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Crambe (*Crambe abyssinica*) growth cultivated in soils amended with biochar and irrigated with saline waters(1)

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ABSTRACT: Biochar (charcoal) is the term given to biomass subjected to the process of decomposition or change in the composition by the action of heat at high temperatures. The potential use of biochar as a soil amendment to mitigate the stress induced by salt in the plant has received little attention. This study aimed to evaluate the effects of biochar in the development of crambe irrigated with saline waters. The experiment was carried out in a greenhouse, following a completely randomized design with five levels of biochar and two irrigation waters, with four replications, totaling 40 experimental units. The analyzed parameters of plants were height, shoot and grain weight. Crambe growth was decreased as an effect of the doses of biochar used in this study. The electric conductivity of the waters used in this experiment did not caused influence in the analyzed parameters.

Keywords: salinity, poultry litter waste, growth of crambe.

INTRODUCTION

Biochar (charcoal) is the term given to biomass subjected to the process of decomposition or change in the composition by the action of heat at high temperatures. Chemically it is difficult to characterize the biochar due to the large variety of potential biomass to be employed for its production as well as the carbonization conditions employed for the conversion of biomass into biochar (Lehmann et al., 2006). In many agricultural and forestry production systems there is a significant amount of waste such as forest waste and crop residues left in the field after harvest. In addition to these waste, poultry litter can also be converted to biochar (Lehmann and Joseph, 2009; Chan et al., 2008). Many of the agricultural and forestry waste can be used to produce biochar that can be applied to agricultural land for both sequester carbon and to improve crop production potential. In many cases, these residues have little value and their disposal incurs costs. When applied to the soil, biochar acts as a soil conditioner promoting plant growth by retaining the nutrients and enhance the physical and chemical properties of the soil (Glaser et al 2002; Lehmann and Rondon, 2006). Experiments conducted in field with biochar application in the soil and its benefits to agricultural productivity are recognized. Furthermore, the application of biochar provides environmental benefits. The establishment of mechanisms by which external environmental benefits can be monetized or internalized may be important for the adoption of biochar production technologies (Lehmann et al., 2006). The potential of biochar to increase crop productivity has been demonstrated in a large number of studies on tropical agricultural products. It has been found that treatments with biochar increased crop yields averaged 10%, with larger effects observed in acid soils and thick texture (Jeffery et al., 2011). The high capacity activated carbons to adsorb a variety of salts has been observed, and for this reason the biochar have been used in industrial processes such as desalination (Zou et al., 2008). However, the potential use of biochar as a soil amendment to mitigate the stress induced by salt in the plant has received little attention. In this sense, this study aimed to evaluate the effects of biochar in the development of crambe irrigated with saline waters.

MATERIAL AND METHODS

The experiment was carried out in a greenhouse located at the Federal University of Campina Grande. The experiment followed a completely randomized design with five levels of biochar (0; 1%, 2%, 3%; and 4%) and two irrigation waters (public supply water [W1]: 1.2 dS m^{-1}; and pubic supply water + NaCl: 3.0 dS m^{-1} [W2]), with four replications, totaling 40 experimental units. The NaCl salt was added to the local water supply, in order to obtain an electrical conductivity (EC) of 3.0 dS m^{-1}. The quantity of NaCl (Q) for water W2 was determined by the equation Q (mg L^{-1}) = 640 x ECw (dS m^{-1}), as Rhoades et al. (2000) state, in which ECw represents the desired value of electrical conductivity of the water. The soil, after being air-dried and sieved, was chemically analyzed and it presented the following results: pH_{H2O} (1:2.5): 5.60; electrical conductivity (E.C.): 0.14 dS m^{-1}; Ca, Mg, Na, K, H + Al, 33.2; 6.7; 1.0; 2.1; 35.1 $mmol_c$ kg^{-1}, respectively; P, 23.1 mg dm^{-3}, organic matter: 11.0 g dm^{-3}. The biochar was analyzed empirically by the following methodology: 12.5 grams of biochar were placed with 125 mL of distilled water in polyethylene tube with a drain partially closed by cotton, in order to prevent the loss of biochar. The results were the following: pH: 9.39; E.C.: 8.87 dS m^{-1}; Na, K, Ca and Mg: 465.1; 3020.2; 9.6; and 88.4 mg L^{-1}, respectively; and P: 56.9 mg L^{-1}. The soil was placed into pots with 20 dm^3 of capacity, with the respective doses of biochar for each treatment. In the sequence, the soil was moisturized with rainfall water at field capacity and it remained incubated for 30 days with corresponding moisture to field capacity. Two seedlings of crambe were transplanted in each pot, remaining one plant after 20 days. In the sequence, the irrigation with W1 and W2 waters were started and it remained for 30 more days, when the plants presented symptoms of stress caused by the treatments. The total experimental period lasted 80 days. After this period, the height of plants was measured, harvested, wrapped in paper bags, and placed in an oven with forced air circulation, at 65°C for 72 hours. Subsequently, the plants were weighed and the grains were separated from each plant in order to determine its weight separately.

RESULTS AND DISCUSSION

The doses of biochar (B) used in this study presented significant effects for height, shoot and grain weights. On the other hand, the waters (W1 and W2) did not present significant effects for those parameters. In the same way, the interaction between water and biochar did not presented significance (Table 1). However, after deploying biochar into water, the linear model was significant for the analyzed plants parameters, except for height of plants irrigated with water of public supply (W1). In Figure 1, we can observe that the increase in biochar doses resulted in the tendency of decreasing in all parameters, for both waters. Biochar has been related in the literature as a good amendment material for soils (Chan et al., 2008), however it seems that the diversity of raw material for the production of biochar and, as a consequence, the variety of its chemical composition, has been one of the challenges to establish the suitable use of biochar to meet soil and plant needs (Chan et al., 2007).

Salinity levels have been reported as a factor for decreasing crambe biomass production and plant growth (Ionov et al., 2013; Vasconcelos et al., 2015). However, in the present study it has noticed that the waters used for irrigation did not influenced the analyzed parameters. In this sense, we can state that biochar doses were the main responsible for the results obtained in it. The biochar used in this study is originated from poultry litter waste and according to its chemical characterization it can be observed the high amount of Na (465.1 mg L^{-1}), K (3020.2 mg L^{-1}), and P (56.9 mg L^{-1}) in its composition. Besides, the high value of E.C. is another aspect to consider in this biochar. Although the applied doses of biochar in the soil were low (ranging from 0 to 4%), they were responsible for the decrease in the values of plant parameters (Table 2), which indicates that this biochar may present adverse aspects in plant growth. The high amounts of elements uptaken by crambe plants may cause imbalances in their metabolism, which can compromise their adequate growth. Establishing the appropriate doses of biochar to meet the availability of nutrients to the soil and the nutritional needs of plants has been a major challenge in this research field. In this sense, this paper presented a contribution to the advancement of this research.

CONCLUSIONS

Crambe growth was decreased as an effect of the doses of biochar used in this study. The electric conductivity of the waters used in this experiment did not caused influence in the analyzed parameters.

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Table 1. Analysis of variance for the variables of crambe growth

Source of variation	D.F.	Mean Squares		
		Height	Shoot weight	Grain weight
Water (W)	1	22.50 ns	26.86 ns	8.50 ns
Biochar (B)	4	445.37*	166.63**	23.69**
Linear	1	1584.20**	659.29**	92.85**
Quadratic	1	185.14 ns	4.56 ns	0.35 ns
Deviation	2	6.07 ns	1.34 ns	0.78 ns
W x B	4	200.75 ns	53.62 ns	4.40 ns
B within W1				
Linear	1	562.50 ns	290.08**	66.77**
Quadratic	1	60.07 ns	9.05 ns	6.56 ns
Deviation	2	223.21 ns	48.56 ns	0.21 ns
B within W2				
Linear	1	1060.90*	371.73**	29.77**
Quadratic	1	132.07 ns	0.00 ns	2.97 ns
Deviation	2	161.26 ns	56.51 ns	2.93 ns
Error	30	157.23	27.58	3.30
CV (%)		15.11	27.05	50.02
Mean		83.00	19.41	3.63

Table 2. Crambe parameters as a function of splitting: types of water within biochar doses.

Water	Biochar (g/pot)				
	0	200	400	600	800
	Height (cm)				
W1	94.50 a	80.50 a	77.50 a	85.50 a	73.25 a
W2	94.50 a	92.25 a	81.75 a	70.75 a	79.50 a
	Shoot weight (g)				
W1	27.75 a	20.19 a	18.44 a	20.79 a	13.99 a
W2	23.06 a	24.82 a	18.85 a	12.01 b	14.22 a
	Grain weight (g)				
W1	7.43 a	4.93 a	3.30 a	2.71 a	2.08 a
W2	4.17 b	4.65 a	4.05 a	1.58 a	1.39 a

Figure 1. Height (a), shoot weight (b) and grain weight (c) of crambe as function of biochar and salinity.