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Scientific Article

Salt stress and potassium fertilization on the agronomic performance of peanut crop

Estresse salino e adubação potássica no desempenho agronômico da cultura do amendoim

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ABSTRACT - In semi-arid regions, the use of brackish water for irrigation can reduce crop yields. However, the use of mineral fertilizer has been tested to mitigate salt stress. In this context, the objective was to evaluate the effect of salt stress at different phenological stages on the yield of peanut under potassium fertilization. The experiment was carried out from August to November 2021, in the experimental area of the Universidade da Integração da Lusofonia Afro-Brasileira (UNILAB), Redenção, Ceará, Brazil. The experimental design was completely randomized (CRD), in a 6 × 3 factorial scheme, with 6 replicates. Six strategies of irrigation with brackish water were applied from the following stages: vegetative (S1); flowering (S2); gynophore appearance (S3); pod formation (S4); fruiting (S5) and without salt stress (S6), and three doses of potassium: 0, 50 and 100% of the recommended dose. The use of brackish water in the vegetative stage led to lower pod length, pod mass, number of pods, number of marketable pods and yield. The dose corresponding to 100% of the recommended potassium dose mitigated salt stress in the pod formation and flowering stages, promoting a greater number of marketable pods, number of non-marketable pods, total number of pods and pod mass. The use of water with lower salinity throughout the cycle promoted greater pod mass, number of marketable pods and yield.

Keywords: *Arachis hypogaea* L.. Plant nutrition. Salt stress.

RESUMO - Em regiões semiáridas, o uso de águas salobras na irrigação pode reduzir o rendimento das culturas. No entanto, a utilização da adubação mineral vem sendo testada para mitigar o estresse salino. Neste sentido, objetivou-se avaliar o efeito do estresse salino em diversos estágios fenológicos na produtividade do amendoim, sob adubação potássica. O experimento foi realizado no período de agosto a novembro de 2021, na área experimental da Universidade da Integração da Lusofonia Afro-Brasileira (UNILAB), Redenção, Ceará. O delineamento experimental foi o inteiramente casualizado (DIC), em um esquema fatorial 6 × 3, com 6 repetições. Foram utilizadas seis estratégias de irrigação com água salobra a partir das seguintes fases: vegetativa (S1); florescimento (S2); aparecimento dos ginóforos (S3); formação de vagens (S4); frutificação (S5) e sem estresse salino (S6) e três doses de potássio; 0, 50 e 100% da dose recomendada. O uso de água salobra na fase vegetativa evidenciou menor comprimento da vagem, massa das vagens, número de vagem, número de vagens comerciais e produtividade. A dose correspondente à 100% recomendada de potássio mitigou o estresse salino nas fases de formação de vagens e floração, proporcionando maior número de vagem comercial, não comercial e total e massa de vagem. O uso de água de menor salinidade durante todo o ciclo proporcionou maior massa de vagem, número de vagens comerciais e produtividade.

Palavras-chave: *Arachis hypogaea* L.. Nutrição de plantas. Estresse salino.

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INTRODUCTION

Peanut (*Arachis hypogaea L.*) is a crop with high nutritional value, rich in lipids, proteins, carbohydrates, essential fatty acids, vitamins, and minerals, and is used for various purposes, such as human and animal diets, canning industry, biodiesel, and confectioneries (SANTOS et al., 2021). However, regions with irregular rainfall, such as the Northeast of Brazil, associated with the use of lower quality waters, such as brackish waters, have led to lower yields for agricultural crops (SILVA et al., 2022a).

Irrigated agriculture in the Brazilian semi-arid regions has faced problems with water and soil salinity. This problem may be associated with both the edaphoclimatic conditions of the region and the inadequate management of brackish water (LESSA et al., 2023; SOUSA et al., 2023). The use of these waters in irrigation reduces the osmotic potential of the soil solution, consequently reducing water availability, absorption and transport of nutrients for plant growth and yield (TAIZ et al., 2017; SILVA et al., 2022b).

Application of brackish water in the phenological stages of agricultural crops has been used as a strategy to mitigate the effects of salt stress on agricultural yield and reduce the accumulation of salts in the soil in the semi-arid region (LIMA et al., 2022). Guilherme et al. (2021), when evaluating the use of brackish water at various phenological stages in peanut crop, concluded that the use of water with higher salinity in the fruiting and pod formation stages and with lower salinity associated with phosphate fertilization throughout the cycle promoted higher yield.

The use of potassium fertilization appears as another strategy to mitigate the deleterious effects of salts on plants, as potassium is the second most required element for peanut cultivation. Potassium participates in several important functions in plants, such as the activation of enzymes involved in respiration and photosynthesis, and acts as an agent of osmoregulation, allowing the control of stomatal opening and closing, in addition to controlling cell turgidity and reducing excessive absorption of ions such as Na^+ (DIAS et al., 2019; LIMA et al., 2022).

Studies that reveal promising effects of the interaction between salinity and potassium fertilization, to minimize the deleterious effects caused by salts on plants, were reported by Lima et al. (2018), who observed a mitigating effect of potassium fertilization on West Indian cherry tomatoes irrigated with saline water. Abd El-Mageed et al. (2022) also found a mitigating effect of potassium fertilization on the growth of sugar beet irrigated with increasingly brackish water.

In this context, the present study aimed to evaluate the effects of salt stress applied at various phenological stages on the yield of peanut under potassium fertilization.

MATERIAL AND METHODS

The study was conducted from August to November 2021, at the Auroras Seedling Production Unit (UPMA), belonging to the Universidade da Integração da Lusofonia Afro-Brasileira (UNILAB), Redenção, Ceará, Brazil. The city is located at 04°14’53” S latitude, 38°45’10” W longitude and an altitude of 240 m

The climate of the region is classified as Tropical Hot Humid and Tropical Hot Subhumid, with an average rainfall of 1,062 mm and average temperature ranging from 26 to 28 ° C (IPECE, 2017). Figure 1 shows the meteorological data during the experimental period.

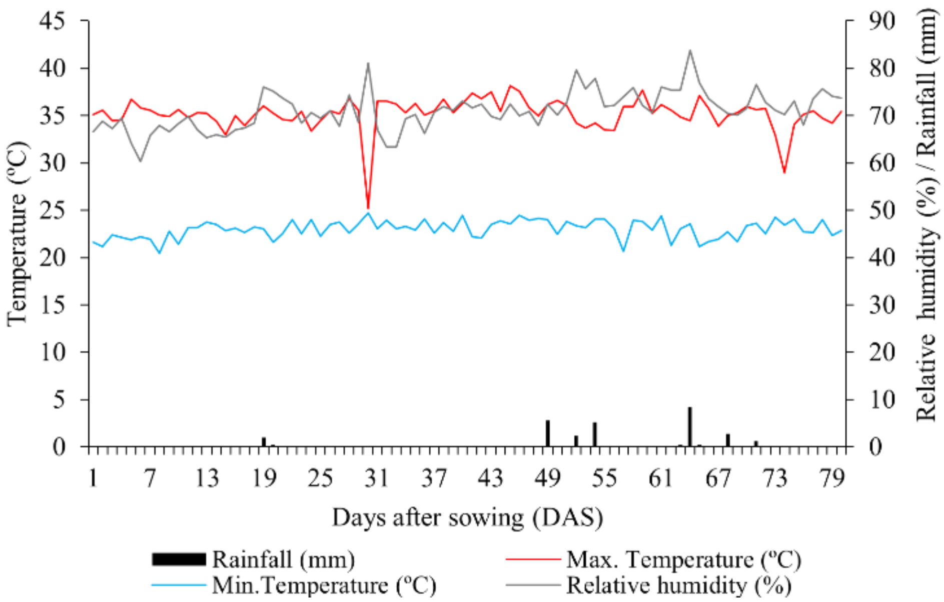


Figure 1. Meteorological data during the experimental period.

The experimental design was completely randomized (CRD), in a 6 × 3 factorial scheme, and the treatments consisted of six strategies for the use of brackish water applied at different stages of plant development (SE - irrigation with low-salinity water during the entire crop cycle; VE, FL, GA, PF and FR - irrigation with high salinity water, respectively in the vegetative, flowering, gynophore appearance, pod formation and fruiting) and three potassium doses (0, 50 and 100% of the recommended dose), with 5 replicates.

The cultivar used was BR-1, belonging to the Valência group, supplied by the germplasm bank of Embrapa Cotton. Planting was carried out in 11-L polyethylene pots, with six seeds per pot being placed at 2.0 cm depth. At 15 DAS (days after sowing), thinning was performed, leaving only one seedling per pot.

The substrate used was composed of arisco (light-textured sandy material normally used in constructions in Northeast Brazil), sand and aged cattle manure, in the ratio of 5:2:1, respectively. Chemical attributes (Table 1) were determined according to the methodology of Teixeira et al. (2017).

Fertilization was carried out according to the recommendations for mineral fertilization of Fernandes (1993), corresponding to 15 kg ha^{-1} of N, 62.5 kg ha^{-1} of P_2O_5 and 50 kg ha^{-1} of K_2O. For the stand of 10,000 plants, the maximum dose per plant in the cycle was 1.5 g of N, 6.25 g of P_2O_5 and 5.0 g of K_2O, using urea (45% N) as source of N, single superphosphate (18% P) as source of P and potassium chloride (60% K) as source of K. Potassium application was based on 100% of the recommended dose, which was equivalent to 50 kg ha^{-1}. This dose was used to define the others evaluated, which were equivalent to K0 = 0.0, K1 = 50 and K2 = 100% of the recommended potassium fertilization.

Table 1. Chemical characteristics of the soil used in the experiment.

OM	N	P	Mg	K	Ca	Na	pH H_2O	ESP (%)	ECse dS m^{-1}
-------------g kg^{-1}-------------		mg kg^{-1}	------------------------cmol$_c$ dm^{-3}------------------------						
17.05	0.31	5.95	1	0.11	5	0.08	6.46	1.28	1.2

OM = organic matter; ECse = electrical conductivity of the soil saturation extract; ESP = exchangeable sodium percentage.

Brackish water irrigation management was initiated according to the strategies, i.e., based on the phenology of the crop, following the principle of the drainage lysimeter (BERNARDO et al., 2019), with a daily frequency, according to Equation 1:

$$VI = \frac{(Vp - Vd)}{(1 - LF)} \quad (1)$$

where: VI = volume of water to be applied in irrigation (ml); Vp = volume of water applied in the previous irrigation (ml); Vd = volume of water drained (ml) and LF = leaching fraction of 0.15.

Brackish irrigation water was prepared from public-supply water (0.3 dS m^{-1}), using the salts NaCl, $CaCl_2.H_2O$ and $MgCl_2.6H_2O$, following the methodology of Rhoades, Kandiah, Mashali (2000), obtaining the desired ECw (4.0 dS m^{-1}) in the proportion of 7:2:1, respectively, according to the relationship between ECw and their concentration (mmol$_c$ L^{-1} = EC × 10), and irrigation was carried out manually in the afternoon, at 4:00 p.m.

At 80 DAS, the plants were harvested, placed in identified Kraft paper bags, and then dried for 15 days in a protected environment until they reached a constant mass. After drying, the following variables were evaluated: pod length (PL, in cm), measured with a graduated ruler; pod diameter (PD, in mm), measured with a digital caliper; number of marketable pods (NMP, in units), obtained by counting fully formed pods; number of non-marketable pods (NNMP, in units), obtained by counting seedless pods; total number of pods (TNP, in units), corresponding to the sum of marketable and non-marketable pods; pod mass (PM, g), measured on a digital scale with accuracy of 0.001 g; and yield (YLD), obtained by the ratio between grain mass (in g) and pot area (0.045 cm²), later transformed into g pot^{-1}.

To assess normality, the obtained data were subjected to the Kolmogorov-Smirnov test ($p \leq 0.05$). After verification of normality, the obtained data were subjected to analysis of variance (ANOVA) by the F test, and the means were compared by Tukey test at $p \leq 0.05$, using the statistical program ASSISTAT 7.7 Beta (SILVA; AZEVEDO, 2016).

RESULTS AND DISCUSSION

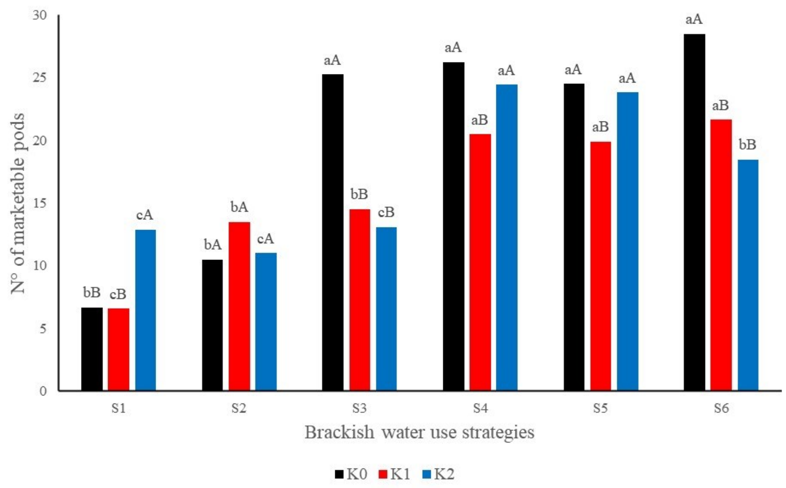
There was a significant interaction between brackish water irrigation strategies (BWIS) and potassium doses (KD) for all variables ($p \leq 0.01$), except for pod length (PL), for which the interaction was significant at $p \leq 0.05$ (Table 2).

Table 2. Summary of the analysis of variance for number of marketable pods (NMP), number of non-marketable pods (NNMP), total number of pods (TNP), pod mass (PM), pod length (PL), pod diameter (PD) and yield (YLD) in peanut crop under brackish water irrigation strategies and potassium doses.

SV	DF	MEAN SQUARE						
		NMP	NNMP	TNP	PM	PL	PD	YLD
BWIS (1)	5	616.739**	24.2791**	565.555**	700.749**	0.42197**	1.44211**	1736.625**
KD (2)	2	139.523**	39.9133**	87.299**	276.812**	0.02065^{ns}	0.03928^{ns}	669.341**
1 x 2	10	73.0955**	13.0458**	88.449**	57.6403**	0.20550*	1.20250**	111.490**
Treatments	17	240.805**	19.5106**	228.639**	272.575**	0.24742**	1.13612**	655.100**
Residual	72	5.91013	1.2701	6.38169	6.10807	0.08548	0.34246	13.26238
CV (%)	-	13.59	20.04	10.69	14.99	9.58	5.17	17.06

SV = sources of variation; DF = degree of freedom; CV = coefficient of variation; $^{*, **, ns}$ - Significant at $p \leq 0.05$, $p \leq 0.01$ and not significant, respectively; BWIS = brackish water irrigation strategies; KD = potassium doses.

In general, irrigation with brackish water significantly influenced the number of marketable pods (Figure 2), and S1 and S2 had the lowest mean values. This reduction in the number of marketable pods under the use of S1 (6.56 at the K1 dose) may be related to the prolonged use of brackish water (66 DAS). The excess of salts inhibits leaf expansion, causing reduction of leaf turgor, consequently reducing the net assimilation of carbon, negatively affecting crop yield (TAIZ et al., 2017; LIMA et al., 2022).



Means followed by the same uppercase letter did not differ significantly in terms of the mean values of potassium doses in each strategy, and means followed by the same lowercase letter did not differ significantly in terms of the mean of the different brackish water use strategies at the same potassium dose, both by Tukey test ($p \leq 0.05$)

Figure 2. Number of marketable pods (NMP) of peanut plants under brackish water use strategies and potassium fertilization doses.

As for potassium doses, there was no statistical difference only in S2. In S1, the K2 dose was superior to K0 and K1; in S3 and S6, the K0 dose was superior to K1 and K2; and in S4 and S5, K0 and K2 were superior to K1. The positive effect of lower salinity water and potassium fertilization may also be related to the effect of this mineral element, which directly participates in pod quality. Likewise, Lima et al. (2022) also found a positive effect of this interaction on passion fruit. These same authors concluded that the use of 60% of the recommended potassium fertilization, associated with lower salinity water, increased the number of fruits. On the other hand, the use of water with higher salinity causes reduction in leaf production and advances leaf senescence, generating a lower production of photoassimilates, which induces a lower capacity for the formation of viable pods (CANJÁ et al., 2021; SOUSA et al., 2023).

Peanut plants without fertilization (K0) and subjected to the strategies S3, S4 and S6 obtained the highest values for number of marketable pods (25.25, 26.25 and 28.50, respectively) compared to K1 and K2 doses (Figure 2). This result may be related to the salt stress, which began in the gynophore appearance stage (S3) and lasted until harvest. Probably, sodium partially replaced potassium, impairing osmoregulation, carbohydrate synthesis, stomatal opening and closing, and enzymatic activation of ATPase in the plants (TAIZ et al., 2017; AHANGER et al., 2017). Corroborating these data, Canjá et al. (2021) reported that salt stress reduced the number of marketable pods in peanut crop.

Figure 3 shows that in S1, S5 and S6 there was no statistical difference between potassium doses, while in S2 and S3 the K2 dose was statistically inferior to the K0 and K1 doses. In S4, the K0 dose was statistically inferior to K1 and K2.

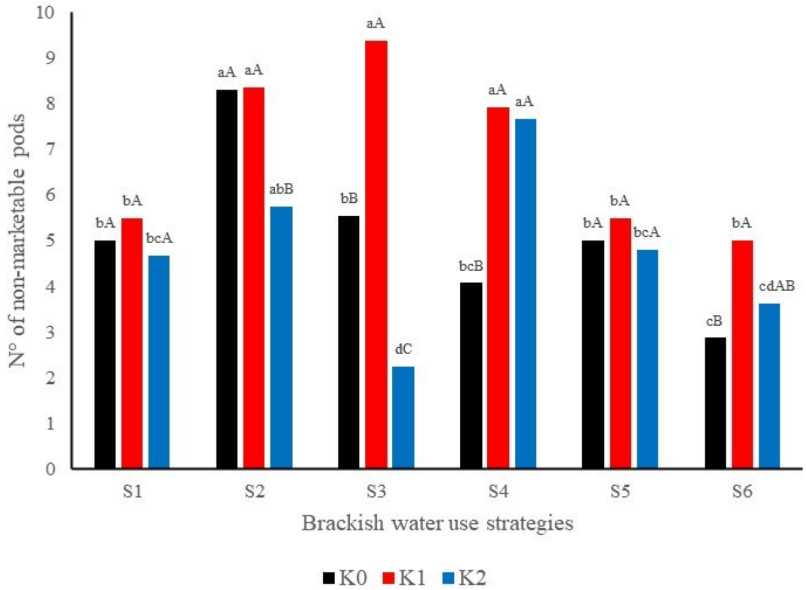
For the number of non-marketable pods of peanut (Figure 3), plants fertilized with 100% of the K_2O recommendation and subjected to S3 obtained the lowest NNMP value (2.25). This reduction in NNMP demonstrates the role of potassium in the supply of ATP for the translocation of photoassimilates in the peanut crop, helping in grain filling (CATUCHI et al., 2012; HASANUZZAMAN et al., 2018).

Plants subjected to irrigation with brackish water from the flowering stage under doses of 0 and 50% K_2O obtained the highest values of NNMP (8.31 and 8.35, respectively). These values indicate that prolonged exposure to salt stress is unsatisfactory for the formation of perfect pods, since excess salts modify the biochemical and physiological functions of plants (TAIZ et al., 2017) and, consequently, affect their production performance.

Figure 3 shows that, in S4, the use of 50% and 100% potassium fertilization led to higher values for number of non-marketable pods (7.91 and 7.67, respectively). These results show that the use of KCl as a substrate may have intensified salt stress in peanut plants, as it is a fertilizer with high salt index, which intensifies the osmotic effect, reducing the production of perfect fruits (LIMA et al., 2022).

When working with peanut cultivation and the use of brackish water in irrigation, Canjá et al. (2021) observed a 7.5% increase in the number of non-marketable pods when using water with electrical conductivity of 5 dS m^{-1}, compared to the use of 0.8 dS m^{-1} water.

As for TNP, the best strategies were S3, S4 and S5, associated with the doses K0, K2 and K1, respectively, being statistically superior to S1 and S2 (Figure 4). The inferiority of S1 reveals that the prolonged time of exposure of the peanut crop to salts reduces the number of pods, due to the toxic, nutritional and osmotic effects of salt stress, which affect carbon assimilation, accelerating the senescence of mature leaves and inhibiting leaf expansion, causing reduction of the area available for photosynthesis and limiting the production of photoassimilates (TAIZ et al., 2017; LESSA et al., 2021).



Means followed by the same uppercase letter did not differ significantly in terms of the mean values of potassium doses in each strategy, and means followed by the same lowercase letter did not differ significantly in terms of the mean of the different brackish water use strategies at the same potassium dose, both by Tukey test (p≤0.05)

Figure 3. Number of non-marketable pods (NNMP) of peanut plants as a function of different brackish water use strategies and potassium doses.

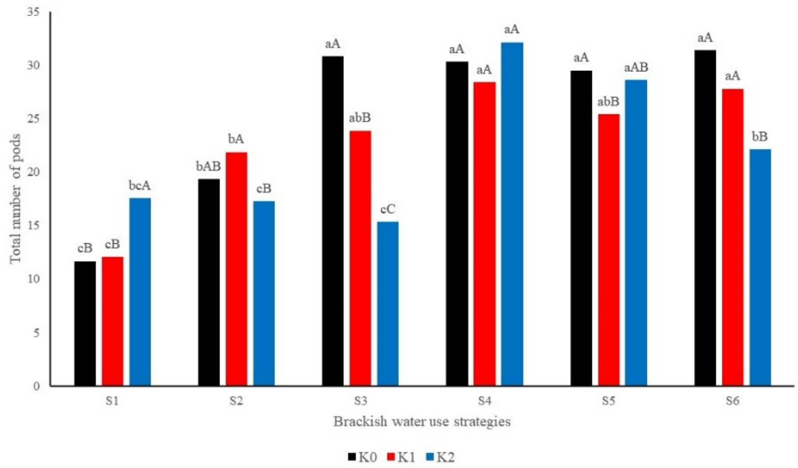


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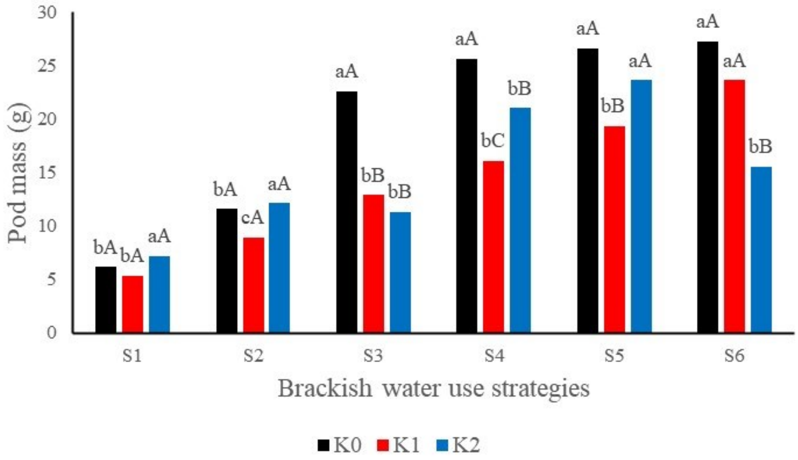
Figure 4. Total number of pods (TNP) of peanut plants under brackish water use strategies and potassium fertilization doses.

Possibly, the increase in potassium fertilization during the fruiting stage mitigated the negative effects caused by the use of brackish water, since the accumulation of potassium in plant tissue enables the creation of an osmotic gradient that helps in the movement of water and, consequently, promotes greater distribution of nutrients, such as phosphorus, which is important in the formation of gynophore, that is, resulting in a greater number of pods. Similarly, Guilherme et al. (2021) showed a higher total number of pods in peanut plants under phosphate fertilization with 100% of the recommended dose under salt stress

For the use of S3, the potassium dose K3 reduced the total number of pods (mean of 15.33). This result is probably related to the higher input of salts, both from the irrigation water and from the fertilization source itself. Although potassium is considered an important element in the osmotic functions of crops, the increase in its concentration due to the presence of NaCl intensifies the deleterious effects caused by the use of brackish water (SILVA et. al., 2022c). A trend similar to that of S3 was reported by Goes et al. (2021), who observed a sharp decrease in the number of peanut pods with the increase in irrigation water salinity levels.

Regarding pod mass, the best strategies to use brackish water were S3, S4, S5 and S6, being statistically superior to S1 and S2 (Figure 5). Such reduction in pod mass may be related to the harmful effects caused by salts, considering that irrigation with brackish water in strategy S1 began at 14 DAS, i.e., salt stress reduced water availability, consequently hindering the absorption of water and nutrients and delaying production aspects (LIMA et al., 2022; GUILHERME et al.,



Means followed by the same uppercase letter did not differ significantly in terms of the mean values of potassium doses in each strategy, and means followed by the same lowercase letter did not differ significantly in terms of the mean of the different brackish water use strategies at the same potassium dose, both by Tukey test (p≤0.05)

Figure 5. Pod mass (PM) of peanut plants under brackish water use strategies and potassium fertilization doses.

The K0 and K1 doses were superior to K2 in S6. Plants grown without salt stress, associated with lower chloride deposition to the soil, had greater pod mass. This result may be associated with the source of potassium fertilization used in the study, i.e., the fertilizer may have increased the salt contents in the soil and compromised the absorption of phosphorus in this stage, a fundamental nutrient for the formation of the gynophore and, consequently, of the pod.

Similarly, Guilherme et al. (2021) observed a reduction in pod mass values in this same phenological stage of the peanut crop under chemical fertilization. A similar trend was obtained by Canjá et al. (2021), who evaluated the effects of salt stress on peanut crop and found reduction in pod mass when using irrigation water with 5.0 dS m^{-1}.

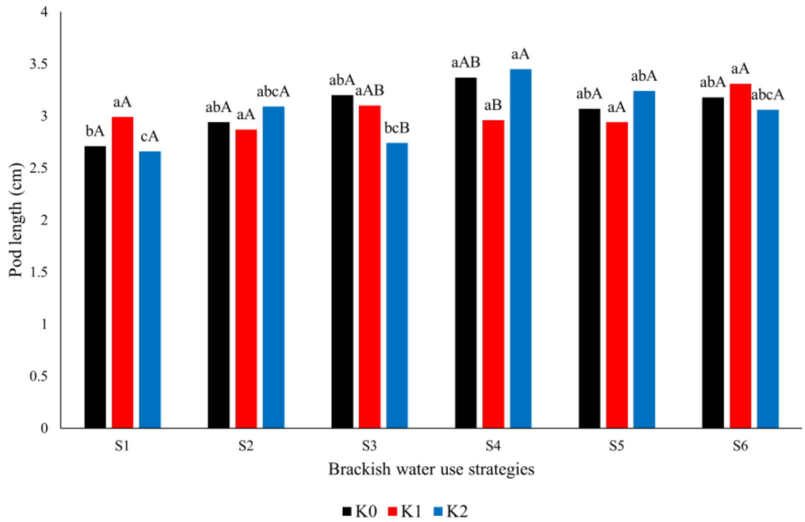
Regarding pod length (PL), the maximum value (3.45 cm) was observed in S4 (beginning of brackish water irrigation in pod formation), with the dose of 5.0 g pot^{-1}, corresponding to 100% of potassium fertilization, but not statistically differing from the strategies S2, S5 and S6, which imposed salt stresses in the flowering stage, final stage and no stress, respectively (Figure 6). The lowest values were found in S1 (beginning of brackish water irrigation in the vegetative stage), associated with the dose of 100% potassium, with mean of 2.66 cm.

The superiority of S4 reveals that there was possibly a compartmentalization of potassium in this phenological stage of the peanut crop, i.e., showing that the late beginning of salt stress application would no longer affect the participation of this mineral element in the final stage of its cycle. This result demonstrates a relevant tolerance of the peanut crop to salt stress in the fruiting stage, and a reduction in the Na^+ content in plant cells may have occurred at the maximum dose of potassium, favoring plant growth and salt tolerance (HASANUZZAMAN et al., 2018).

On the other hand, the decrease in pod length in plants fertilized with the maximum dose and irrigated with brackish water in the vegetative stage may be related to the high salt index of the KCl used in the experiment as a source of potassium, associated with the salinity of the water used in irrigation. That is, it reduced the osmotic potential of the soil and, consequently, reduced the availability of water and nutrients, causing metabolic and/or physiological disorders in the plant (DIAS et al., 2019; SILVA et al., 2022b).

Results similar to those found in S1 were observed by Oliveira et al. (2015), who reported that the beginning of irrigation with brackish water during the vegetative stage reduced pod length in cowpea crop. Divergent trends from those found in the present study in strategies S2 and S4 were observed by Soares et al. (2021), who worked with cowpea crop and found that pod length was reduced in the fruiting and flowering stages when plants were jointly subjected to higher doses of potassium.

Pod diameter in S3 was statistically higher than the values found in the others (Figure 7). The beginning of salt stress application in this phenological stage did not cause an antagonistic effect of Na with P; consequently, it favored the absorption of K in the cell vacuole. This effect probably favored a greater shell thickness and, subsequently, a larger pod diameter, with value of 12.78 mm.



Means followed by the same uppercase letter did not differ significantly in terms of the mean values of potassium doses in each strategy, and means followed by the same lowercase letter did not differ significantly in terms of the mean of the different brackish water use strategies at the same potassium dose, both by Tukey test (p≤0.05)

Figure 6. Pod length (PL) of peanut plants as a function of different brackish water use strategies and potassium doses.

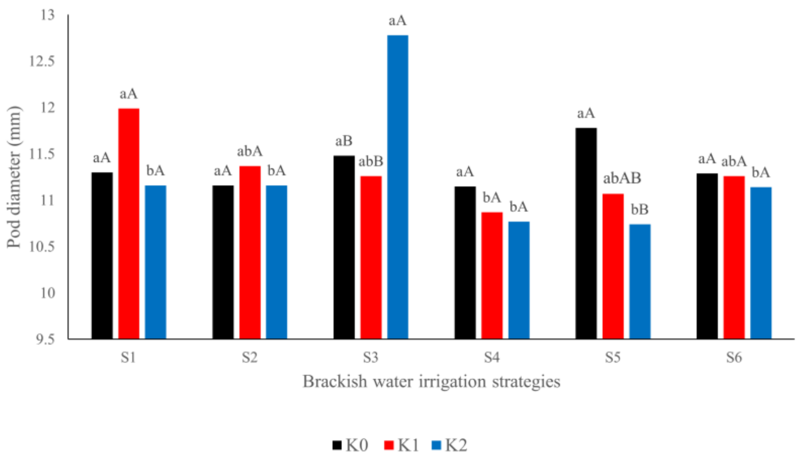


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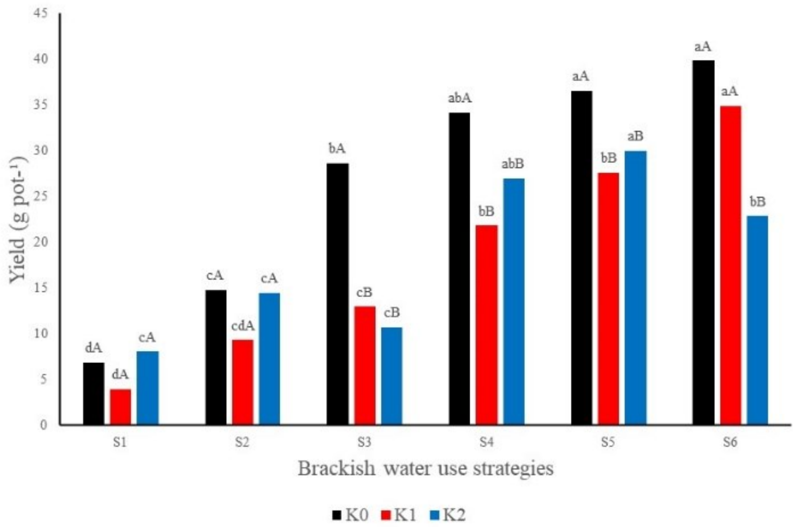
Figure 7. Pod diameter (PD) of peanut plants as a function of brackish water irrigation strategies and potassium doses.

Regarding the effect of potassium doses between strategies, significant differences were observed only in the strategies S3 and S5. In S3, the K2 dose led to higher mean values compared to the K0 and K1 doses. This result may be related to the action of potassium, as it is a relevant nutrient in plant turgidity and in the transport of sugars, favoring the production of proteins and enzymes, which help in plant growth and yield (DIAS et al., 2019).

In S5, the K0 and K1 doses were statistically superior to K2. This effect may be associated with the higher salt index from the greater amount of potassium chloride present at the 100% dose and irrigation with brackish water in the final stage of flowering (S5), resulting in a lower mean for pod diameter (10.74 mm). Rodrigues et al. (2021) describe that salt stress causes the osmotic effect and toxicity to plants, reducing the absorption and translocation of nutrients, especially K^+, restricting crop development. Goes et al. (2021), when working with salt stress in peanut crop under field conditions, also observed a reduction in pod diameter in the phenological stage 3 (gynophore appearance).

The highest yields of peanut plant were observed in S3, S4, S5 and S6 (Figure 8). The statistical superiority compared to S1 and S2 may be related to the lower salt stress imposed on these plants. This reduction in yield, caused by salt stress, may have occurred due to the reduction of leaf transpiration and conductance, which consequently reduces the production of photoassimilates and increases leaf temperature, causing reduction in grain yield (LESSA et al., 2021; GUILHERME et al., 2021).



Means followed by the same uppercase letter did not differ significantly in terms of the mean values of potassium doses in each strategy, and means followed by the same lowercase letter did not differ significantly in terms of the mean of the different brackish water use strategies at the same potassium dose, both by Tukey test ($p \leq 0.05$)

Figure 8. Yield (YLD) of peanut plants under brackish water use strategies and potassium fertilization doses.

Regarding the potassium doses used in the different strategies, it is possible to verify that in S1 and S2 there was no statistical difference between the doses. In S3, S4 and S5, the K0 dose was statistically superior to K1 and K2, while in S6, the K0 and K1 doses were superior to K3. The highest peanut yield was obtained in S6 (39.81 g pot^{-1}) with the K0 dose, without statistically differing from plants fertilized with K1 (34.91 g pot^{-1}), but being superior to K2 (22.84 g pot^{-1}). Possibly, with the increased application of potassium chloride as a source of potassium, the negative effects of salt stress on peanut crop may have been intensified, reducing grain yield. Results similar to those of the present study were reported by Canjá et al. (2021), who recorded reduction in the yield of peanut crop irrigated with brackish water and cultivated under pot conditions.

Corroborating this work, Taglieber et al. (2022) evaluated different doses of potassium chloride in soybean irrigated with water of lower salinity throughout the cycle and obtained the best values in treatments without potassium addition. Opposite results were reported by Pinheiro et al. (2022), who evaluated the interaction between brackish water irrigation strategies and potassium doses on 'BRS GA1' yellow passion fruit and found individual effect only for salt stress, with no attenuating effect of this source of mineral fertilization for irrigation water salinity.

CONCLUSIONS

The use of brackish water in the vegetative stage led to lower pod length, pod mass, number of marketable pods and yield.

The 100% recommended dose of potassium mitigated salt stress in the pod formation and flowering stages, promoting a higher number of marketable pods, number of non-marketable pods, total number of pods and pod mass.

The use of lower salinity water throughout the cycle promoted higher pod mass, number of marketable pods and yield.

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