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Original Article

Natural antioxidants: salinity atenuators and bio-stimulants

Antioxidantes naturais: atenuadores de salinidade e bioestimulantes

D. R. Alves[a], A. J. S. Viana[b], J. C. A. Andrade[a], M. R. da Costa[c] and D. A. C. Nobre[a*]

[a]Universidade Federal dos Vales do Jequitinhonha e Mucuri – UFVJM, Departamento de Agronomia – DAG, Laboratório de Processamento Vegetal, Núcleo de Estudos em Tecnologias para Secagem e Armazenamento – NETSA, Diamantina, MG, Brasil

[b]Universidade Federal dos Vales do Jequitinhonha e Mucuri – UFVJM, Laboratório Integrado de Pesquisas Multiusuário dos Vales do Jequitinhonha e Mucuri, Diamantina, MG, Brasil

[c]Universidade Federal dos Vales do Jequitinhonha e Mucuri – UFVJM, Departamento de Agronomia – DAG, Núcleo de Estudos em Biotecnologia, Inovações e Melhoramento de Plantas – NEBIM, Setor de Olericultura, Diamantina, MG, Brasil

Abstract

Salinity limits the growth and productivity of crops, to reverse these effects, natural pigments with antioxidant bioactivity can be studied, such as turmeric (*Curcuma longa* L.) and paprika (*Capsicum annum* L.). Therefore, it aimed to evaluate turmeric and paprika as possible saline stress attenuators and biostimulants during germination and initial development of smooth lettuce seedlings. In the laboratory, the seeds were treated for 1 hour with a solution of paprika and turmeric at doses 0 (negative control), 1, 2, 3 and 4 g L^{-1}, and placed on a substrate with saline solution of sodium chloride 4 g L^{-1} (-0,4 Mpa), and a positive control, composed of dry seeds arranged in a substrate moistened with distilled water. Physiological quality analysis were carried out, and for the dose that showed the best result (4 g L^{-1}), the treated seeds were grown in a greenhouse, and received weekly applications via foliar with a 4 g L^{-1} solution for turmeric and paprika. After the crop cycle, morphometric analyzes were performed. The turmeric and paprika solutions were analyzed by High-Performance Liquid Chromatography (HPLC) to identify the presence of bioactive substances. The turmeric doses were not efficient in overcoming the effects of salinity on seeds and seedlings, which was attributed to the low solubility of turmeric in water. Paprika, although it did not provide the biostimulant effect, was efficient in attenuating the effects of excess salt, at a concentration of 4 g L^{-1}, promoting increases in physiological quality. In HPLC, a very low signal response was noted in relation to samples composed of turmeric and paprika solutions, indicating a low percentage of soluble compounds, which compromises bioactivity, and leads to the need for further analyses using surfactants and/or other solvents with which there is greater affinity.

Keywords: *Curcuma longa*, *Capsicum annum*, salt stress, germination, *Lactuca sativa*.

Resumo

A salinidade limita o crescimento e a produtividade das culturas, para reverter esses efeitos podem ser estudados pigmentos naturais com bioatividade antioxidante, como a cúrcuma (*Curcuma longa* L.) e a páprica (*Capsicum annum* L.). Portanto, objetivou-se avaliar a cúrcuma e a páprica como possíveis atenuadores do estresse salino e bioestimulantes durante a germinação e desenvolvimento inicial de plantas de alface lisa. No laboratório, as sementes foram tratadas por 1 hora com solução de páprica e cúrcuma nas doses 0 (controle negativo), 1, 2, 3 e 4 g L^{-1}, e colocadas em substrato com solução salina de cloreto de sódio 4 g L^{-1} (-0,4 Mpa) e um controle positivo, composta por sementes secas dispostas em substrato umedecido com água destilada. Foram realizados análises de qualidade fisiológica e para a dose que apresentou melhor resultado (4 g L^{-1}) as sementes tratadas foram cultivadas em casa de vegetação e receberam aplicações semanais via foliar com solução 4 g L^{-1} de cúrcuma e páprica. Após o ciclo da cultura foram realizadas análises morfométricas. As soluções de cúrcuma e páprica foram analisadas por Cromatografia Líquida de Alta Eficiência (CLAE) para identificação da presença das substâncias bioativas. As doses de cúrcuma não foram eficientes em superar os efeitos da salinidade nas sementes e mudas, o que foi atribuído à baixa solubilidade da cúrcuma em água. A páprica, embora não tenha proporcionado o efeito bioestimulante, foi eficiente em atenuar os efeitos do excesso de sal, na concentração de 4 g L^{-1}, promovendo aumentos na qualidade fisiológica. Na CLAE foi observado um sinal de resposta muito baixo em relação às amostras compostas por soluções de cúrcuma e páprica, indicando um baixo percentual de compostos solúveis, o que compromete a bioatividade, e leva à necessidade de novas análises com o uso de surfactantes e/ou de outros solventes com os quais haja maior afinidade.

Palavras-chave: *Curcuma longa*, *Capsicum annum*, estresse salino, germinação, *Lactuca sativa*.

*e-mail: danubia.nobre@ufvjm.edu.br
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1. Introduction

Cultivation in arid and semi-arid regions is subject to biotic and abiotic stresses, extremely favorable conditions for the production of reactive oxygen species (ROS) (Gul and Ullah, 2022). This process is inevitable under aerobic conditions, being continuously produced and eliminated; however, in excess, it results in the disruption of cellular metabolism and regulatory pathways, promoting oxidative stress, which is detrimental to germination (Kumar et al., 2015; Awasthi et al., 2017).

One of the most important abiotic stresses is salinity, which affects various physiological and biochemical aspects of plants, potentially reducing crop yields (Lemes et al., 2018; Oliveira et al., 2024). Excessive irrigation associated with poor drainage in the area contribute to salt accumulation in the soil (Saibo and Ibraimo, 2022). However, salinity expresses greater sensitivity during germination and the early stages of growth (Stefanello et al., 2018).

To mitigate the effects of stress on plant development, organic compounds can be applied exogenously (Sebai et al., 2023). In this context, the use of antioxidant compounds that stimulate plant resilience by protecting seeds against excessive ROS production can be effective, due to the production of enzymes that sequester or degrade free radicals, or even act as biostimulants in the vigor and germination of seeds and seedlings (Macedo et al., 2017; Nedved et al., 2022; Sebai et al., 2023).

Yellow and red pigments of plant origin, such as turmeric (*Curcuma longa* L.) and paprika (*Capsicum annuum* L.), respectively, have recognized health benefits (Almalki et al., 2023; Santos et al., 2023), being functional due to their protection against oxidative stress through their antioxidant capacity, protecting against diseases, being sources of vitamins, carotenoids, and phenolic compounds, as well as having antifungal effects (Kim et al., 2021).

Turmeric is a functional food and has medicinal properties due to the presence of curcuminoid components (Almosa et al., 2020). The major component is curcumin (Oliveira and Pieniz, 2024) associated with various bioactivities such as antioxidant, antimicrobial, anti-inflammatory, antitumoral (Firoz et al., 2023; Oliveira and Pieniz, 2024). Paprika is obtained from varieties of peppers (Kim et al., 2021), have recognized antioxidant activity (Jeong et al., 2023), as well as exhibiting antimicrobial, anti-inflammatory, and anticancer bioactivities (Kennedy et al., 2021; Qin et al., 2024). The antioxidant power is mainly due to carotenoids such as capsanthin and capsaicinoid such as capsaicin (Kim et al., 2023; Poornima et al., 2024).

In view of the above, it is hypothesized that the use of antioxidants such as turmeric and paprika may be an alternative for use in organic farming, being a viable, inexpensive, and readily available natural biostimulant in the market, in addition to enabling sustainable agriculture and nutraceuticals, providing food security.

Therefore, the objective of the present study was to analyze turmeric and paprika as possible mitigators of saline stress and their biostimulant effects on the germination and development of butterhead lettuce (*Lactuca sativa*), a species somewhat sensitive to salinity (Souza et al., 2022), especially in the early stages (Stefanello et al., 2018).

2. Material and Methods

The analysis were conducted at the Laboratory for the Processing of Products of Plant Origin, during the months of November and December 2021, and in a greenhouse, between February and April 2022, in the Department of Agronomy, and in the chromatography room of the Department of Food Engineering, in March 2022, at the Federal University of the Jequitinhonha and Mucuri Valleys, Campus JK, Diamantina-MG, Brazil.

2.1. Seed treatment

The turmeric and paprika solutions at concentrations of 1, 2, 3 and 4 g L^{-1} were prepared through simple dilutions using distilled water. Then, 100 mL of each concentration were transferred to an Erlenmeyer flask, where the smooth lettuce seeds, cultivar Regina, were submerged for 1 h, then the seeds were removed from the solution and placed to dry under laboratory conditions (average temperature: 20.6°C; average relative humidity: 71.8%).

2.2. Saline solution for substrate in laboratory

Sanitized and disinfected Petri dishes with 70% alcohol were used to package the treated seeds. Two sheets of germitest® paper were added to each plate.

For the salt stress condition, a P.A sodium chloride solution 4 g L^{-1} (NaCl, analytical purity ≥ 99%) was prepared, used to moisten the germitest® paper in a proportion of 2.5 times the dry mass of the paper, simulating the potential osmotic pressure of -0.4 MPa.

2.3. Description in the laboratory: physiological quality assay for the two antioxidants

Seeds treated with different concentrations of turmeric and paprika were arranged in Petri dishes with the substrate under saline stress (-0.4 MPa) and the addition of two controls, the positive control (+) dry seeds arranged in substrate under distilled water without the saline condition, and the negative control (-) seeds preconditioned in distilled water for 1h and arranged in substrate under saline stress condition.

The design used was completely randomized, with 50 seeds for each repetition (Petri dish), with four repetitions per treatment, for a total of six treatments (Control + and -, doses 1, 2, 3 and 4 g L^{-1} of turmeric and paprika).

The Petri dishes were placed in plastic trays containing water, to simulate a humid chamber, kept under laboratory conditions (71.8% RH and 20.6°C) for seven days to evaluate the physiological quality of the seeds and seedlings.

For the germination analysis, on the seventh day after mounting the test, the number of normal seedlings (complete essential structures, developed, proportional and healthy), abnormal seedlings and dead seeds (Brasil, 2009) was counted, the results were expressed in percentage.

The root protrusion analysis was performed 24 hours after the test was set up, adapted of Nobre et al. (2021), where the rupture of the endosperm and emission of the radicle by the embryonic axis were observed, with the seeds that had at least 2 millimeters (mm) of visible length being computed. The results were expressed in percentage.

In evaluating the germination speed index (GSI), the number of seeds germinated daily was recorded for seven days, with the GSI obtained according to Formula 1, Maguire (1962):

$$GSI = \frac{G1}{N1} + \frac{G2}{N2} + \ldots + \frac{Gn}{Nn} \quad (1)$$

Where GSI = Germination Speed Index; G1, G2, and Gn = number of normal seedlings counted on the first, second, and last counts, respectively; N1, N2, and Nn = number of days from sowing to the first, second, and last counts, respectively.

The average length of seedlings was obtained on the seventh day after setting up the test, with ten seedlings randomly selected from the germination test, measured with a millimeter ruler in centimeters (cm). And to determine the weight of seedlings, twenty randomly selected seedlings were weighed on a precision scale (0.0001 g), obtaining the fresh weight in grams.

The twenty seedlings used to obtain the fresh weight (PF) were immersed in 20 mL of distilled water for 24 hours, then they were weighed again to obtain the wet weight (PU). After that, the samples were placed in an oven with forced air circulation for 48 hours at 65°C, and then they were weighed to determine the dry weight (DW) and, subsequently, the relative water content was determined, according to Slavik (1974).

2.4. Description in a greenhouse: morphological assay with the best dose of antioxidants

The antioxidant concentration of 4 g L^{-1} of turmeric and paprika, determined through statistical analysis as the most effective after laboratory conditions, was applied in a greenhouse. The experiment was conducted in a randomized block design with three blocks and four replications per block.

The treated seeds were arranged in seedbeds for seedling development and after emergence, the seedlings were transferred to 5L pots containing soil. During the crop cycle, the solution of the best dose of turmeric and paprika obtained in previous tests (4 g L^{-1}) was applied weekly in the foliar route until reaching the wetting point.

At 40 days after transplanting the lettuce seedlings, morphometric evaluations were performed on the plants in the three blocks: plant height was obtained with a millimeter ruler (cm); the total number of leaves of the plant was counted; the collar diameter (mm) was measured using digital caliper readings. Then, the plants were weighed to obtain the fresh mass of the aerial part, with a precision scale (0.01g), and the leaf area (AF) was determined, as indicated by Lédo et al. (2000).

2.5. Evaluation of the chromatographic profile of turmeric and paprika solutions

To determine the chromatographic profile of solutions 1, 2, 3 and 4 g L^{-1} of turmeric and paprika, analyzes were performed by analytical High Performance Liquid Chromatography (HPLC) using the Chromatograph Agilent Technologies® Deutschland GmbH, Waldbronn, Germany, Agilent 1260 Infinity Series, equipped with Quaternary Pump VL, Diode Array Detector VL. To obtain the samples, solutions were initially prepared evaluated by simple dilutions and the use of ultrapure water (Milli-Q®) for dilution. The prepared solutions were centrifuged, and the supernatant was removed to compose the samples analyzed in the equipment, from which 10 µL were removed for injection in the chromatograph. To carry out the analyses, an HPLC Discovery C18 column was used, particle size 5 µm, 25 cm x 4.6 mm, maintained at a temperature of 40 °C, flow rate of 1.0 mL $min^{-1.}$ The detection was carried out in the ultraviolet region with a wavelength of 190 a 360 nm.

2.6. Statistical analysis

The data from the laboratory experiment, with four replications, were analyzed separately for each compound studied, through analysis of variance, and the concentrations of turmeric and paprika applied were compared by regression, where the estimates of the parameters of the regression equation were significant at 5% by the test “t”. The data collected in the greenhouse test, with four replications, were submitted to analysis of variance, and the means of both antioxidants (turmeric and paprika) and the control were compared using the Tukey test at 5% probability, with the aid of the SISVAR® software.

3. Results

The results of the analysis of variance from the laboratory physiological quality test with turmeric showed significance ($p<0.01$) for the variables seedling length and germination speed index, both of which are important vigor tests.

For seedling length (Figure 1a), in conditions where saline stress was not imposed (control +), the average was higher (4.0 cm), while for negative control, the highest average (3.1 cm) was observed in comparison with turmeric doses.

For the germination speed index (GSI), in the positive control, as already assumed, the average was higher, with an index of 33.4 (Figure 1b); and again the negative control (Figure 1b), presented a higher GSI in relation to the other doses of turmeric (23.5).

Although turmeric is not capable of helping to overcome the effects of salinity during germination, it promoted noticeable increases in 4 g L^{-1} compared to the other doses of turmeric (Figure 1a and 1b), therefore it is suggested that there may be attenuation of salinity effects with increasing doses.

The results of the analysis of variance of the physiological quality test with paprika in the laboratory showed significance for the evaluated variables ($p<0.01$), with the exception of root protrusion and relative water content.

As already assumed, in the positive control, germination was high, with an average of 79.2% (Figure 2a), however, paprika promoted increases in germination under stress conditions (Figure 2a), with better results in the dosage of 4 g L^{-1} (63.8%) compared to the negative control (53.9%). As expected, the positive control showed high germination, with an average of 79.2% (Figure 2a). However, paprika promoted increases in germination under stress conditions (Figure 2a), with the best results at a dosage of 4 g L^{-1} (63.8%) compared to the negative control (53.9%).

Regarding the percentage of abnormal seedlings, there was a reduction with increasing doses of paprika (Figure 2b). The lowest percentage of abnormal seedlings (9.2%) was found at the dose of 4 g L^{-1}, when compared to the negative control (13.4%), which is in line with the greater germination that occurred at that dose (Figure 2a).

Dead seeds (Figure 3b) were observed in smaller amounts (25.6%) at the dosage of 4 g L^{-1}, when compared to the negative control (31.9%), which is in line with the greater germination that occurred in such dose (Figure 2a).

Regarding the germination speed index (GSI), the highest value was found in the positive control (22.3), as expected, followed by the negative control (13.6), and with increments in the dose of 4 g L^{-1} of paprika compared to the other doses (Figure 3b).

The above scenario shows that the paprika doses tested have no effect on the GSI (Figure 3b), however, the highest index at the dose of 4 g L^{-1} (11.7), indicates the possibility of increases in the GSI with the increase in the dose of the product, which requires the performance of new tests with dose adjustments.

For seedling length (Figure 4a), the dosage of 4 g L^{-1} expressed a higher average (2.4 cm) among the paprika doses tested, although growth was lower than that

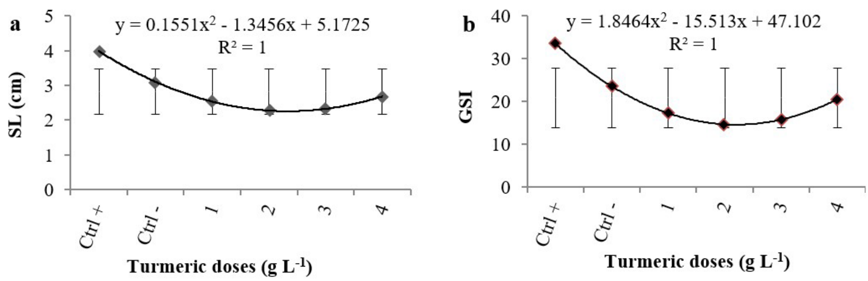

Figure 1. Seedling length - SL (a) and germination speed index - GSI (b) of smooth lettuce, cv. Regina, under doses of turmeric and saline stress.

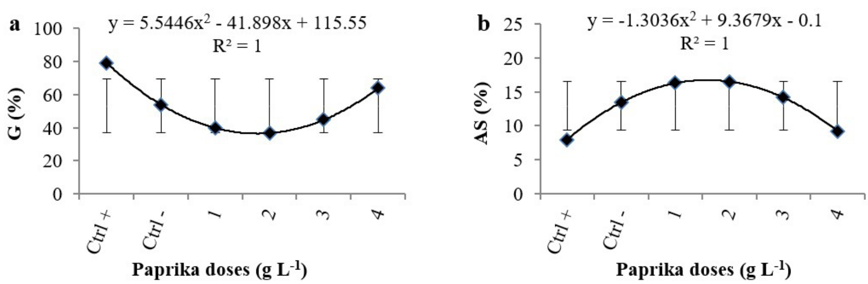

Figure 2. Germination - G (a) and abnormal seedlings - AS (b) from smooth lettuce seeds, cv. Regina, under doses of paprika and saline stress.

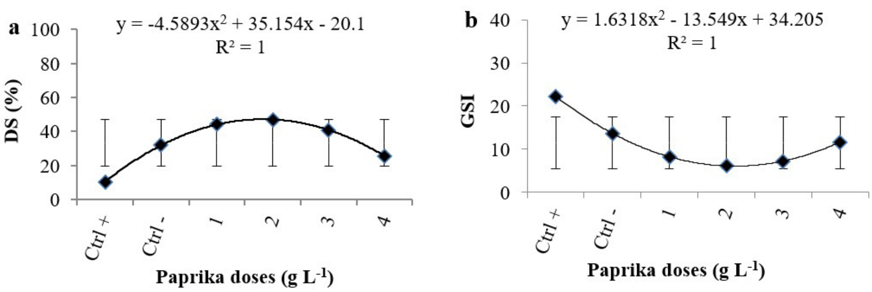

Figure 3. Percentage of dead seeds - DS (a) and Germination Speed Index - GSI (b) of smooth lettuce, cv. Regina, under doses of paprika and saline stress.

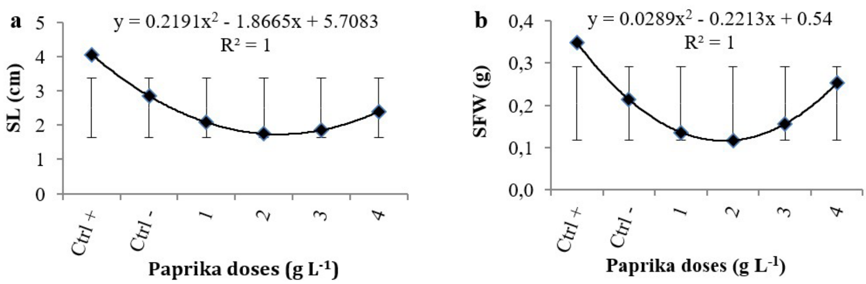

Figure 4. Seedling length - SL (a) and seedling fresh weight - SFW (b), from smooth lettuce seeds, cv. Regina, under doses of paprika and saline stress.

found in the negative control (2. 9 cm), there is a tendency that with the increase of the dose of the product there can be increases in the length of seedlings.

Higher fresh weight of seedlings was found in the dosage of 4 g L^{-1} (0.25 g), when compared to the negative control (0.21 g). As expected, the average in the positive control was the one that expressed the best result, around 0.35 g (Figure 4b).

In the greenhouse test with the best dose of turmeric and paprika, significance ($p<0.05$) was observed only for the collar diameter variable. The difference was evident between treatments with paprika and turmeric, with no significant difference when compared with the control (Figure 5).

Was observed in samples composed of solutions of 1, 2, 3, and 4 g L^{-1} of turmeric and paprika. Despite the relatively high concentrations of turmeric and paprika used (1, 2, 3, and 4 g L^{-1}), these samples exhibited low aqueous solubility, indicating that the chemical compounds were not highly present in the solution (not dissolved). The turmeric solutions showed well-defined peaks, indicating the presence of compounds, but the peak signal was relatively low, suggesting a limited concentration of components in the solution. On the other hand, the paprika samples did not show defined peaks, making it difficult to identify the compounds. These results emphasize the importance of studying the solubility of compounds for their application in various treatments, especially when dealing with substances with limited potential for aqueous dissolution.

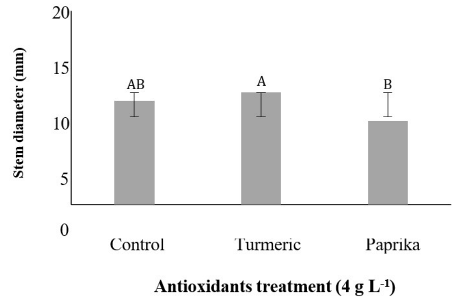

Figure 5. Lettuce stem diameter, cv. Regina, under doses of 4 g L^{-1} solution of turmeric and paprika applied to seeds and foliar. Distinct letters indicate significant differences between treatments ($p<0.05$).

4. Discussion

4.1. Physiological quality test with turmeric

For Silva et al. (2017), lettuce is sensitive to salinity, and there is a reduction in seedling length as salt levels increase. The same was observed for the present study (Figure 1a), however, when comparing only the turmeric doses, it is possible to notice that at 4 g L^{-1} (2.7 cm) there was a better result, which allows us to hypothesize that as the dose increases, length increases may occur even under saline stress.

Cruz et al. (2020), point out that salinity negatively interferes with seedling mass production and germination percentage, which justifies the reduction of GSI in the present study, when seeds were subjected to saline stress.

For Borges et al. (2019), the effects are presented by curcumin, a bioactive substance, which acts against ROS through chemical bonds with such molecules or the induction of antioxidant enzymes. However, for the present study, the fact that its application did not have an effect on overcoming salt stress can be attributed to factors such as the inefficiency of the doses tested, the form of application, the low solubility in water and the bioavailability of curcumin to the solvent used (water).

There is evidence that curcuminoids have low water solubility and slow dissolution due to their hydrophobic nature, meaning they are not fully absorbed and have low bioavailability (Chin et al., 2013). Additionally, using turmeric in powder form may contribute to increasing this low solubility because the contact area between the powder and the solvent is reduced as the powder floats on the water surface, further hindering the solubilization of curcuminoids, which already have limitations in aqueous dissolution. (Carvalho et al., 2015).

The application method of turmeric used for treating lettuce seeds may have been responsible for the non-significant effect of the product in the present study. The use of aqueous turmeric solutions may have been inadequate due to the compound's low solubility, meaning the solution did not have the required concentration. Thus, the solution absorbed by the seeds could have contained an insufficient amount of curcumin mass for satisfactory antioxidant activity under saline stress conditions. This may explain the increases in seedling length and GSI (Figure 1a and b) at the highest dose of turmeric applied.

The use and advances in research on natural antioxidants such as turmeric are included as a likely strategy to enable cultivation in saline soils, which are increasingly present in Brazilian territory.

4.2. Physiological quality test with páprica

Given the increase in germination observed for the 4 g L^{-1} dose compared to the negative control (Figure 2a), it is suggested that the application of paprika solution attenuates the effect of excess salts on the number of normal seedlings, since the salinity results in their reduction, with inhibition of germination due to the osmotic and toxic effects, which directly reflects on the final production, due to the smaller number of plants and/or the need for greater amounts of seeds for establishment of a crop (Schossler et al., 2012; Borges et al., 2014).

According to Ibrahim (2016), saline stress affects germination, inhibiting or delaying it, and the results of the present study suggest that paprika can act on the effects of salinity during the germination process for lettuce seeds.

In the condition of salt stress, there is a high probability of the formation of abnormal seedlings and the increase of dead seeds (Nogueira et al., 2020), however, it can be inferred that paprika acts in overcoming the effects of salt stress, positively interfering in the reduction of abnormal seedlings and dead seeds of lettuce (Figure 2b and 3a, respectively).

Sousa et al. (2021) and Sousa et al. (2022) state that under conditions of saline stress, plants suffer losses in their development due to changes in the nutrient absorption process, which in turn cause nutritional imbalances in plants. In addition, salinity causes less water availability due to the decrease in water potential and affects cell metabolism (Dias et al., 2016).

Such negative interferences caused by saline stress may have been limiting the growth of lettuce seedlings in the present research, however, with the use of paprika, positive effects can be assumed, being necessary to test other concentrations to achieve better results.

Rodrigues et al. (2015) found in their studies that exposure to increasing levels of saline water causes a linear reduction in lettuce fresh mass. Thus, the highest fresh weight found in the treatment with the highest dose of paprika (Figure 4b) demonstrates the product's performance in reversing the process that causes the decrease in fresh weight of seedlings in the saline stress condition.

The use of compounds present in vegetables has shown improvements in plant cultivation (Lorensi et al., 2017), and those with antioxidant properties (Jan et al., 2021), such as the compounds contained in paprika (Kim et al., 2016), can come to help in overcoming the oxidative stress resulting from the saline condition.

That said, and given the results found in the current study, it can be inferred that the 4 g L^{-1} paprika solution, through its properties that eliminate excess ROS (Nimse and Pal, 2015), has the ability to attenuate the effects of saline stress. Paprika's antioxidant activity results from the action of its capsaicinoid, phenolic, ascorbic acid and carotenoid compounds, which act by neutralizing reactive species (Kim et al., 2023; Poornima et al., 2024).

In general, in relation to the better results found for paprika compared to turmeric, it is assumed that these are attributed to the greater absorption that the antioxidant compound capsaicin presents in relation to curcumin (Suresh and Srinivasan, 2010). Furthermore, unlike turmeric, paprika has superior bioactivity in aqueous extracts (Kim et al., 2016). However, despite showing bioactivity in physiological quality tests compared to turmeric, it was observed that paprika also does not completely dissolve in water, i.e., solid residues remained insoluble. Therefore, it can be inferred that with the pursuit of increased paprika dissolution in aqueous media or the use of new application methods, the enhancement in seed physiological quality could be significant. This result necessitates a study to optimize the solubility of the product and/or the analysis of other solvents with which there is greater affinity, thus making the compounds viable for use in sustainable agriculture and nutraceuticals.

4.3. Test with the best dose of turmeric and paprika in a greenhouse

Only for the collar diameter, where the difference was shown between the treatments with paprika and turmeric. Plants with a larger collar diameter may have greater survival, mainly due to the formation and growth of new roots (Taiz and Zeiger, 2013). For lettuce seedlings, larger collar diameters provide greater support and resistance to tipping over (Paula et al., 2020).

The use of biostimulants has obtained satisfactory results in plant growth and development (Melo et al., 2018; Santos et al., 2019). Plants have a diversity of compounds involved in activities essential to plants, such as, for example, related to growth and defense mechanisms (Morzelle et al., 2017) and thus, due to their bioactivities, they have the potential to act as biostimulants in agriculture.

Thus, it is believed that the current results have been obtained due to the low solubility of the compounds. The low solubility, absorption and bioavailability of the compounds are limiting the use of turmeric and paprika as a bioactive (Chin et al., 2013; Kuroiwa and Higuchi, 2022).

4.4. Characterization of turmeric and paprika doses

The result was attributed to the low solubility of turmeric and paprika, at the time of sample preparation, it was noted that a large fraction of these compounds were present at the bottom of the falcon tube after centrifugation.

For Gama and Chaves (2019), sample preparation is one of the steps that provides the greatest possibility of errors in HPLC analysis. Agilent Technologies (2016) states that for the correct detection of substances through HPLC, it is necessary that they are completely solubilized in the prepared sample, which did not occur in the present study and, therefore, it is assumed that this was another motivation for that no target substances have been detected. Paschoal et al. (2021) obtained good results in the analysis of turmeric by HPLC solubilizing the sample with methanol and Lalić et al. (2022) obtained good efficiency and viability using 96% ethanol and acetonitrile as a solvent for capsaicinoids.

The efficiency found for paprika, even in the face of the low intensity of the substances' signals by HPLC, can be attributed to the possibility that the small amounts of solubilized compounds in the solution may present good bioavailability, which possibly did not happen for turmeric. Capsaicin has greater absorption than curcumin (Suresh and Srinivasan, 2010), and greater bioactivity in water (Kim et al., 2016).

5. Conclusions

Turmeric was not able to attenuate the effects of salinity on the germination and initial development of seedlings of smooth lettuce, cultivar Regina. On the other hand, paprika increases the germination and initial development of lettuce seedlings, reducing the effects caused by salinity, proving to be promising for indication in organic agriculture, requiring dose adjustment.

However, both turmeric and paprika did not have a biostimulant effect on lettuce plants. Both products do not have good aqueous solubility, proven by the non-identification of compounds through HPLC, and testing for optimize the solubility of the product in water, how to use surfactants, and/or the analysis of other solvents with which there is greater affinity, and do not compromise seed viability.

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