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PRODUTIVIDADE DA CULTURA DO AMENDOIM SOB DIFERENTES SUPRESSÕES DA IRRIGAÇÃO COM ÁGUA SALINA

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1 RESUMO

O déficit hídrico associada ao estresse salino afetam a produtividade das culturas agrícolas. Objetivou-se avaliar a produtividade da cultura de amendoim irrigado com água de baixa e alta salinidade submetida a diferentes intervalos de supressão. O experimento foi conduzido em condições de campo, no período de agosto a outubro de 2019 na Fazenda Experimental de Piroás, Redenção-CE. O delineamento experimental utilizado foi o de blocos ao acaso em arranjo fatorial, sendo o primeiro fator a salinidade das águas de irrigação (1,0 e 4,0 dS m^{-1}) e o segundo fator, quatro intervalos de supressões (IS1= 40 a 55 DAS; IS2 = 55 a 70 DAS; IS3 = 70 a 85 DAS e IS4 = sem intervalos de supressão), com quatro repetições. Foram avaliadas as seguintes variáveis: número, massa, comprimento e diâmetro de vagem e a produtividade. O tratamento sem intervalo de supressão hídrica associado a água de menor salinidade proporcionam maior número e diâmetro de vagem. A água de maior salinidade afeta a massa e comprimento de vagem. A utilização da água de maior ou menor salinidade sem intervalo de supressão da irrigação proporciona maior produtividade da cultura do amendoim.

PALAVRAS CHAVES: *Arachis hypogaea L.,* déficit hídrico, estresse salino

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2 ABSTRACT

The water deficit associated with salt stress affects the productivity of agricultural crops. The objective was to evaluate the productivity of peanut culture irrigated with low and high salinity water submitted to different suppression intervals. The experiment was conducted under field conditions, from August to October 2019 at the Experimental Farm of Piroás, Redenção-CE. The experimental design used for the randomized blocks in a factorial arrangement, with the first factor is the salinity of the irrigation water (1.0 and 4.0 dS m^{-1}) and the second factor, four suppression intervals (IS1 = 40 a 55 DAS; IS2 = 55 to 70 DAS; IS3 = 70 to 85 DAS and IS4 = without suppression intervals), with four repetitions. The following variables were evaluated: number, mass, pod length and diameter and yield. Treatment without water suppression interval associated with less saline water provides a greater number and diameter of pods. Higher salinity water affects pod mass and length. The use of water of greater or lesser salinity without interval of suppression of irrigation offers the highest yield of the peanut culture.

Keywords: *Arachis hypogaea L.,* water déficit, saline stress.

3 INTRODUCTION

Among oilseeds in Brazil, the peanut tree *(Arachis hypogaea L.)* has agricultural and industrial functions and is of great economic importance, as it has high nutritional value and can be used directly in human food, in the canning industry, in confectionery and in biodiesel (NAKAGAWA; ROSOLEM, 2011). According to CONAB (AMENDOIM, 2020), the crop has an average productivity of 3,738 kg ha $^{-1}$, proving to be profitable and promising, providing producers with an economic return, since peanuts have several nutritional functions.

Irrigation is a strategy that ensures production safety, as it promotes ideal conditions for crop development. On the other hand, water quality is a limiting factor, as excess soluble salts associated with water deficits are responsible for the decline in crop productivity, especially in arid and semiarid regions (FENG et al., 2017; RODRIGUES et al., 2020).

The salinity of irrigation water is one of the main environmental stresses that affects plant metabolism, compromising the physiological and biochemical indices of plants, which results in disturbances in water relationships, changes in the absorption and use of nutrients, the accumulation of toxic ions and, consequently, the productivity of agricultural crops (PEREIRA FILHO et al., 2019; TAIZ et al., 2017).

According to Carvalho et al. (2016), the negative effects of water deficit can vary according to species, cultivar, exposure time and soil factors. Under conditions of water suppression, plants reduce stomatal conductance and transpiration, causing photosynthesis disorders and affecting plant development and production (FREITAS et al., 2020; MELO et al., 2020).

In view of the above, the present work aims to evaluate the productivity of peanut crops irrigated with low- and high-salinity water subjected to different suppression intervals.

4 MATERIALS AND METHODS

The research was carried out in July 2019 at the experimental farm of the University of International Integration of

Afro-Brazilian Lusophony (UNILAB), Redenção, Ceará. The climate of the region is of the Aw ' type and is characterized as tropical rainy and very hot, with predominant rainfall in the summer and autumn seasons (K Ö PPEN, 1923).

The soil in the experimental area is classified as Red–Yellow Argisol (EMBRAPA, 2018), with a soil density of 1.4 dm $^{-1}$ and a textural class of sandy loam. The chemical properties are shown in Table 1.

Table 1. Physical and chemical characteristics of the soil

Features	Values
MO (g kg $^{-1}$)	11.9
N (g kg $^{-1}$)	0.75
P (mg kg $^{-1}$)	16
K^{+} (cmol $_{c}$ kg $^{-1}$)	0.14
Ca^{2+} (cmol $_{c}$ kg $^{-1}$)	4.5
Mg^{2+} (cmol $_{c}$ kg $^{-1}$)	1.9
Na^{+} (cmol $_{c}$ kg $^{-1}$)	0.23
$H^{+}+Al^{3+}$ (cmol $_{c}$ kg $^{-1}$)	1.98
Al (cmol $_{c}$ kg $^{-1}$)	0.2
SB (cmol $_{c}$ kg $^{-1}$)	6.8
CEC (cmolc kg $^{-1}$)	8.8
V (%)	77
CEes (dS m $^{-1}$)	0.19
pH	6.6

MO = organic matter, SB = sum of bases, CEC = cation exchange capacity, V = base saturation and CEes = electrical conductivity of the saturated soil extract

The peanut crop was sown manually on July 4, 2019, at a spacing of 1.0 × 0.3 m. At 10 days after sowing (DAS), 100% germination was observed; thinning was then carried out, leaving only one plant per hole. Treatment differentiation occurred at 40 DAS (beginning of gynophore appearance).

The experimental design was randomized blocks in a factorial arrangement with four replications, with the first factor being the salinity of the irrigation water (1.0 and 4.0 dS m $^{-1}$) and the second factor being four suppression intervals: IS1 = 40 to 55 DAS (gynophore appearance and pod formation); IS2 = 55 to 70 DAS (pod formation and end of flowering); IS3 = 70 to 85 DAS (complete pod maturation); and IS4 = no suppression intervals. Each treatment consisted of 15 days without irrigation on different dates throughout the days after planting (DAP). Until the first irrigation suppression interval, irrigation was carried out with waters of 1.0 and 4.0 dS m $^{-1,}$ with an irrigation frequency of two days for all the treatments.

The irrigation system used was a drip system. The emitter flow rate was 8.0 L h $^{-1}$, with a spacing of 0.30 m between drippers, and a 0.5 hp centrifugal pump pumped water from the water tanks to the system itself. The amount of water applied was calculated on the basis of the crop coefficient (Kc) (DOORENBOS; KASSAM, 1994) and reference evapotranspiration (ET $_{0}$) estimated via the class A tank method, which was installed near the experimental area, with a 2-day irrigation shift.

The saline water samples were prepared with the salts NaCl, CaCl2.2H2O and MgCl2.6H2O, at a ratio of 7:2:1, in nonsaline water (0.5 dS m^{-1}), and the results were in accordance with the relationship between the ECa and its concentration (mmol $_c$ L $^{-1}$ = CE × 10), according to Rhoades, Kandiah and Mashali (2000). For irrigation, a coefficient of distribution uniformity (CUD) of approximately 92% was used.

The irrigation time was estimated via Eq. 1:

$$Ti=\frac{ETc \times Ep}{Ea \times q}\times 60 \quad (1)$$

where:
Ti - irrigation time (min);
ET $_c$ - crop evapotranspiration (mm);
Ep - spacing between drippers (m);
Ea - application efficiency (0.9); and,
q - flow rate (L h^{-1}).

A leaching fraction of 0.15 was added to the depth to be applied before and during treatment differentiation (AYERS; WESTCOT, 1999). The depths applied at the different suppression intervals are indicated in Table 2.

Table 2. Total water depth before and after the suppression interval

Treatments	AIS [1]	DIS [2]	Total [3]
		(mm)	
IS1	140	305	445
IS2	218	265	483
IS3	335	185	520
IS4 (No suppression)	-	-	550

[1, 2] Before and after the suppression interval, respectively; [3] = corresponds to the total amount of water applied per treatment.

At the end of the peanut growth cycle (90 DAS), of the twelve plants in each experimental plot, six were harvested from the central row (useful plot) and identified. They were then allowed to dry in a forced circulation oven at 60 °C for 72 hours or until they reached constant mass. After drying, the samples were processed, and the following variables were evaluated: number of pods per plant (NVP) (counting commercial pods), pod mass (MV) (using a precision scale), pod length (CVa) (measured with a ruler graduated in centimeters), pod diameter (DV) (checked with a digital caliper, expressed in millimeters) and productivity (calculating the mass of 1,000 grains and dividing by one hectare).

The data obtained were subjected to analysis of variance (ANOVA). For significant variables according to the F test, the means were compared via the Tukey test ($p \leq 0.05$) via ASSISTAT. 7.7 Beta computer program. (SILVA; AZEVEDO, 2016).

5 RESULTS AND DISCUSSION

According to the analysis of variance (Table 3), there was an interaction effect between the factors saline water (AS) and the suppression interval (IS) for the variables number of pods per plant (NV), pod diameter (DV) and productivity (PROD) and an isolated effect for pod length (CVa) and pod mass (MV) at the 5% probability level ($p < 0.05$).

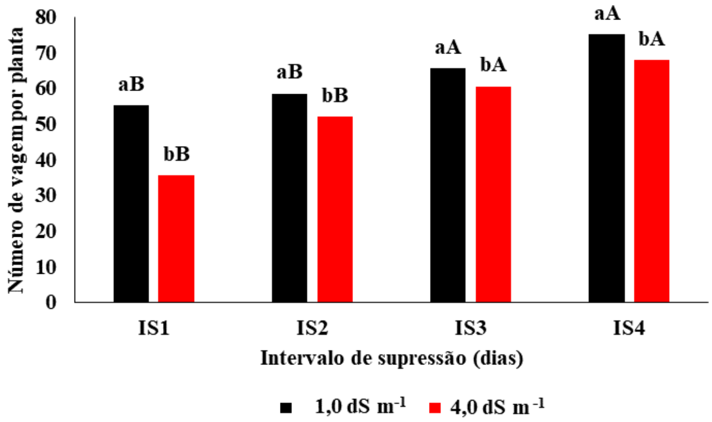
Table 3. Summary of analysis of variance for the number of pods (NV), pod mass (MV), pod length (CVa), pod diameter (DV) and yield (PROD) of peanut plants subjected to irrigation suppression intervals and saltwater.

FV	GL	Mean square				
		NV	MV	CVa	DV	PROD
Saline water (SA)	1	743.47**	0.00118*	1.71**	8.27**	987,192.31**
Suppression Interval (SI)	3	991.62**	0.00195**	0.57**	5.28**	4,670,699.88**
AS x IS	3	92.26*	0.00003 ns	0.14 ns	4.39**	623,244.88**
Treatments	7	570.73**	0.00102**	0.55**	0.55**	2,409,860.94**
Residue	24	29.92	0.00016	0.08	0.67	92,003.47
Total	31	-	-	-	-	-
CV%	-	9.3	30.27	9.94	6.65	17.94
MG	-	58.79	0.042	3	12.37	1691.08

FV = source of variation, CV = coefficient of variation, MG = overall mean, GL = degree of freedom, ** significant at the 5% probability level ($p < 0.05$). NS = not significant; MG = overall mean.

Figure 1 shows that pod number was influenced by the interaction between irrigation water and suppression intervals, in which 1.0 dS m $^{-1}$ water was superior and differed statistically from 4.0 dS m $^{-1}$ water in all suppression intervals, with intervals IS3 and IS4 days being superior to the others. These results reveal a possible tolerance to water and salt stress in peanut crops under field conditions.

Figure 1. Number of pods per peanut plant as a function of water electrical conductivity under different irrigation suppression intervals.



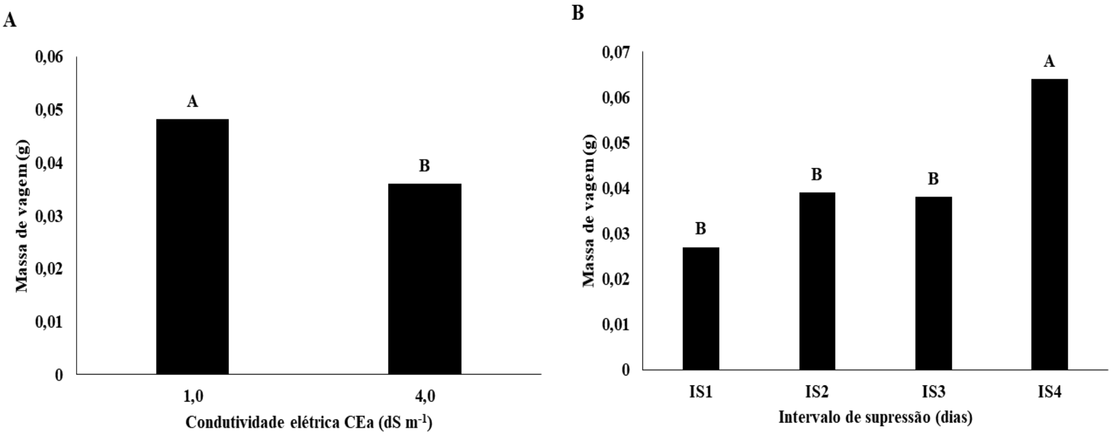
Columns followed by the same uppercase letters at the same suppression interval level, or lowercase letters at the same salinity level, do not differ significantly from each other according to the Tukey test ($p \leq 0.05$).

The effect of salinity stress associated with water stress on the IS1 intervals and IS2 caused a reduction in the emission of reproductive branches, in addition to increasing the abortion rate, reducing the length and quantity of pods, and directly reflecting the later stages (complete maturation of the pod and grain).

Correia et al. (2009), evaluating the use of saline water at a five-day irrigation interval, also reported a decrease in the number of pods. Similarly, Lima et al. (2020) demonstrated similarities with sesame crops. These same authors reported that the use of saline water during the vegetative and flowering phases contributes to a reduction in the number of pods.

Figure 2A shows that the lower-salinity water was statistically superior to the higher-salinity water for VM. This reduction can be attributed to the detrimental effect that salinity has on water flow in the plant and, consequently, to the nutritional disturbance that may have negatively interfered with grain filling. Similarly, Dias et al. (2017) reported that the highest fruit mass values were obtained in sesame plants treated with low-salinity water.

Figure 2. Peanut pod mass as a function of the electrical conductivity of the irrigation water (A) and the suppression interval (B).

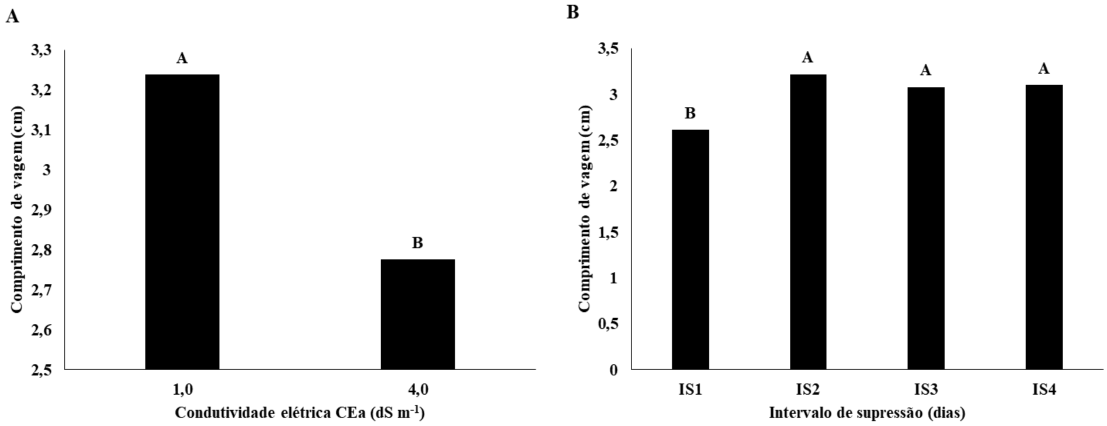


Letters indicate significant differences according to Tukey's test at 5%.

With respect to the suppression interval (Figure 2B), the treatment without suppression was superior to the IS1, IS2, and IS3 intervals, which did not differ from each other. In other words, water deficit was harmful at all crop stages. A similar trend was observed by Azevedo et al. (2014), who reported a reduction in the pod mass of peanuts grown under irrigation suppression at 45 days after sowing. The authors attributed this reduction to the water deficit that occurred after the appearance of the gynophore, that is, it induced a lower pod mass.

For the pod length variable (Figure 3A), water with lower salinity presented higher average values than did water with high salinity. Notably, saline stress can cause low osmotic potentials, decrease the relative water content, and delay productive aspects (LIMA et al., 2020).

Figure 3. Peanut pod length as a function of the electrical conductivity of the irrigation water (A) and the suppression interval (B).



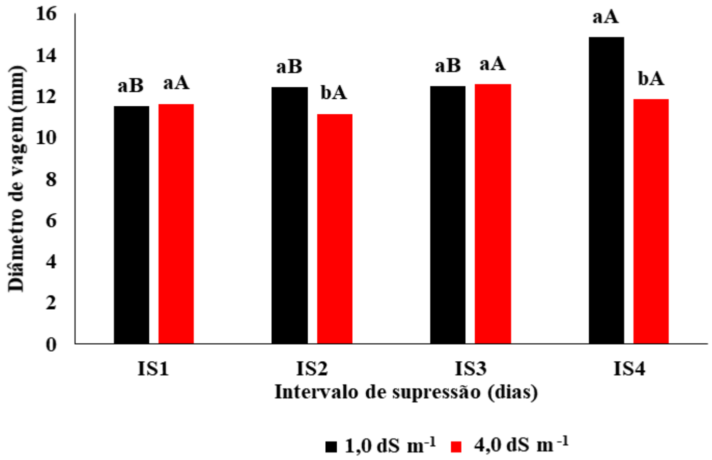
Letters indicate significant differences according to Tukey's test at 5%.

Oliveira et al. (2015), studying cowpea crops as a function of salinity, reported similar results for pod length. A similar trend was reported by Lima et al. (2014), who reported that irrigation with saline water negatively affected the length of castor bean races.

In Figure 3B, the suppression intervals IS2, IS3, and IS4 were greater than the IS1 interval. When working with peanuts according to the timing of irrigation suppression, Azevedo et al. (2014) reported similar results when they reported an increase in pod length during irrigation periods of 70 and 85 days.

In terms of pod diameter, as shown in Figure 4, low-salinity irrigation water was superior in the IS2 and IS4 intervals, whereas in the IS1 and IS3 intervals, there was no significant difference between the waters.

Figure 4. Peanut plant pod diameter as a function of water electrical conductivity under different irrigation suppression intervals.



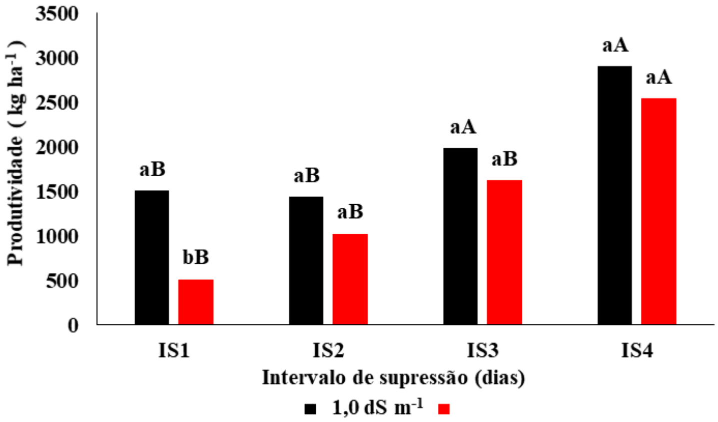
Columns followed by the same uppercase letters at the same suppression interval level, or lowercase letters at the same salinity level, do not differ significantly from each other according to the Tukey test ($p \leq 0.05$).

Notably, at 55 days, the peanut tree had formed pods. Therefore, saline stress associated with water stress negatively impacts pod diameter and, consequently, productivity. Excess soluble salts in irrigation water can cause nutritional disorders and affect plant water absorption. Water stress can cause physiological damage to crops, reduce plant photosynthetic rates, and reduce transpiration, which affects CO_2 absorption (OLIVEIRA et al., 2015; TAIZ; ZEIGER, 2017).

França et al. (2020) obtained similar results for pod diameter and studied the agronomic performance of the commercial and Japanese yellow snap bean cultivars under different water replacement conditions.

Figure 5 shows that productivity was affected by high-salinity water only in IS1. This behavior reveals that in this phenological phase of the crop (appearance, enlargement of the gynophore and pod formation), the presence of salts possibly inhibited the absorption of phosphorus (important for fruiting), compromising yield (SOUSA et al., 2012).

Figure 5. Peanut productivity as a function of water electrical conductivity under different irrigation suppression intervals.



Columns followed by the same uppercase letters at the same suppression interval level, or lowercase letters at the same salinity level, do not differ significantly from each other according to the Tukey test ($p \leq 0.05$).

Similarly, Rodrigues et al. (2020) reported that increased salinity of irrigation water caused a reduction in corn crop productivity. A similar result was also obtained by Lima et al. (2020) in sesame crops, both of which were irrigated with high-salinity water.

With respect to water deficit, Sousa et al. (2014), working with peanut crops, reported lower productivity performance with increasing water stress, demonstrating the difficulty that crops have in maintaining high production when there is a limited amount of irrigation water.

6 CONCLUSION

The treatments without a water withdrawal interval associated with relatively low-salinity water resulted in greater numbers and diameters of pods.

High-salinity water affects pod mass and length.

The use of water with relatively high or low salinity without irrigation interruption results in greater productivity for peanut crops.

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