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Utilization of vitamins in the production of cucumber seedlings under saline stress

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Abstract
Numerous factors lead to the use of water with saline levels above those suitable for plant development, resulting in negative consequences on crops. Studies have sought techniques that aim to mitigate such consequences and the use of vitamins is promising, since these compounds improve the development conditions of vegetables. Thus, the study aimed to verify the ability of vitamins to mitigate the deleterious effects of using saline water, applied via irrigation during the formation of cucumber seedlings. Cucumber seeds were subjected to imbibition in three vitamin solutions (100 mg L^{-1} thiamine; 100 mg L^{-1} niacin; 50 mg L^{-1} thiamine + 50 mg L^{-1} niacin), in addition to two controls, both with water imbibition . After sowing, irrigation was carried out with saline water (100 mM NaCl), for all treatments, except for one of the controls. It was found that irrigation with saline water affected all variables studied, without, however, having a positive effect from the application of vitamins. Thus, it was concluded that the vitamins were not able to mitigate the deleterious effects caused by the application of saline water under the conditions in which the study was carried out and that future studies should be carried out to evaluate different concentrations and forms of application of the vitamins.
Keywords: abiotic stress; seedling production; osmoregulation; *Cucumis sativus* L.

Utilização de vitaminas na produção de mudas de pepineiro sob estresse salino

Resumo
Inúmeros fatores levam à utilização de água com teores salinos acima daqueles adequados ao desenvolvimento vegetal, acarretando consequências negativas sobre os cultivos. Estudos têm buscado técnicas que visem amenizar tais consequências e a utilização de vitaminas é promissora, uma vez que esses compostos melhoram as condições de desenvolvimento dos vegetais. Assim, o estudo teve como objetivo verificar a capacidade das vitaminas em mitigar os efeitos deletérios da utilização de água salina, aplicada via irrigação durante a formação de mudas de pepino. Sementes de pepineiro foram submetidas à embebição em três soluções vitamínicas (100 mg L^{-1} tiamina; 100 mg L^{-1} niacina; 50 mg L^{-1} tiamina + 50 mg L^{-1} niacina), além dois controles, ambos com embebição em água. Após a semeadura a irrigação foi realizada com água salina (100 mM de NaCl), para todos os tratamentos, com exceção de um dos controles. Verificou-se que a irrigação com água salina afetou todas as variáveis estudas, sem que, no entanto, houvesse efeito positivo da aplicação das vitaminas. Dessa maneira, concluiu-se que as vitaminas não foram capazes de mitigar os efeitos deletérios causados pela aplicação de água salina nas condições em que o estudo foi realizado e que estudos futuros devem ser realizados para avaliar diferentes concentrações e formas de aplicação das vitaminas.
Palavras-Chave: estresse abiótico; produção de mudas; osmorregulação; *Cucumis sativus* L.

Introduction

Among all the stages of development of a plant, salinity interferes negatively in all, being more severe in germination, emergence and initial growth, in most agricultural crops (ARAUJO *et al*., 2016). The accumulation of salts affects the functioning of the root by reducing the osmotic potential, causing an ionic imbalance in the soil, which reduces the absorption of some essential mineral nutrients, these changes are variable

between species and between cultivars, and may be more severe or not (MEDEIROS *et al*., 2007; BRITO *et al*., 2014; ARAUJO *et al*., 2016).

We can also highlight that salinity becomes a serious obstacle to the production system, both due to changes in the physical and chemical aspects of the soil, as well as by the action of some specific ions on the germination, growth, production and nutrition of plants (CAVALCANTE *et al*., 2010; BEZERRA *et al*., 2016). Ahmed and Montani (2010) and Bezerra *et al*. (2016) report, in this same context, that the most notable consequences of salinity on plants are related to changes in osmotic potential, ionic toxicity and imbalance in the absorption of nutrients, consequently reducing their growth and production.

Briefly, the effect of salinity on plant growth is due to the increase in osmotic pressure of the soil or substrate, which as a reflex acts negatively on physiological processes, decreasing water absorption by the roots, preventing meristematic activity and cell stretching (LIMA *et al*., 2015). It also causes morphophysiological changes, such as nutritional imbalance, reduction in stomatal conductance and lower proportions in the rates of transpiration, photosynthesis and internal CO_2 concentration in the leaves, resulting morphologically in the reduction of biomass in the plant and in fruit yield (BOSCO *et al*., 2009; LIMA *et al*., 2015).

Albuquerque *et al*. (2016) observed an influence of salinity in terms of emergence, growth and dry mass accumulation in different cucumber cultivars. According to him, the influence on the emergence of seedlings may have happened by reducing the ability to imbibe the seed, due to the increase in the osmotic potential of the cultivation medium, preventing or delaying germination, and consequently the emergence of seedlings. The influence on growth, on the other hand, may be related to the high concentrations of sodium salts that interact negatively in the physiology of plants by promoting ionic, osmotic and nutritional interactions that are harmful to plants. As for the accumulation of dry mass, the influence is given to the increase in the electrical conductivity of the water, to the nutritional imbalance and toxicity, which result in loss of breath, root expansion, water absorption and CO_2 fixation, thus reducing the total dry mass.

Techniques and products to alleviate the deleterious effects of abiotic stresses have been studied due to the large number of factors that exert some type of influence on cultures of economic interest. In this context, the exogenous application of vitamins has been studied as a stress-relieving technique caused by both biotic and abiotic factors (ABDALLAH *et al*., 2016). The use of vitamins can also improve physiological conditions, since it provides an increase in energy (EL-BASSIOUNY, 2005) and nutritional reserves, essential for the correct development of plant organs (TAIZ *et al*., 2017).

In a study developed with the application of vitamin in the culture of wheat, the immersion of the seeds in thiamine solution, provided the absorption and accumulation of nutrients, improving the development and increasing the productivity of the plants cultivated in fertilized soil with half of the fertilization recommendation. (EL-BASSIOUNY *et al*., 2014). For corn cultivars subjected to salt stress, the use of thiamine via seed immersion or via foliar application increased the levels of N, P, Ca and K in the tissues of plant organs (KAYA *et al*., 2015). The increase in biometric and productive characteristics was also obtained with the application of niacin to the cultures of quinoa, when the leaf application was performed (Abdallah *et al*., 2016) and for sweet corn and beans when the application was made via seed treatment (VENDRUSCOLO *et al*., 2018; VENDRUSCOLO; SELEGUINI, 2020).

Thus, the study aimed to verify the ability of vitamins to mitigate the deleterious effects of using saline water, applied via irrigation during the formation of cucumber seedlings.

Material and Methods

The work was developed in an agricultural screen environment with black monofilament screen with 30% shading, in the experimental area of the State University of Mato Grosso do Sul (UEMS), University Unit of Cassilândia (UUC), between the months of August to November 2019.

Prior to the implementation of the experiment, of *Cucumis sativus* seeds (cv. Esmeralda) were soaked in four solutions (100 mg L^{-1} thiamine solution; 100 mg L^{-1} niacin solution; 50 mg L^{-1} thiamine + 50 mg L^{-1} niacin solution) , in addition to distilled water, for 24 h, in a growth room with controlled temperature (25 ± 0.5 °C).

After the imbibition period, sowing was carried out, depositing one seed per cell in

expanded polystyrene trays, with 128 cells, filled with commercial organic substrate. The trays with the seeds were distributed on a metal bench inside the cultivation environment, composing the experiment in a completely randomized design, with five replications. The five treatments consisted of the aforementioned imbibition solutions and irrigation with saline water (100 mM NaCl), in addition to a control treatment, with seed soaking in distilled water and irrigation with fresh water. Each repetition was composed of 5 plants. The irrigations were carried out daily, in sufficient quantity to moisten the substrate, but without excessive drainage at the bottom of the trays.

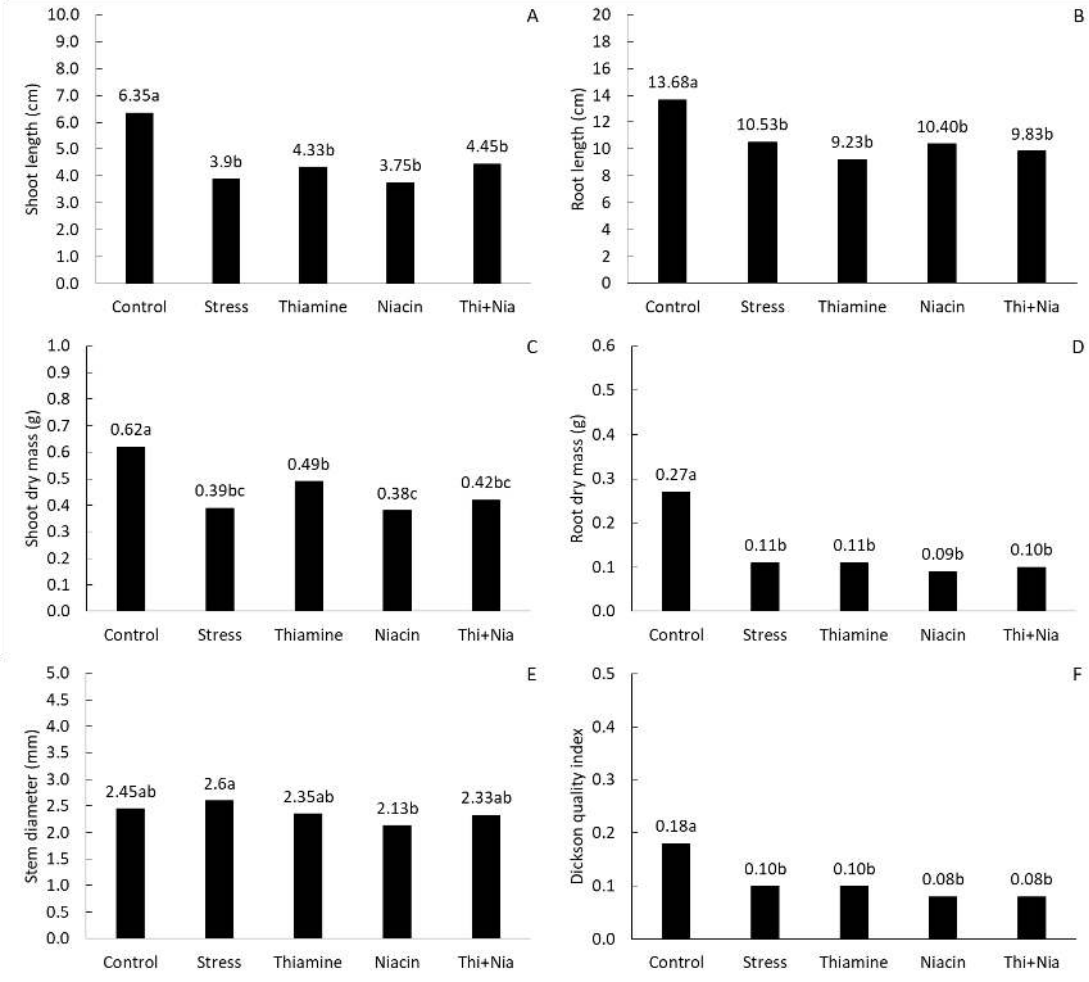
At 16 days after seedling emergence, measurements were made of the shoot length (SL) and root length (RL), stem diameter (SD), leaf area (LA) and number of leaves (NL). It was also evaluated the shoot dry mass (SDM) and root dry mass (RDM): the materials obtained were inserted in paper bags and kept in an oven at 65 °C, with forced air circulation, until a constant mass was obtained. Dickson's quality index (DQI) was also obtained, determined by: DQI = (SDM+RDM) / (SL / SD + SDM / RDM) (DICKSON *et al*., 1960).

Data were subjected to analysis of variance (F test) and the averages were compared by the LSD test, at 5% probability. The analyzes were performed using the statistical software Sisvar® 5.6 version for Windows (FERREIRA, 2014).

Results and Discussion

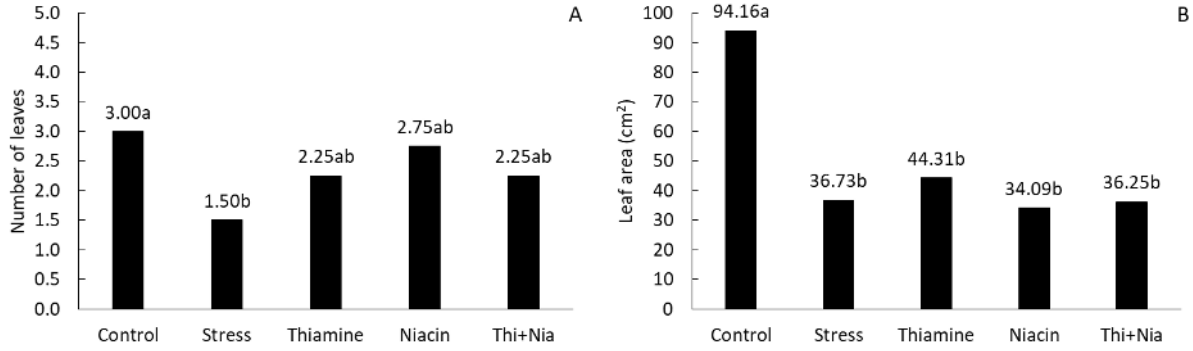
The deleterious effect of irrigation with saline water was verified, even when the seeds were subjected to soaking in vitamin solution, on the variables of shoot and root length, shoot and root dry mass and Dickson's quality index, however there was no significance between the treatments composed by the application of saline water and the control for the diameter of the stem (Figure 1).

Figure 1. Shoot length (A), root length (B), shoot dry mass (C), root dry mass (D), stem diameter (E) and Dickson quality index (F) of cucumber seedlings treated with vitamins and irrigated with saline water.



For the number of leaves, there was a significant difference between the control treatment and the treatment composed only by the application of saline water, with no difference for the treatments in which the vitamins were used (Figure 2A). This result demonstrates the potential of vitamins in mitigating the deleterious effects of irrigation with saline water, corroborating the results obtained by Vendruscolo and Seleguini (2020), who studied similar treatments with the culture of sweet corn. In this study, the authors found that the treatment of seeds, by soaking in solutions composed of 100 mg L^{-1} of niacin, 100 mg L^{-1} of thiamine and the combination of 50 mg L^{-1} of niacin and 50 mg L^{-1} of thiamine, reduced the total dry matter losses of the plants by about 20%, 55% and 85%, respectively, in relation to the control treatment with saline water.

Figure 2. Number of leaves (A) and leaf area (B) of cucumber seedlings treated with vitamins and irrigated with saline water.



Different from what was observed for the number of leaves, the treatments with vitamins did not provide increments in leaf area, not differing from the treatment composed only by irrigation with saline water (Figure 2B). This indicates that the vitamins provided a greater leaf emission, but without influencing the development of the limbus. This may be related to the form of irrigation, in which water containing a high concentration of salts had direct contact with the leaves.

The effects caused by the accumulation of salts, both in the plant and in the substrate, affect all the organs of the plants. In this sense, high concentrations of Na^+ in the substrate, result in less capacity of the plants to carry out the absorption of water and nutrients, in addition to hindering their translocation internally, from the root to the crown (ADIKU *et al*., 2001; PORCEL *et al*., 2012). In addition, when accumulated in plant organs in high concentrations, Na^+ becomes toxic, decreasing photosynthetic capacity and intensifying the occurrence of oxidative stress (ACOSTA-MOTOS *et al*., 2017; MORAIS *et al*., 2018).

In the present study, the action of concentration of salts may have been further leveraged by the form of application, since the irrigation was carried out in such a way that the solution reached the aerial organs of the plant, simulating a sprinkler system. Thus, after the evaporation of excess water, the deposition of the salts occurred directly on the epidermis of the leaves and stem, accentuating the effect of osmosis and even causing injuries to the tissues. With this situation in mind, stress potentiation was evident, culminating in different results from those observed in other studies, in which the effects of salinity and other abiotic factors were reduced with the application of vitamins.

For the culture of corn, it was verified that the soaking of seeds in solution containing up to 150 mg L^{-1} thiamine resulted in better seedling development and an increase of up to 50% in the emergence speed, when they were submitted to salinity (KAYA *et al*., 2015). Also, the application of thiamine solution, in concentrations of 50 and 100 mg L^{-1}, resulted in easing the stresses caused by the lack of water in upland rice plants, increasing panicle length and fertility (VENDRUSCOLO *et al*., 2020).

Other studies also point to the potential use of vitamins, even in conditions where there are no apparent stresses or being applied on purpose. In this context, the application of thiamine and niacin, alone and together,

increased the biometric and fertility characteristics of upland rice plants (VENDRUSCOLO *et al*., 2019). In addition, for vegetable species the application of these vitamins was also effective for increasing the development of mustard plants (VENDRUSCOLO *et al*., 2017b) and melon seedlings (VENDRUSCOLO *et al*., 2017a), acting as a biostimulant.

The effects related to the application of vitamins are mainly protective, in which vitamins play the role of activating secondary metabolism (VENDRUSCOLO *et al*., 2019). In this context, thiamine acts on carbon metabolism, protein synthesis and has a protective effect against the effects caused by biotic and abiotic stresses, also playing a coenzyme role in different metabolic pathways of vegetables (GOYER, 2010; KAYA *et al*., 2015). In addition, niacin has a biostimulating action (VENDRUSCOLO *et al*., 2018), in which it stimulates the accumulation of energy and nutritional reserves in plants, so that they acquire better conditions to go through periods of stress (EL-BASSIOUNY *et al.*, 2014; TAIZ *et al*., 2017).

Conclusion

The vitamins were unable to mitigate the deleterious effects caused by the application of saline water under the conditions in which the study was conducted.

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