; SÁ, C. O.; SÁ, J. L.; AMORIM, J. A. E.; MENEZES, T. S. A.; LÉDO, A. S. (2014). Desenvolvimento inicial *in vitro* de gliricídia em diferentes níveis de salinidade. **Scientia Plena**, v. 10, n. 4 (a), 2014.

SÁ, M. K. N., DE ANDRADE, A. P., MAGALHÃES, A. L. R., DE LIMA VALENÇA, R., CAMPOS, F. S., DOS SANTOS ARAÚJO, F., & DE ARAÚJO, G. G. L. Silagem de palma forrageira com *Gliricidia Sepium*: alternativa alimentar para o Semiárido. **Research, Society and Development**, 10(2), e27210212473-e27210212473, 2021

SANTANA, D.G., RANAL, M.A. **Análise da germinação: um enfoque estatístico**. 1 ed. Universidade de Brasília, Brasília, 2004. 247 p.

SANTOS, J. **Processos hidrológicos e sedimentológicos em clima semiárido tropical**. 2015. 168 f. Thesis (Phd in Agricultural Engineer), Universidade Federal do Ceará, Fortaleza, 2015.

SOUZA, L.F., GASPARETTO, B. F., LOPES, R. R., & BARROS, I. B. Temperature Temperature requirements for seed germination of *Pereskia aculeata* and *Pereskia grandifolia*. **Journal of Thermal Biology**, v. 57, p. 6-10, 2016.