CATTLE MANURE IN MITIGATION OF WATER STRESS IN COWPEA BEANS IRRIGATED WITH SALINE WATER

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ABSTRACT: High salt content in irrigation water is one of the main limitations to crop production worldwide. It is necessary to study management strategies that favor crops affected by saline water. The aim of this study was to evaluate the effects of organic matter on cowpea irrigated with saline water. The experiment was carried out in a protected environment following a randomized block design. Treatments consisted of five electrical conductivities of irrigation water (0.0; 1.5; 3.0; 4 .5 and 6.0 dS m^{-1}) and five cattle manure rates [0 (no application); 10; 20; 30 and 40 t ha^{-1}], with three replications. Osmotic potential of leaves located in the middle third of the canopy was evaluated. It was concluded that cattle manure favors the cultivation of cowpea irrigated with saline water at electrical conductivity above the recommended level for the crop, mainly using a rate of 30 t ha^{-1}.

KEYWORDS: saline water, osmotic potential, moderately tolerant.

ESTERCO BOVINO NA MITIGAÇÃO DO ESTRESSE HÍDRICO EM FEIJÃO - CAUPI IRRIGADO COM ÁGUA SALINA

RESUMO: O alto teor de sais na água de irrigação é uma das principais limitações dos cultivos agrícolas à nível mundial, sendo necessário estudar estratégias de manejo que favoreçam os cultivos afetados por água salina. O objetivo deste estudo foi avaliar os efeitos do esterco bovino em cultivo de feijão-caupi irrigado com água salina. O experimento foi realizado em ambiente

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protegido na área experimental da Universidade Estadual do Sudoeste da Bahia – UESB no delineamento de blocos ao acaso com tratamentos compostos por cinco condutividades elétricas da água de irrigação (0,0; 1,5; 3,0; 4,5 e 6,0 dS m^{-1}) e cinco dosagens de esterco bovino [0 (sem aplicação); 10; 20; 30 e 40 t ha^{-1}], com três repetições. Realizou-se a avaliação do potencial osmótico das folhas localizada no terço médio da copa das plantas permitindo definir que o esterco bovino favorece o cultivo de feijão-caupi irrigado com água salina acima do recomendado para a cultura, principalmente utilizando a dose de 30 t ha^{-1}.
PALAVRAS-CHAVE: água salina, potencial osmótico, moderadamente tolerante.

INTRODUCTION

High salt content in irrigation water is a major abiotic problem that affects global food production, especially in regions with a semi-arid climate. In these regions, the parent material of soils associated with high evaporation rates and low rainfall favors the rise of salts from deeper to upper soil layers (TORRES et al., 2014). Moreover, the use of full or supplemental irrigation with saline water, such as from artesian wells, has favored the increase of salts in topsoil (HOLANDA et al., 2016).

High salt content in soil and/or irrigation water reduces the free energy of water movement from one medium to another, increases osmotic potential in soil, and impairs water uptake by plants, thereby leading to stress (SANTOS et al., 2010). Water stress can negatively impact plants. The severity of the impacts depends on intensity and duration of stress, the plant species, and the phenological stage (NASCIMENTO et al., 2011).

Plants have evolved mechanisms to prevent water loss and/or maximize water use efficiency. The accumulation of compatible osmolytes inside cells to increase osmotic potential is one of these mechanisms because a more negative osmotic potential improves water uptake from soil, prevents cellular dehydration and increases the crop's tolerance to stress (PARIDA & DAS, 2005; GAGNEUL et al., 2007; BLUM, 2016).

Cowpea (*Vigna unguiculata* (L.) Walp) is a drought-tolerant species that can be grown in environments with rainfall instability, high evaporation rates, and saline irrigation (COELHO et al., 2013). Cowpea is classified as moderately tolerant to salinity and can be irrigated with water at an electrical conductivity of up to 3.3 dS m^{-1} without reduction in yield (AYERS & WESTCOT, 1999). However, to activate tolerance mechanisms, the energy demand of the crop is high, which can affect flowering and grain production. Therefore, it is necessary to evaluate viable management strategies to improve crop performance and production under conditions of saline stress (DIAS et al., 2015).

The application of cattle manure to soil is a management strategy that has been studied in cultivated plants and has the potential to reduce damage caused by salinity. Organic matter contained in manure favors physical and chemical properties of soil, thus benefiting soil aggregation and, consequently, water infiltration and water availability for crops (SILVA et al., 2011; PEREIRA et al., 2013). Manure is also a sustainable nutrient source (AYDIN et al., 2012). The hypothesis is cowpea has a different response under salinity levels above the recommended level, which can affect plant growth and yields, and manure can alleviate such negative effects. The aim of this study was to evaluate the effects of organic matter in cowpea irrigated with saline water.

MATERIAL AND METHODS

The study was carried out in a protected environment in the experimental area of the State University of Southwest Bahia (UESB), campus of Vitória da Conquista, Bahia state, Brazil (14º53'08" S, 40º48'02" W). A 5x5 factorial experiment was conducted in pots with a capacity of 30 dm³, in a randomized block design. The treatments consisted of five electrical conductivities of irrigation water (0.0; 1.5; 3.0; 4.5; and 6.0 dS m^{-1}) and five rates of composted cattle manure (0, 10, 20, 30, 40 t ha^{-1}), with three replications, totaling 75 experimental units. Each experimental plot consisted of two cowpea plants, variety BRS Guariba.

A Yellow Latosol (Oxisol) with sandy loam texture was used to fill the pots. Cattle manure was homogenously mixed with soil in the pots. The amounts were 0.140; 0.280; 0.420 and 0.560 kg pot^{-1}, with referred to rates of 10, 20, 30 and 40 t ha^{-1}, respectively, in addition to the control without application (0 kg). The soil and manure were analyzed prior to the implementation of the experiment (Table 1 and 2).

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

P	K^+	Ca^{++}	Mg^{++}	Al^{+3}	H^-	Na^+	SB
mg dm^{-3}	-------------------------------- cmol$_c$ dm^{-3} ------------------------------						
2.0	0.12	0.6	0.3	0.4	2.4	-	1.0
t	T	V	m	ESP	OM	pH	
--------- cmol$_c$ dm^{-3}------		--------------- % ------------			g dm^{-3}	(H_2O)	
1.4	3.8	27	28	-	10	5.0	

Sum of bases (SB); t = SB + Al^{+3}; T = t + H^-; Base saturation (V); Aluminum saturation (m); Exchangeable sodium percentage (ESP); Organic matter (OM).

Table 2. Chemical characteristics of cattle manure used in the experiment.

N	P	K^+	Ca^{++}	Mg^{++}	S	OC	Na^+
%							
1.7	0.4	3.2	1.1	0.5	0.3	15.3	0.1
Zn	Fe	Mn	Cu	B	pH	N/C	
ppm					(H_2O)	-	
128.0	3017.6	200.8	12.0	34.7	9.0	9.1	

Organic carbon (OC); Carbon and Nitrogen ratio (N/C).

Irrigation with saline water started 20 days after germination. To prepare the saline solutions, concentrated sodium chloride (NaCl) solution was added to fresh water (0.0 dS m^{-1}) to obtain electrical conductivities of 1.5, 3.0, 4.5, and 6.0 dS m^{-1}, measured using a portable conductivity meter model R-TEC-4P-MP (Technal) (Table 3).

Irrigation levels were determined by the pot capacity method. 28 kg of dry soil was weighed to fill each pot. Field capacity was kept by irrigating the pots until water drained through the bottom (ADORIAN et al., 2015). A two-day irrigation interval was used and the irrigated depth was obtained from difference between current weight at the time of irrigation and the soil weight at field capacity.

Table 3. Chemical characteristics of saline solutions used in the experiment.

Conductivity	Parameters analysed							
	pH	EC	Ca^{++}	Mg^{++}	K^+	Na^+	SAR	USSL
	-	dS m^{-1}	meq L^{-1}				-	-
0.0	6.9	0.1	0.1	0.1	0.0	1.3	4.1	C_1S_1
1.5	7.6	1.5	0.1	0.1	0.0	16.9	53.6	C_3S_4
3.0	7.0	3.0	0.1	0.1	0.0	29.1	92.1	C_4S_4
4.5	7.0	4.5	0.1	0.1	0.2	40.0	103.3	C_4S_4
6.0	7.0	6.0	0.1	0.1	0.3	59.1	187.0	C_4S_4

Electrical Conductivity (EC); Sodium Adsorption Ratio (SAR); Irrigation Water Classification (USSL) (UNITED STATES SALINITY LABORATORY STAFF, 1954).

To determine the osmotic potential (Ψs), three leaf discs (5 mm in diameter) were collected at flowering stage and frozen in liquid nitrogen. For analysis, a thermocouple psychrometer (Câmara C-52, Wescor) connected to a dew point microvoltmeter (Psy-PRO, Wescor, Logan, USA) was used. Following thawing and temperature stabilization of the samples, the discs were placed in the pressure chamber to obtain Ψs readings. The Ψs values were corrected using the method proposed by Wilson et al. (1979).

The data were tested for normality (Lilliefors) and homogeneity of variances (Cochran and Bartllet). Subsequently, analysis of variance was performed, and the means of treatments were compared to each other using Tukey test at 5% probability.

RESULTS AND DISCUSSION

An interaction of the factors was observed for osmotic potential (Ψs) of cowpea plants. The increase of salts in soil caused a significant reduction in Ψs (Figure 1 and 2). This interaction demonstrated the dependence between treatments and the need to study the treatments precisely because a decrease in Ψs in plants shows reduction in water availability, which affects the development of cowpea (AHANGER et al., 2014, SHELDON et al., 2017).

In analyzing the effect of salinity levels on cattle manure rates, it was observed that, without manure application, there was no reduction in Ψs, which may be due to the crop tolerance to saline water of up to 3.3 dS m^{-1}, varying according to the cowpea variety (AYERS & WESTCOT, 1999). There was no specific effect of the doses on the conductivities, only variation of Ψs without cattle manure application (Figure 1). Moreover, although there is no statistical difference, Ψs values tended to decrease even in presence of the highest salinity levels when cattle manure rates were 30 and 40 t ha^{-1}. The absence of statistical variation may indicate osmotic adjustment (KATERJI et al., 2003), which is an important feature enabling plants to adapt to osmotic stress conditions. However, under osmotic stress, plants accumulate osmotically compatible solutes to decrease osmotic potential and maintenance cell turgor and physiological processes (TURNER, 2017; DUTTA et al., 2018).

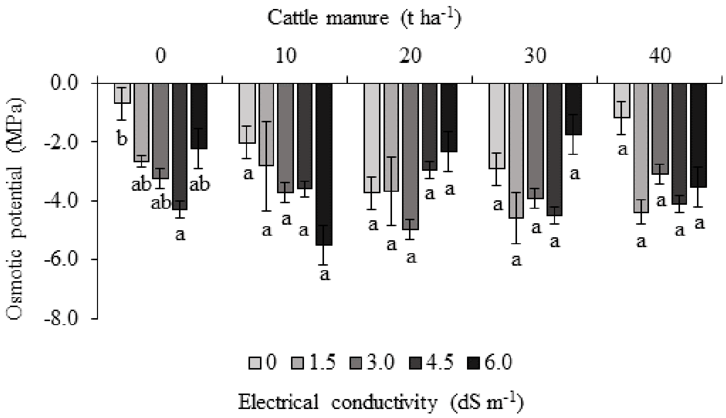

Figure 1. Interaction of cattle manure rates on the saline water in osmotic potential of Vigna unguiculata, cultivar BRS Guariba.

Regarding the effect of rates on conductivities, a significant reduction in Ψs was verified with increasing cattle manure rates. Despite being statistically similar, there was a reduction in Ψs values according to use of cattle manure at salinity levels above the recommended level (3.3 dS m^{-1}). In treatment of high conductivity (6.0 dS m^{-1}) and with 30 t ha^{-1} rate, there was a reduction of 40% in Ψs compared with the absence of cattle manure at this conductivity (Figure 2). This positive result demonstrates that cattle manure has potential to mitigate saline stress in cowpea beans and further study. Such effect corroborates the potential of organic matter sources as an alternative to amend saline soils (SHARIFI et al., 2021). Miranda et al. (2021) evaluated the performance of cowpea cultivars irrigated with saline water and observed increase in Ψs, mainly in treatments of greater electrical conductivity caused by saline water. Moreover, the use of cattle manure has shown benefits in the growth and yield of cowpea beans (DARSIAH, 2021); and emergence of seedlings irrigated with saline water at high conductivities above the recommended for the crop (OLIVEIRA et al., 2019).

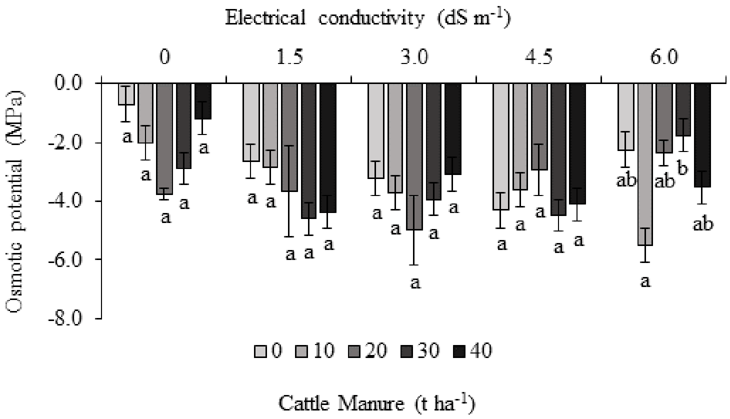

Figure 2. Interaction of saline water on cattle manure rates in osmotic potential of Vigna unguiculata, cultivar BRS Guariba.

CONCLUSIONS

• Significant interactions demonstrate the benefits of using organic matter in cowpea cultivation when salinity levels are above that tolerated by the crop.

• The rate of 30 t ha^{-1} showed better results in reducing osmotic potential in cowpea leaves at the highest salinity level.

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