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PULSED IRRIGATION INCREASES ACCUMULATION OF SECONDARY MACRONUTRIENTS IN PEANUTS TREATED WITH BRACKISH WATER

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ABSTRACT: Salinity causes a reduction in crop production, due to effect of nutritional disorder affecting plant physiology. The objective was to study effect of use of brackish water and pulsed and continuous drip irrigation on accumulation of nutrients (Ca, Mg and S) in peanut crop. The experimental design was randomized blocks, 6 x 2 factorial scheme, with six electrical conductivities of irrigation water (0.2; 1.6; 2.8; 4.0; 5.2 and 6.4 dS m^{-1}) and two forms of irrigation application (with pulses and continuous). At 63 days after sowned, accumulations of nutrients Ca, Mg, S, and elements sodium (Na) and chloride (Cl). Pulse irrigation decreased deleterious effects of salinity, in which greater accumulation of nutrients by peanut crop was observed compared to continuous irrigation. The decreasing order in accumulation of nutrients by crop was: Ca > Mg > S; in both type of management. Despite large accumulation of sodium and chloride, pulse irrigation is an efficient strategy to mitigate harmful effects of salinity on nutrition of peanut crop.

KEYWORDS: Calcium, Magnesium, Nutritional management, Water management.

IRRIGAÇÃO PULSADA AUMENTA ACÚMULO DE MACRONUTRIENTES SECUNDÁRIOS NO AMENDOIM TRATADO COM ÁGUA SALOBRA

RESUMO: A salinidade provoca redução na produção das culturas pelo efeito da desordem nutricional, afetando a fisiologia das plantas. Objetivou-se estudar o efeito do uso de águas salobras e da irrigação por gotejamento pulsado e contínuo sobre o acúmulo de nutrientes (Ca, Mg e S) na cultura do amendoim. O delineamento experimental utilizado foi o de blocos em

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esquema fatorial com seis condutividades elétricas da água de irrigação (0,2; 1,6; 2,8; 4,0; 5,2 e 6,4 dS m^{-1}) e duas formas de aplicação da irrigação (com pulsos e contínua). Aos 63 dias após a semeadura foram quantificados os acúmulos dos macronutrientes cálcio, magnésio e enxofre, além de sódio e cloreto. A irrigação por pulsos diminuiu os efeitos deletérios da salinidade, tendo-se observado maior acúmulo de nutrientes pela cultura do amendoim em comparação à irrigação aplicada de forma contínua. A ordem decrescente, em ambos os tipos de manejo da irrigação, no acúmulo dos nutrientes pela cultura foi: Ca > Mg > S. Apesar da expressiva magnitude de acúmulo de sódio e cloreto pelas plantas, a irrigação por pulso foi eficientemente capaz de mitigar os efeitos nocivos da salinidade sobre a nutrição da cultura do amendoim.
PALAVRAS-CHAVE: Cálcio, Enxofre, Magnésio, Água salina, Manejo nutricional, Manejo da água.

INTRODUCION

In semiarid region of Brazilian Northeast, it is estimated that about nine million hectares of soil are affected by salts (LEITE et al., 2012). Salinization causes adverse effects to soil, affecting plants due to increase in osmotic pressure that makes it difficult to absorb soil solution. It also causes toxicity by absorption of excess of specific ions, by interference of salts in physiological processes and nutritional imbalance of plants (DIAS et al., 2016).

The use of soil-water-plant management strategies to mitigate effects of salinity on irrigation is indispensable for sustainable cultivation systems. Pulse irrigation emerges as strategy that maximizes use of water and fertilizers (MENEZES et al., 2020), which consists of a short period of water application, followed by an interval and another short period of irrigation, this sequence is repeated until every water depth required by plant is applied (ALMEIDA et al., 2018). This technique has shown positive results on productivity and quality of products, savings in water use, maintenance of soil moisture, and reduction of impacts of salinity (EID et al., 2016; ALMEIDA et al., 2018).

Despite adoption of saline water use strategies in agriculture, association between use of brackish water and pulse irrigation in plant growth and production is still little studied. Thus, objective of this study was to evaluate effect of use of brackish water and pulsed and continuous drip irrigation on accumulation of secondary macronutrients in peanut crop.

MATERIAL AND METHODS

The experiment was conduced in September and November 2019, in open field of experimental area of Department of Agricultural Engineering of Federal Rural University of Pernambuco, Campus Recife. According to Köppen classification, climate is characterized as tropical rainy, type As" to Ams", with rainy season from April to July (SILVA et al., 2012). Precipitation, average temperature and relative humidity, reference evapotranspiration (Eto) and global radiation (Figure 1) were recorded in the experimental area, through an automatic Campbell Scientific meteorological station (model CR1000/CFM100/OS100) adjacent to the area. The precipitation in the cultivation period was 103.7 mm.

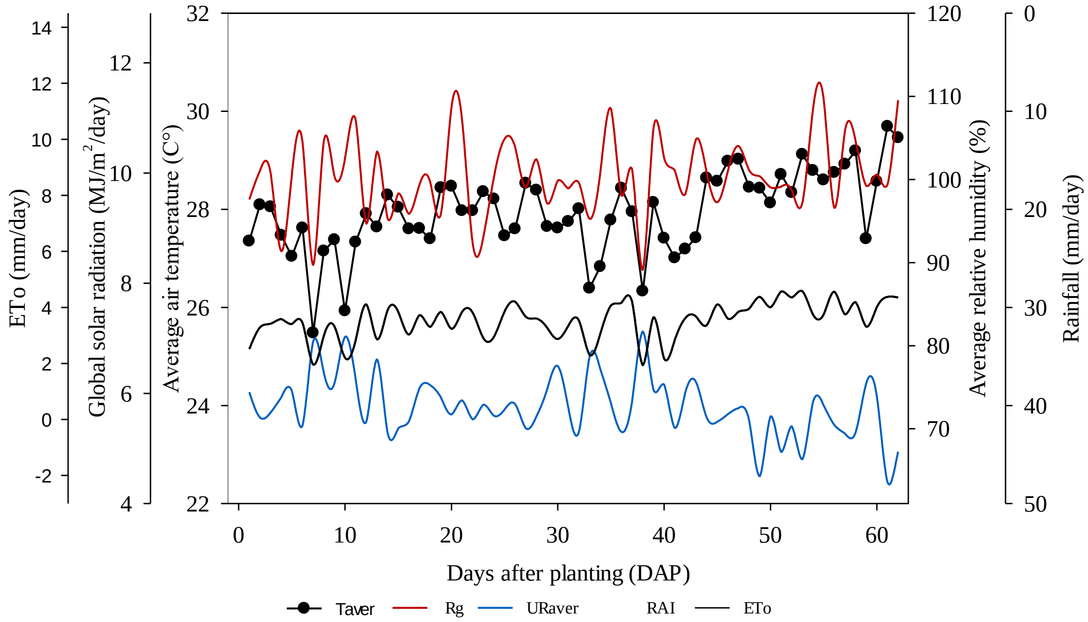

Figure 1. Rainfall depths (RD), mean air temperature (MAT), relative air humidity (RAH), reference evapotranspiration (ETo) and global solar radiation (Rg) during cultivation period.

The experimental design was randomized blocks, 6 x 2 factorial scheme, which consists of six levels of electrical conductivity of irrigation water (ECa: 0.2; 1.6; 2.8; 4.0; 5.2 and 6.4 dS m^{-1}) and two types of irrigation management (pulse and continuous) with four replications, total 48 experimental plots. The electrical conductivity levels of the irrigation were arranged at equidistant intervals until the highest CEa it was established double limiar salinity of the culture by Ayers & Westcot (1999), of 3.2 dS m^{-1}. Electrical conductivity levels of water used in irrigation were obtained by addition of sodium chloride (NaCl) to local urban water supply (ECa = 0.2 dS m^{-1}), which were used with conductivity meter until aimed levels. In control treatment (0.2 dS m^{-1}) only supply water was used.

The experimental area was 38 m lenght and 10.5 m width (supplement 1), 48 drainage lysimeters with capacity to 240 L each one. Also, circular shapes were placed. Each lysimeter had 0.50 m of superior edge external diameter and external height of 0.70 m. The lysimeters were placed equidistant at 1.0 m in lines and between them. The boxes used were 0.40 m above ground surface.

In each lysimeter was added layer of gravel (25 mm granulometry) to facilitate drainage through drain cover. Geotextile blanket was inserted covering entire superior face of gravel to retain soil particles. Drainage system was formed by ½" water hose adapter in the end of lysimeter, which were connected to low density polyethylene tube (LDPE PN 30 DN 16 mm) and 2 L of ethylene terephthalate (PET) bottle. Electrical conductivity levels of water used in irrigation were obtained by addition of sodium chloride (NaCl) to local urban water supply (ECa = 0.2 dS m^{-1}), which were used with conductivity meter until aimed levels. In control treatment (0.2 dS m^{-1}) only supply water was used.

The irrigation system used was drip irrigation system, which consists of six components. For exemplo, six sets of reservoir with capacity of 500 L, disc filter and 0.5 CV horizontal axis centrifugal pump, solenoid type valves controlled by composite control panel of Arduino type electronic controller, 16 channel relay module, 10 A hive type switching power supply with Real Time Clock RTC DS3231, ½" threaded anti vacuum valve and self compensating drippers with nominal flow of 2 L h^{-1}. These were arranged in pairs per lysimeter with distance of each other 0.20 m, adding flow rate of 4 L h^{-1} in each lysimeter. The service pressure was regulated at 10 m.c.a by manometer pressure and water flow control.

The crop evaluated was peanut, cultivar BR 1, early variety, with an average cycle of 90 days that presents good adaptation to climate of semiarid region. Six seeds were sown per lysimeter in depth of 5 cm to ensure germination. The thinning was carried out in 10 DAE, one plant per lysimeter. According to Embrapa (2009), phytosanitary monitoring and cultural treatments were carried out after planted. The harvest was carried out when culture reached physiological maturation point for treatments with high salinity, which was 63 days after sowned (DAS).

At end of culture cycle, aerial parts of evaluated treatments were collected to determine accumulation of calcium (Ca), magnesium (Mg), sulfur (S), and elements sodium (Na) and chloride (Cl). Thus, all plants materials, such as aerial parts and grains were taken to laboratory and washed with deionized water. Then, materials were packed in paper bags properly identified with respective treatments and placed in oven at 65º C until constant weight was obtained. After dried, materials were weighed on electronic scale with precision of 0.0001 g in order to quantify dry biomass. Then, it was processed in sieve mill type Willey with 2 mm, stored to quantification of concentrations of nutrients.

The digestion of the nutrients Ca, Mg, S, and Na was carried out in closed system, which uses microwave oven as heat source and concentrated nitric acid (HNO_3) to digest dry matter (SILVA, 2009). Chloride digestion was performed using hot water extraction method (BEZERRA et al., 2011).

The data obtained were subjected to analysis of variance by F test, there was significant effect, regression analysis (salinity levels) and comparison of means (irrigation management) using Scott-Knott test at 5% probability.

RESULTS AND DISCUSSION

According to analysis of variance (Table 1), there was a significant effect of interaction between factors irrigation management (pulsed irrigation and continuous irrigation) and electrical conductivity of irrigation water (ECa) on accumulation of Ca. There was also an isolated influence of these factors on accumulation of Mg and S.

Table 1. Analysis of variance for the accumulation of secondary micronutrients and Na in peanuts cultivar BR 1, as a function of irrigation management and salinity levels.

SV	DF	Mean Square				
		Macronutrients			Micronutrient	Elemento
		Ca	Mg	S	Cl	Na
Management (M)	1	0.032**	0.070**	0.010**	$26.29x10^5$**	10.087**
Salinity (S)	5	0.020**	0.016**	0.004**	$4.13x10^5$**	3.218**
M x S	5	0.002**	0.000^{ns}	0.000^{ns}	$2.82x10^{4\ ns}$	0.447**
Block	3	19.783*	0.003^{ns}	0.001	$5.23x10^5$*	0.166^{ns}
Resídue	33	0.000	0.001	0.000	21899	0.098
CV	%	0.75	11.10	10.34	14.55	20.76

** significant ($p \leq 0,01$), * significant ($p \leq 0,05$) and ns not significant by the F test.

Supply of brackish water through pulsed or continuous drip irrigation promoted nutritional disorders in peanut crop with increase in ECa levels. As shown in Figure 2A, increase in ECa levels reduced accumulation of Ca linearly in both types of irrigation management. For pulsed irrigation, reduction was 0.08 g per plant^{-1} for each unit increase of ECa.

ECa levels of 0.2; 1.6; 2.8; 4.0; 5.2 and 6.4 dS m^{-1} increased by 21.9; 23.9; 25.9; 27.0; 31.1 and 30.5% the accumulation of Ca when applied to pulsed irrigation in relation to continuous irrigation (Figure 2A). Supplying saline water through furrow irrigation throughout string bean crop cycle reduced Ca extraction by 35% (NEVES et al., 2009). Salinity may decrease absorption of Ca because Na reduces its influx through root, decreasing Ca binding sites in plasma membrane and osmotic potential under saline conditions (LYNCH et al., 1988; HADI et al., 2012; SAHIN et al., 2018). In the present study, low accumulation and exportation of Ca by peanuts can be attributed to Na, which competes for absorption sites in roots for Ca absorption (COELHO et al., 2017).

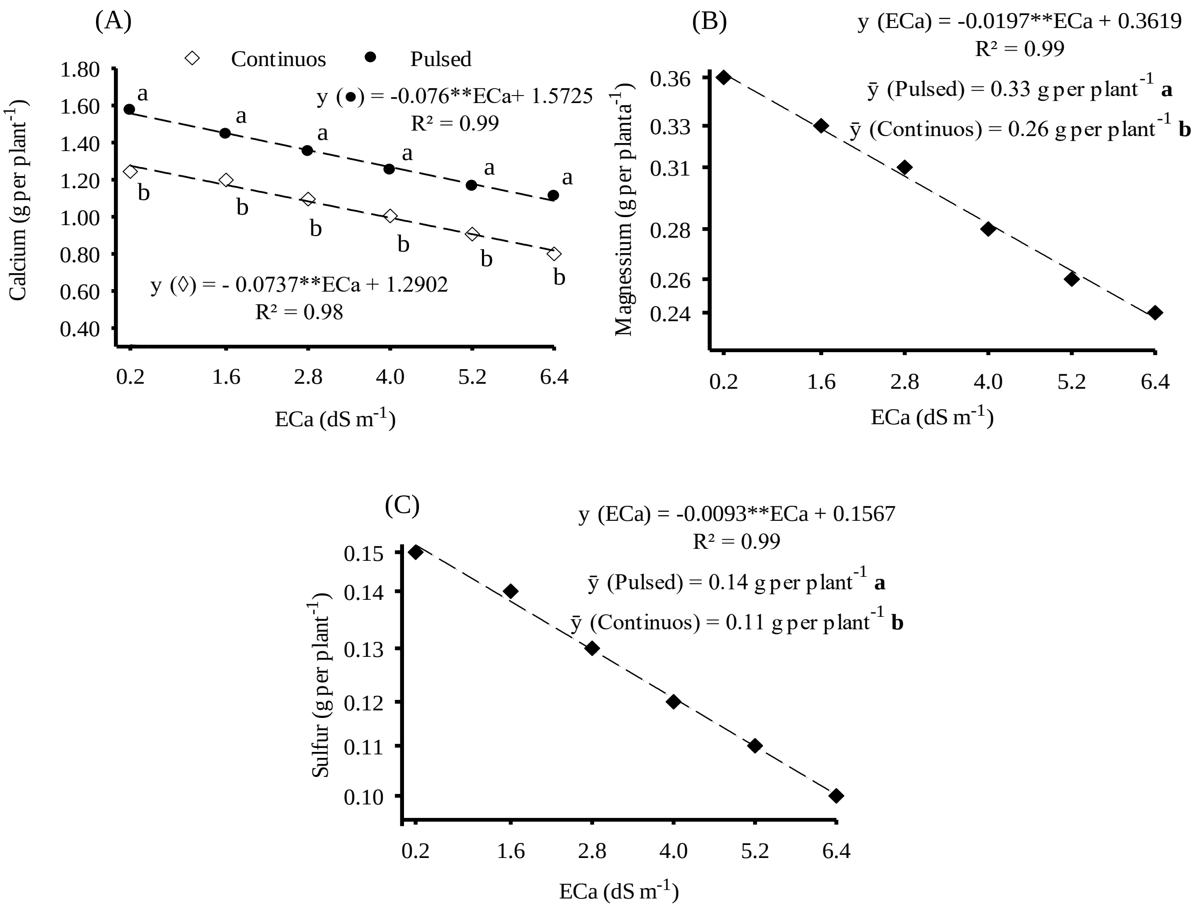

Figure 2. Accumulation of calcium (A), magnesium (B) and sulfur (C) in the BR 1 peanut plant, depending on salinity levels and types of irrigation management. Recife, 2020. Different letters indicate significant differences between the types of irrigation management (pulsed and continuous) by the Scott Knott test ($p < 0.05$).

Mg accumulation was reduced by 0.02 g per plant^{-1} for each unit increased in ECa levels (Figure 2B). Pulsed irrigation provided an increase of 26.9% in accumulation of Mg in relation to continuous irrigation. In a study with soybean plants, ECa levels of 6.5 and 8.5 dS m^{-1} of salinity of irrigation water reduced leaf content of Mg by 40 and 64.9% respectively (ESSA, 2002). Reduction in Mg content was observed in eggplant subjected to salt stress (BOSCO et al., 2009). Negative effect of salinity on Mg content was observed in research with corn about salt stress (GARCIA et al., 2007). High concentrations of Na and Cl reduces activity of nutrient ions and alter nutrients ratio, generating Na^+/Ca^{2+}, Na^+/K^+, Na/Mg^{2+} and Cl^-/NO^- ratios that reduces plant growth and production (GRATTAN & GRIEVE, 1999).

ECa levels linearly reduced accumulation of S (Figure 2C). Pulsed irrigation mitigated effects of ECa and promoted an increase of 27.3% in accumulation of S in relation to continuous irrigation. Experiments with garlic put into 200 mM NaCl have shown reduction of approximately 50% in total S contents compared to control treatment (AGHAJANZADEH et al., 2019). Sulfur was macronutrient less absorbed by crop. However, it is necessary component for plant tolerance to abiotic stresses, being an integral part of amino acids, proteins and lipids (KHAN et al., 2014; NOCITO et al., 2007). Decrease in accumulation of S by ECa levels may be related to competitive effect between Cl^- and SO_4^{2-} by site root absorption. Cl affects macronutrients uptake and utilization as evidenced with S in tomato plants submitted to chloride application (ZHONG & MA, 1993).

CONCLUSIONS

The salinity reduced the accumulation of all the nutrients evaluated. Despite this, pulse irrigation promoted greater accumulation of nutrients by the peanut crop in relation to continuous irrigation. The accumulation of nutrients by the culture in descending order was: Ca > Mg > S; in both type of management. Pulse irrigation is an important strategy to mitigate the harmful effects of salinity on the nutrition of the peanut crop.

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