EMERGENCE OF CRAMBE AND FORAGE SORGHUM UNDER SALINITY

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ABSTRACT: Salinity causes reductions in the emergence and growth of the plants; thus, it is essential to study the potential of salinized areas or areas in the process of salinization. One possibility is the forage production of salinity by means of tolerant species. The plants of crambe and sorghum present great potential in the production of forage, that can have its parameters of quality improved by the salinity. In order to evaluate the potential use of sorghum and crambe in these areas, five osmotic potentials were established with NaCl, where the main emergence parameters were analyzed. Crambe seeds showed strong reductions in germination and germination speed, indicating the need for replanting in areas under salinity while sorghum presented excellent germinative performance, but its seedlings were negatively impacted on growth, which, on the other hand, it was not observed in crambe seedlings. The crambe and sorghum cultivars studied confirmed the potential of implementation in salinized areas, which are more sensitive in seed germination and seedling initial growth phases, respectively.

KEYWORDS: *Crambe abyssinica, Sorghum bicolor,* salt stress.

EMERGÊNCIA DE CRAMBE E SORGO FORRAGEIRO SOB SALINIDADE

RESUMO: A salinidade provoca reduções na emergência e crescimento das plantas, deste modo é imprescindível estudos voltados ao aproveitamento do potencial de áreas salinizadas ou em processo de salinização. Uma possibilidade é a produção de forragem a partir de

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espécies tolerantes a salinidade. As plantas de crambe e sorgo apresentam grande potencial na produção de forragem, já que podem ter seus parâmetros de qualidade melhorados pela salinidade. Para se avaliar o potencial de uso de sorgo e crambe nestas áreas foram estabelecidos cinco potenciais osmóticos com NaCl, onde os principais parâmetros de emergência foram analisados. As sementes de crambe apresentaram fortes reduções na germinação e na velocidade de germinação, indicando a necessidade de replantios em áreas sob salinidade enquanto o sorgo apresentou excelente desempenho germinativo, mas suas plântulas sofreram impactos negativos no crescimento, o que, por outro lado, não foi observado em plântulas de crambe. As cultivares crambe e sorgo estudadas confirmaram o potencial de implementação em áreas salinizadas, sendo estas mais sensíveis nas fases de germinação e de crescimento inicial das mudas, respectivamente.

PALAVRAS-CHAVE: *Crambe abyssinica, Sorghum bicolor,* estresse salino.

INTRODUCTION

Crambe (*Crambe abyssinica* Hochst) is an annual and short cycle, which stands out for good yield and high oil content in its seeds. Crambe seeds have been pointed out as a potential oil source for biodiesel production and a by-product of oil extraction for animal feed (Falasca *et al*., 2010; Mizubuti *et al*., 2016). There are reports of the potential for growing in arid and semi-arid environments, where water scarcity and soil salinity are common (Pivetta *et al*., 2016). Sorghum [*Sorghum bicolor* (L.) Moench] may have several applications but var. CSF 20 has forage production and has been designated as a salt-tolerant variety (Lacerda *et al*., 2003). Salt stress during germination affects the seedlings emergence in the field and, consequently, the stand of the plants and crop growth, but on the other hand, it can improve forage quality parameters by significantly increasing crude protein and decreasing acid-detergent fiber (Yacoubi *et al*., 2013; Abu-Alrub *et al*., 2018). Therefore, it is necessary to investigate the tolerance level and understand the physiological responses to salt stress during the germination of these species. Thus, the objective of this study was to investigate the possibility of using salinized or salinization areas in the production of crambe var. FBS Brilhante and forage sorghum var. CSF 20 to produce animal feed.

MATERIAL AND METHODS

The experiments were conducted in the laboratory of Plant Physiology, Department of Biochemistry and Molecular Biology, Federal University of Ceará (UFC) in Fortaleza-CE, using a BOD chamber (Biochemical Oxygen Demand) at 25 °C, relative humidity greater than 90% and 12-h photoperiod. Seeds of two plant species were used: forage sorghum cv. CSF 20 that was previously evaluated as tolerant to saline stress during the vegetative growth phase and served as a plant material of tolerance to salinity, and crambe cv. FBS Brilhante, only a Brazilian variety of crambe launched by the MS Foundation in 2007 (Lenz *et al*., 2015).

The experiment design was completely randomized in a 2 × 5 factorial scheme, composed of two different plant species, crambe var. FBS Brilhante and forage sorghum var. CSF 20, and five osmotic potentials (Ψs), 0.0, -0.2, -0.4, -0.6 and -0.8 MPa, with four replicates (each repetition composed by hundred seeds) for each treatment. To simulate salt stress, sodium chloride (NaCl) solutions were prepared following the equation of Van`t Hoff and the osmotic potentials of solutions were check by osmometer (Wescor Vapor Pressure 5500). The seeding was done inside germitest paper dampened with Ψs of 0.0, -0.2, -0.4, -0,6 and -0.8 MPa, which corresponds approximately to 0, 40, 80, 120 and 160 mM NaCl or 0, 4, 8, 12 and 16 dS m^{-1}, respectively.

The first count was performed on the fourth day of imbibition and new daily counts until the seventh day to crambe and until the tenth day for sorghum, according to Brasil (2009). Geminated seeds are those that produce any part of a seedling, dead Seeds were considered seeds which are neither hard nor dormant or have not produced any part of a seedling, and hard seeds were those that at the end of the test did not absorb water. The germination speed index (GSI) was calculated by the formula defined by Maguire (1983) and the mean germination time (MGT) was calculated using the formula proposed by Labouriau (1983), and the results are expressed in days. After the germination days of each species, the seedlings were measured using a digital caliper, the same seedlings were oven-dried and weighed to determine the dry mass of the seedlings.

The experimental design was completely randomized. The data were subjected to the Shapiro-Wilk test before being subjecting the analysis of variance (ANOVA F-test). The mean treatment values were separated by a regression test ($p \leq 0.05$), using the SISVAR program (Ferreira, 2011).

RESULTS AND DISCUSSION

Under the non-saline condition, the crambe and sorghum seeds presented excellent germination, thus proving the good vigor and quality of these seeds (Figure 1). In addition, they did not differ in the percentage of germination (±89.5%) nor of hard seeds (±9.6%). However, when the seeds of these species were challenged at different saline conditions, they had notorious differences in germination.

Although Oliveira & Gomes-filho (2009) attributed reductions of germination and vigor to seeds of sorghum cv. CSF 20 under hydric and saline stress at 25°C, while these seeds showed excellent germination under salinity at 30°C (Figure 1a). But crambe showed reductions with salinity until Ψs of -0.6 MPa. Silva *et al*. (2019) did not observe reductions in the same potentials produced with the salt KCl, in this way the influence of the type of salt in the effects on the germination is notorious. The percentage of hard crambe seeds increased significantly from Ψs of -0.2 MPa, which indicates problems in water absorption before root protrusion (Figure 1b). Pivetta *et al*., 2016 also noted this problem in the emergence of crambe seedlings under saline soil conditions. The percentage of dead seed was only 1.4% for both sorghum and crambe seeds at any Ψs.

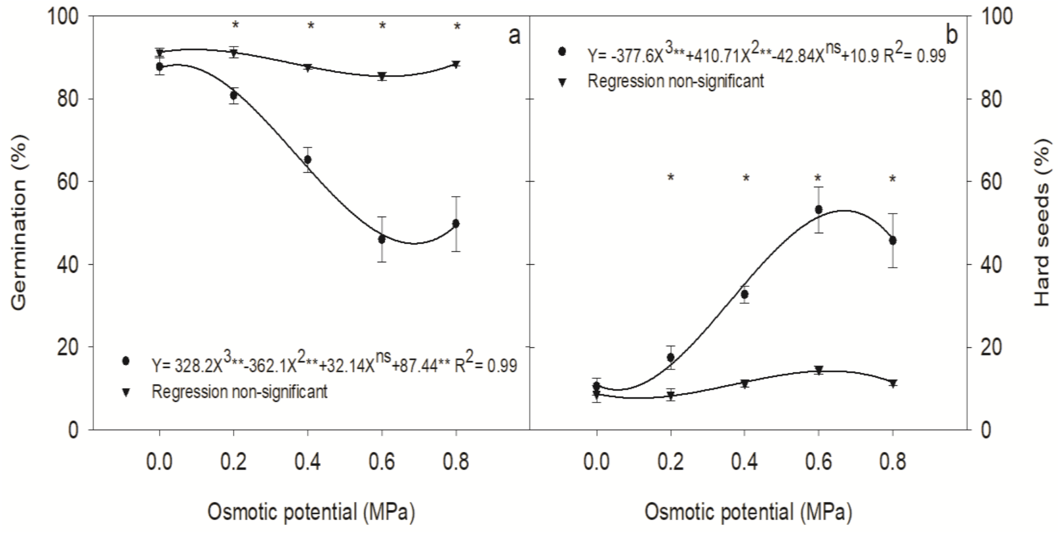

Figure 1. Germination (a) and percentage of hard seeds (b) of crambe (●) and sorghum (▼) seeds under different osmotic potential (|Ψs|) with NaCl. ** $p \leq 0.01$, * $p \leq 0.05$ and ^{ns} not significant.

The GSI of sorghum seeds did not differ under different Ψs in which they were submitted, resulting in a GSI of approximately 22 (Figure 2a). While the crambe seeds showed a reduction of approximately 50% in the GSI under Ψs of -0.6 MPa. Despite this, the

MGT was 4.16 days for both sorghum and crambe seeds at any Ψs. Sorghum seedlings have a higher dry mass at any potential, but a 31% greater reduction than crambe seedlings with the reduction in salinity potential (Figure 2b). Thus, sorghum seedlings showed greater reductions in growth than those of crambe with increased salinity.

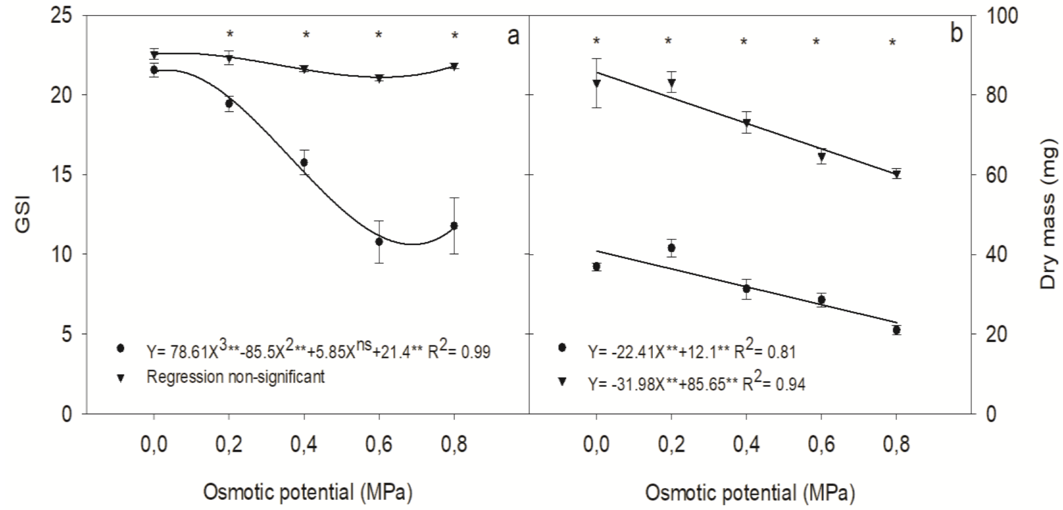

Figure 2. Germination speed index (GSI, a) and seedling dry mass (b) of crambe (●) and sorghum (▼) seedlings under different osmotic potential (|Ψs|) with NaCl. ** $p \leq 0.01$, * $p \leq 0.05$ and ^{ns} not significant.

Sorghum seedlings had a greater coleoptile length than those of crambe in all evaluated Ψs, but they also presented a reduction 177% larger than crambe seedlings with increased salinity (Figure 3a). The sorghum seedlings radicles also suffered strong reductions in size with the increase of salinity, presenting a constant decrease of 5.46% with a reduction of 0.1 potential (Figure 3b). Meanwhile, the crambe seedlings showed an improvement in root growth under Ψs of -0.2 MPa, but a reduction in their growth only under Ψs of -0.8MPa.

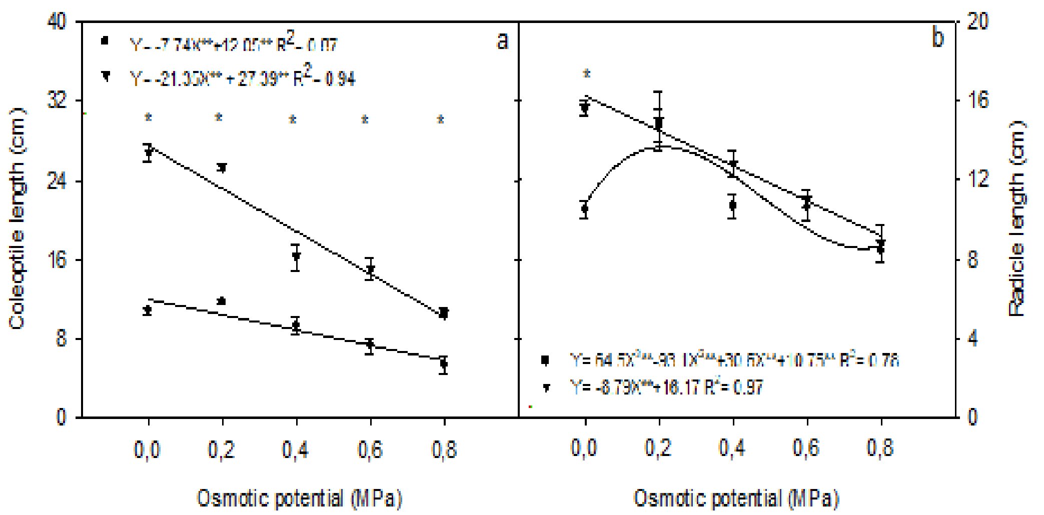

Figure 3. Coleoptile (a) and radicle (b) length of crambe (●) and sorghum (▼) seedlings under different osmotic potential (|Ψs|) with NaCl. ** $p \leq 0.01$, * $p \leq 0.05$ and ^{ns} not significant.

Under salinity, both crambe and sorghum seedlings radicles had similar lengths. Thus, a salt-tolerance of crambe seedlings was accompanied by a difficulty in water uptake during germination, which can be overcome using appropriate seed priming techniques to avoid failures in the plant stand and the need for replanting (Lopes *et al*., 2018). This technique can favor the effort to capture water under saline conditions by adjusting the expression and activation of K^+ and Na^+ transporters and of H^+ pumps generating the driving force to transport (Bahmani *et al*., 2015). In addition, Masetto *et al*. (2011) also observed strong influence only on the germination of crambe seeds in a study with water potential up to - 0.4 MPa, as also observed by Teixeira *et al*. (2011) in potentials up to -1.4 MPa. While Ionov *et al*. (2013) showed that irrigation of *Crambe abyssinica* with moderate salinities water (EC 6 dS m^{-1}) is feasible, thus supporting the need for investment in the physiological conditioning of seeds.

CONCLUSIONS

The crambe and sorghum cultivars studied confirmed the potential of implementation of these cultures in salinized areas. The main negative effects of saline stress were in the germination phase of crambe seeds and on the initial vegetative growth phase of sorghum seedlings, without, however, making it impossible to produce normal seedlings.

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