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KINETIN EFFECTS ON THE PHYSIOLOGICAL TRAITS OF SPEARMINT (*MENTHA SPICATA* L.) USING FOLIAR AND SEED SOAKING APPROACHES UNDER SALINITY STRESS CONDITIONS

SH.M. HAMZA

Department of Biology, College of Science, University of Basrah, Basrah, Iraq
Email: shatha.hamza@uobasrah.edu.iq

SUMMARY

Spearmint (*Mentha spicata* L.) has several known names, such as garden mint, common mint, lamb mint, and mackerel mint. Salinity is considerably one of the most vital causes negatively affecting plant life, reducing productivity. Kinetin, a cytokinin-like synthetic plant hormone, can promote plant growth against salinity. The potential research sought to study seeds soaking and foliar application of kinetin to mitigate harmful salinity effects, which cause chemo-physiological variations in spearmint due to increased salinity in the irrigation water. In the experiment, two salt concentrations (2.3 dS m^{-1} and 6.2 dS m^{-1}) helped develop the salinity environment, with kinetin (5 mg/L) used for seeds' soaking for four hours and as an exogenous treatment by foliar spraying of the spearmint seedlings. The results revealed an increased electron leakage percentage (ELP) related to a rise in salinity elements (Na^+ and Cl^-) at 6.2 dS m^{-1} in both groups with reducing K^+ levels. Likewise, a reduction was prominent in salinity elements with an enhancement in K^+ level with foliar application than the seeds soaked with kinetin. Increased proline content, H_2O_2, MDA, and an increase in antioxidant activity of CAT and SOD were evident in salinity treatment, which declined by treating with kinetin (5 mg L^{-1}) foliar application. The results proved that kinetin foliar spraying is the best in supporting *Mentha spicata* L. plant versus kinetin seeds soaking against the adverse effects of salinity.

Keywords: Spearmint (*Mentha spicata* L.), salinity levels, kinetin, antioxidant, chemical changes, seeds soaking, foliar spray

Key findings: Using kinetin with foliar spray was superior to soaking seeds with it to promote *Mentha spicata* L. plants for reducing salt elements Na^+, Cl^-, MDA, ELP, and proline content with increased K^+ content and antioxidant active.

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INTRODUCTION

Humans depend upon the food and medicines provided by healthy and no stressed plants because the stress may change the biochemical characteristics of the plant into a form that may be harmful to human health. Vegetable crops rarely grow in a favorable environment due to continuous climate changes and seldom obtain a maximum crop as one of the chief problems facing agriculture worldwide, especially salinity and its harmful effects (FAO, 2023). Many activities cause an increase in soil salinity, such as excessive fertilization, specifically with boron, or drainage of rivers (Singh and Prasad, 2019; Singh, 2022).

Seawater perceptively is the first event to cause an increase in salinity, resulting in atmospheric deposition, rising seawater levels, and temperatures that cause significant evaporation in the groundwater and the accumulation of salinity on the soil surface (Machado and Serralheiro, 2017). A high level of salinity means an increase in the level of toxic elements, such as Na^+ and Cl^- poisoning plant cells, especially the roots, and, thus, causing high osmosis, which prevents the plant from absorbing water that exposes the plant to its death (Isayenkov *et al*., 2019). The plants vary in their response to salinity based on the species, the environment, and the concentration of salinity elements (Mathuis, 2019).

Kinetin is a cytokinin-like synthetic plant hormone that can promote cell division, as well as, break apical dominance, encourage the growth of lateral shoots, and delay leaf senescence, helping the plant's resistance to salt stress (Robert *et al*., 2020). The kinetin's scientific name is 6-furfuryl amino purine, with chemical formula $C_{10}H_9ONS$ and a 215.2 molecular weight. Kinetin dissolves in organic solvents and can be prepared in the laboratory, characterized by biological activity in accelerating cell division. Past studies reported a significant improvement in plant growth by treating with kinetin under salt-stress conditions, reducing sodium ion toxicity and increasing potassium (K^+) levels (Al-Taey and Majid, 2018; Ghasemian and Riahi, 2021).

Spearmint (*M. spicata* L.) belongs to the family Lamiaceae, with commercial and medical importance as an alternative to chemical drugs because of their therapeutic efficacy (Ganesan *et al*., 2021). *M. spicata* L. has extensive cultivation worldwide because of its nutritional and medicinal value, treating colds, cough, obesity, fever, asthma, and digestive problems; one of the most valuable characteristics of this plant is a rhizome, herbaceous, aromatic, and perennial plant (Naoual *et al*., 2022). Several of the most crucial chemicals contained in this plant are polyphenols, a high-quality antioxidant (Karina *et al*., 2022). The phenolic compounds and essential oil extracted from the Lamiaceae family, such as the *M. spicata* plant, have good biological effectiveness, benefitting various applications and the food and drug industry because of the antioxidant qualities of these compounds, i.e., caffeic acid, eugenol, rosmarinic acid, and ɑ-tocopherol (Ganeson *et al*., 2021).

Several past studies showed the effect of kinetin, including a study on maize plants, concluding that treating the maize plants with different concentrations of kinetin increased the percentage of seed germination and improved the level of photosynthetic pigment (Kryslyna and Aleksandra, 2011). In another study conducted on the *Indigofera* plant, it was evident that treating the plant with kinetin with different concentrations (1.0, 1.5, and 2.0 mg/L) improved the growth characteristics of this plant (Royani *et al*., 2021). Some previous studies indicated the effect of kinetin treatments in reducing salt stress by treating wheat plants with kinetin (Kaya *et al*., 2009; Zahra and Fouad, 2021).

Other studies conducted on *Mentha spicata* L. existed, such as Chrysargyris *et al*. (2019) and Roumaissa *et al*. (2021), showing the effect of salinity on this plant and concluding reduced growth parameters and changes in biochemical traits under salinity conditions. Maize plants treated with different concentrations of kinetin decreased the salinity elements (sodium and chloride) and an increase in potassium absorption. *Solanum melongena,* with some concentrations of kinetin, significantly improved the antioxidant system in this plant and a delay in proline aggregation (Lawand *et al.,* 2023). The treatment of plant tissues of the strawberry plant using the culture technique showed that the plants gave more shoot/explant compared with the control treatment. Given the greater importance of the menthe plant and its extensive uses in food and medicine, and because of the increased salinity in irrigation water providing healthy, non-stressful food for people, the presented study pursued determining and comparing the effects of seeds soaking priming and foliar application of kinetin to reduce the negative impacts of salinity on the spearmint.

MATERIALS AND METHODS

The procured spearmint (*M. spicata* L.) seeds came from the Department of Field Crops, College of Agriculture, University of Basrah, Basrah, Iraq. Using a random seeds sample, tested the germination capacity of the seeds by planting 25 seeds in 9-cm Petri dishes in a dark condition by covering the Petri dishes at room temperature before watering them with distilled water for a week, after which the germination rate calculation proceeded with the following formula:

$$\text{Germination percentage} = \text{number of germinated seeds} / \text{total number of seeds} \times 100$$

Hence, the germination percentage was 95%. The characteristics of the soil analysis are available in Table 1. The spearmint seeds incurred two groups before planting in pots. Group 1 comprised the seeds soaked with kinetin (5 mg/L) for four hours, and Group 2 (without immersion) received the foliar spray of the kinetin (5 mg/L). Supplying kinetin with irrigated water only in the seedling stage, the two groups' planting in the potting soil occurred after preparing the soil with half strength of the Hoagland solution, with its components shown in Table 2. The pots' irrigation with the prepared salt concentrations (2.3 and 6.2 dS m^{-1}) included dissolving a specific weight of NaCl produced by Thomas-Baker-India (Table 3). The control treatment received irrigation with distilled water only. Data recording transpired after two weeks. The growth under semi-greenhouse conditions (for 21 days) and chemical analysis continued in the laboratory at the Department of Biology, College of Science, University of Basrah, Basrah, Iraq, where the temperature was 25 °C–27 °C and relative humidity of 75%–85%. Providing the complete Hoagland solution to pots ensued after seedling emergence.

Table 1. Soil characteristics of the experiment.

FC	PWP%	PH	CEC (mg/kg)	EC (ds/m)	N%	P (mg/kg)	K^+ (mg/kg)
22.0	9.0	7.2	1.3	1.02	0.05	13.00	59.0

FC: Field capacity, PWP: Permanent wilting point, EC: Electrical conductivity of mixture soil, CEC: Action exchange, capacity, N: nitrogen, P: Phosphorus, K: potassium.

Table 2. Hoagland components solution, Chemical Composition (mg/L).

NH4H2PO4	80	ZnSO4.7H2O	0.22
KNO3	503	CuSO4.5H2O	0.08
Ca(NO3) 24H2O	945	(NH4) MO7O24.H2O	0.02
MgSO2.7H2O	493	H2BO3	0.05
MgSO2.7H2O	493	NaFeDTPA (10%Fe)	0.30

Table 3. Concentration of treatments of experiments.

Treatments	Concentration of salinity treatments and interaction with kinetin	Irrigated water types
0.0	control	distilled water
S1	2.3 dsm^{-1}	salinity water
S2	6.3 dsm^{-1}	salinity water
S1K	2.3 dsm^{-1}+ 5 mg/L.	salinity water + kinetin
S2K	6.2 dsm^{-1} + 5 mg/L.	salinity water + kinetin

Mineral estimation (Na^+, Cl^-, K^+ mg/g DW, K^+/Na^+ %)

The 0.5 g spearmint leaves drying materialized at 65 °C for 48 h, followed by the dried leaves' digesting in 95% sulfuric acid and 4% perchloric acid (Cresser and Parson, 1979). The Na^+ estimation employed the Flame Photometer device using digested leaves and Cl^- evaluated with $AgNO_3$ 0.05 normality and utilizing a potassium chromate reagent. Using the Flame Photometer also helped assess the potassium (K^+), with the K^+/Na^+ ratio estimated by dividing the K^+ content by the Na^+ content in the spearmint leaves.

Electron leakage percentage (ELP %)

The electron leakage percentage (ELP) measurement engaged the method of Helena *et al*. (2019). Dissolving the 0.25 g fresh leaves tissue of spearmint in a 0.5 ml menthol solution took three hours at room temperature. Later, measuring the electrical conductivity used the device - Conduct metric Fi-Titration E 365 B, with the first reading recorded and then the samples placed in an electric oven at 90 °C for 10 min to completely kill the tissues (to ensure ionic leakage through the membranes). Afterward, repeat the measurements with the same device to record the second values. Expressing the amount of ion leakage followed the formula below:

$$ELP (\%) = (C_1 / C_2) \times 100 \quad C_1 = \text{First reading}$$

C_1 and C_2 = First and second reading

Enzyme estimation

The spearmint's 0.5 g fresh leaves grinding in liquid nitrogen proceeded adding to a reaction mixture consisting of 100 mM potassium phosphate buffer solution at pH = 7, 0.1 mM EDTA (Ethylenediaminetetraacetic Acid), 0.1 PVP (polyvinyl pyridine), 1 mM PMSF (Phenylmethylsulfonyl fluoride), completing the enzyme extract (Pitotti *et al*., 1995).

Catalase (CAT unit/min/g) estimation

According to Aebi (1983), the 40 µl from enzymatic extract with 2 ml H_2O_2 (0.01M) in 20 potassium phosphate buffer (pH = 7) measured the absorbance at 240 nm.

Super oxide dismutase (SOD unit/min/gm) estimation

The 40 µl from enzymatic extract with 2 ml tris-buffer and 0.5 ml from pyragallol had the absorbance measurement at 240 nm (Marklund and Marklund, 1974).

Proline content (µg/g)

Estimating the amount of proline ensued by the gradient 0.05 g of dry leaves in 10 ml of 3% sulfosalicylic acid in ceramic mortar at a temperature of 65 °C, using Ninhydrin acid to estimate the proline **(**Bates *et al*., 1973).

H_2O_2 estimation (µmol/g)

The 0.5 g leaves sustained grinding in 3 ml of TC (Trichloroacetic acid) and 1 ml of filtrate added to 0.5 ml of potassium phosphate buffer solution (pH = 7) with 1 ml of KI, with the absorbance measured with a spectrophotometer at a wavelength of 390 nm (Re *et al*.,1999).

Malonaldehyde (MDA) estimation (µmol/g)

Using a reaction mixture consisting of 5 ml of TCA, filtering the solution in a centrifuge and 1 ml of 5% of TBA (Thiobarbituric acid), and the absorbance measurement by spectrophotometer had a wavelength of 600 nm and 532 nm, and with the extinction coefficient of 155 (Cai *et al.,* 2004).

Statically analysis

The experiment design had three replications for each treatment, with the results analyzed using a two-way analysis of variance (ANOVA) and Duncan's multiple range test (DMRT) using the SPSS version 25 (Duncan, 1955).

RESULTS AND DISCUSSION

The results obtained came from treating spearmint (*M. spicata* L.) plants with two salt concentrations (2.3 and 6.3 dS m^{-1}) in both groups of the *Mentha spicata* plants with kinetin (5 mg/L) seed soaking and foliar application. The appearance of signs of salt toxicity in treatment 6.2 dS m^{-1} showed wilting in the plant and the appearance of burning marks on the leaves in Groups 1 and 2. In treatment 2.3 dS m^{-1}, these signs did not appear during two weeks of treatment in both groups of plants treated with saline water and without kinetin in Groups 1 and 2.

It was apparent that the saline water treatments 2.3 and 6.3 dS m^{-1} increased the concentration of salinity elements (Na^+ and Cl^-) in the leaves of *M. spicata* L. plants (Figure 1). However, it was evident that salt elements accumulated in Group 2 by 40% more than in Group 1. It might be due to the Group 1 seeds' priming in kinetin before planting, revealing the effectiveness of kinetin in protecting cellular membranes from permeability. Mathios *et al*. (2020) studied *Capsicum annuum,* and the ionic accumulation of Na^+ and Cl^- in the treatment 6.2 dS m^{-1} was higher than the 2.3 dS m^{-1} treatment. It also appeared that the interaction between kinetin with two salt treatments (2.3 and 6.3 dS m^{-1}) had significantly decreased the saline water elements in both groups of plants (Figure 1). It also appeared that the decline in the salinity elements (Na^+ and Cl^-) by treating with kinetin foliar spray was better than the seed priming with kinetin, which indicates that the foliar application with kinetin was better in reducing salinity elements than the seed priming with kinetin (Figure 2).

The accumulation of Na^+ and Cl^- linked with the burning and wilting of the whole plant by exposing the plants to salinity, causing an imbalance within the plant through the change in the osmotic potential surrounding the roots (Kaya *et al*., 2009; Bardees *et al*., 2019). The alteration in the balance of ions interlinked with signs of toxicity in the leaves, and it is consistent with the past findings of Muhammed *et al*. (2019 and 2020) on some species of grain legumes, wheat, and barley crops. Increasing salinity elements in the plant leads to cellular oxidation and permeability in the membranes, with results aligning with the observations of Ghosh *et al*. (2015) as they found an increase in the salinity elements through the roots salt concentration increased, raising the cellular oxidation and the formation of MDA; hence, the permeability of membranes and the influence of salt elements into plant cells rose when exposing the *Lycopersicon esculentum* plants to salinity.

At the same time, a decrease manifested in the K^+ content in the leaves of *M. spicata* L. plants in both salinity treatments (2.3 and 6.2 dS m^{-1}); and notably, it related to a decrease in the ratio of K^+/Na^+ in both groups of plants. However, in Group 2 plants, the reduction for potassium was higher than in Group 1, with a significant decrease in the K^+ ratio by 44% (Figure 3). It indicates that the seed priming with kinetin has a positive role in maintaining membrane permeability, and salinity stress reduces the content of K^+ and the rest of the positive ions that are vitally involved in the photosynthesis process

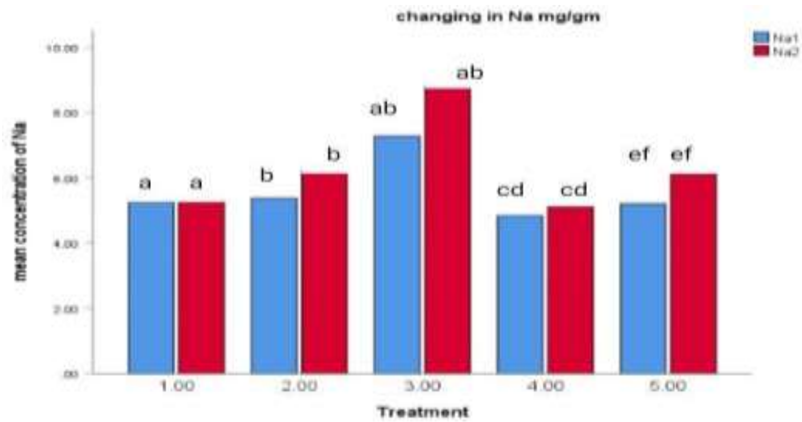

Figure 1. Effect of salinity and interaction with kinetin, 1: soaking seeds with kinetin, 2: foliar spray with kinetin on the Na+ content (mg/g) of *Mentha spicata* L. plant.

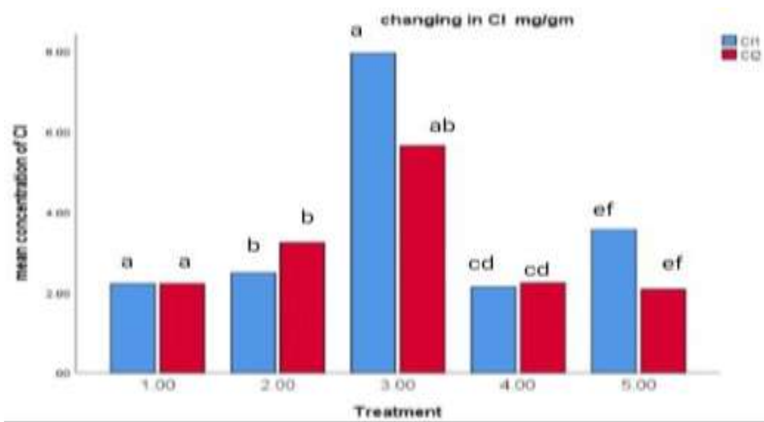

Figure 2. Effect of salinity and interaction with kinetin, 1: soaking seeds with kinetin, 2: foliar spray with kinetin on the Cl- content (mg/g) of *Mentha spicata* L. plant.

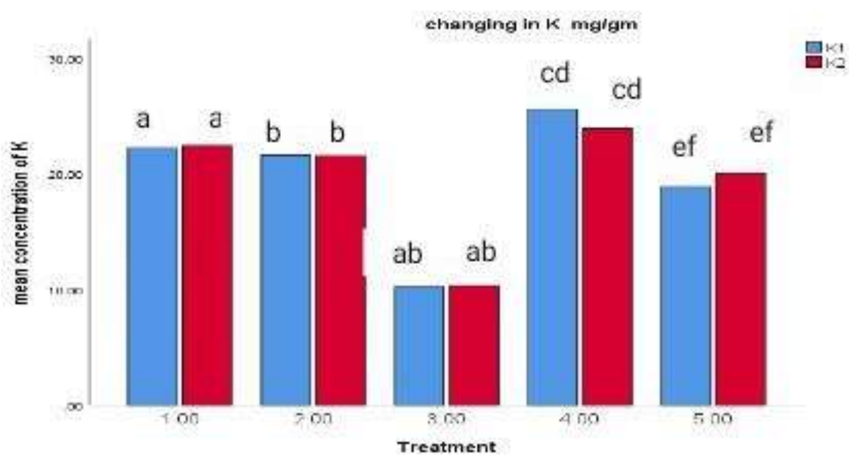

Figure 3. Effect of salinity and interaction with kinetin, 1: soaking seeds with kinetin, 2: foliar spray with kinetin on the K+ content (mg/g) of *Mentha spicata* L. plant.

(Muhammed *et al*., 2019, 2020). The reason may refer to the competition of ions Na^+ and K^+, Na^+ replacing K^+, reducing the level of K^+ in the plant as Na^+ displaces Ca^+ in the membranes and thus leaks out the K^+ concentration. These results agreed with the findings of Garg and Manchand (2016) in chickpeas. The K^+/Na^+ ratio also rose significantly at a $p < 0.05$ in the interaction of kinetin (5 mg/L) with the 2.3 and 6.2 dS m^{-1} treatments in both groups of spearmint plants. The K^+ content in Group 2 (foliar spray by kinetin) was better than Group 1 plants (with seed priming). The salinity treatment, 2.3 dS m^{-1}, was higher than in K^+ and K^+/Na^+ ratio by interaction with kinetin in both groups of plants (Figure 4).

Kinetin is one of the cytokinin plant hormones, stimulating growth and cell division and increasing plants' ability to face salt-stress conditions. Through its stimulating ability to divide, the cellular balance can succeed by reducing salt elements and maintaining cell membranes and growth (Swati *et al*., 2021). Also, noticeably, with the interaction of kinetin with saline water stress (6.2 dS m^{-1}), a significant reduction occurred in the salt elements by 45% in Group 2 and 35% in Group 1 plants. For the salt treatment (2.3 dS m^{-1}) and the interaction with kinetin in groups 1 and 2, the salts lowered at a higher rate than the treatment 6.2 dS m^{-1} in both groups. However, at the same time, a clear improvement appeared in the K^+ and K^+/Na^+ ratios in both groups of plants (Figure 4).

Significantly, with 2.3 dS m^{-1} treatment in both groups and at a lower rate in treatment 6.2 dS m^{-1}, it was prominent that Group 2 was superior in the level of reduction, which indicates that the foliar spray of kinetin was better. It illustrates the catalytic role of kinetin in the growth and maintenance of membranes against stresses in the plant cell. The results also revealed that the treatments with kinetin led to an increase in the efficiency of K^+ absorption in the control treatment, and the interaction of kinetin with two treatments reduced the amount of ion leakage significantly in two saline treatments (2.3 and 6.2 dS m^{-1}). However, treatment 6.2 dS m^{-1} showed a decline in the value of ELP by 48% in Group 2 and 32% in Group 1 plants, indicating that foliar spraying with kinetin was faster than kinetin seed priming (Figure 5). The interaction of kinetin with 2.3 dS m^{-1} significantly reduced ELP by 67%, with the integrity of the membrane considered one of the most critical factors affected by environmental stresses and reflects the extent of plants' ability to withstand stresses (Muhammed *et al*., 2019, 2020).

In this study, observing the ion leakage was prominent in the saline treatment (6.2 dS m^{-1}) in both groups of plants. It indicated an increase in the permeability of cellular membranes related to an increase in lipid oxidation and an increase in MDA due to salt elements' accumulation in the cells, raising the formation of ROS elements and thus an upsurge in oxidation and permeability of cellular membranes, with these results agreeing with the findings of Mansi *et al*. (2020) in sunflower. The interaction of kinetin with 6.2 dS m^{-1} treatment in both groups led to an apparent and significant ($p < 0.05$) reduction in ELP value (Figure 5). The interaction of kinetin with 6.2 dS m^{-1} treatment in both groups significantly decreased the ELP value, indicating a reduction in lipid peroxidation, lowering the permeability of cellular membranes associated with the ROS elements' reduction. The study findings agreed with past observations that reducing the level of ROS elements led to a decline in lipid oxidation in *Capsicum annuum* L. plants, thus decreasing the permeability of cellular membranes (Al-Taweel *et al*., 2019; Mathios *et al*., 2020; Novita *et al*., 2023).

Proline is one of the indicators of physiological changes in plants, providing a sign of the stress effect on plants, contributing to water stress reduction, and increasing the osmotic stress gradient between the roots and the surrounding medium to ensure that water enters the plant (Ahmed *et al*., 2020). The latest study noticed an increase in proline concentration with saline irrigation water, in salinity treatment 2.3 dS m^{-1} and a significant upsurge by treating with 6.2 dS m^{-1} in both groups of spearmint plants, which was apparent in Group 2 compared with Group 1 (Figure 6). Seed priming with kinetin showed

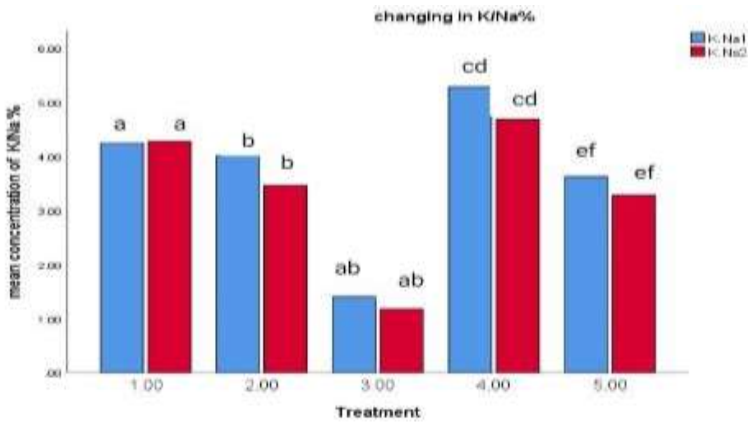

Figure 4. Effect of salinity and interaction with kinetin, 1: soaking seeds with kinetin, 2: foliar spray with kinetin on the K+/Na (%) of *Mentha spicata* L. plant.

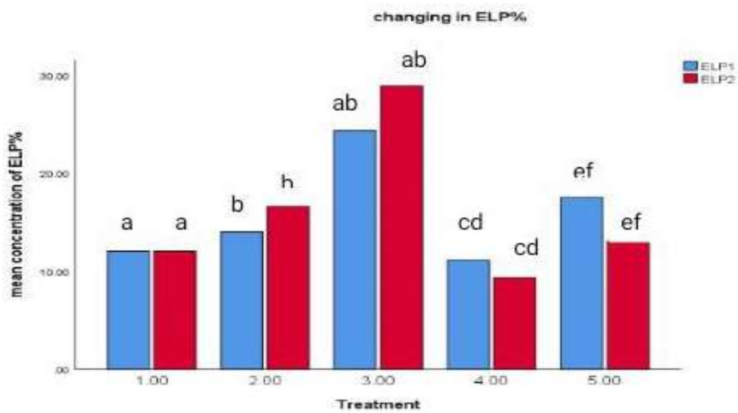

Figure 5. Effect of salinity and interaction with kinetin, 1: soaking seeds with kinetin, 2: foliar spray with kinetin on the ELP (%) of *Mentha spicata* L. plant.

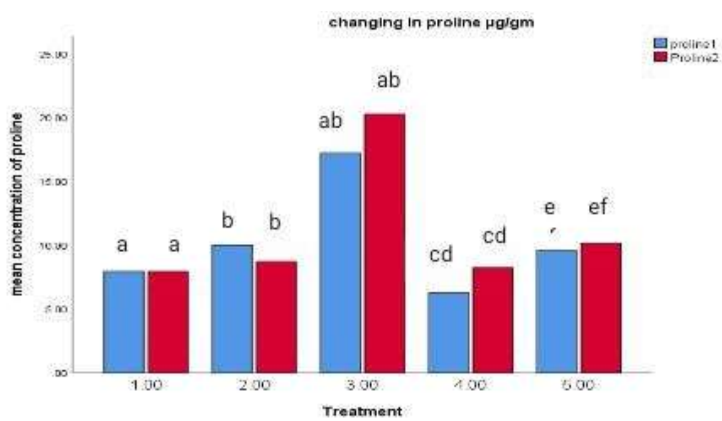

Figure 6. Effect of salinity and interaction with kinetin, 1: soaking seeds with kinetin, 2: foliar spray with kinetin on the proline content (µg/g) of *Mentha spicata* L. plant.

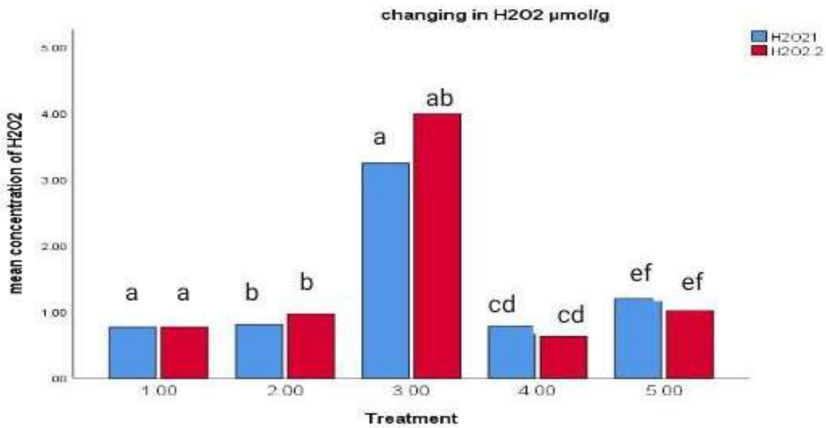

Figure 7. Effect of salinity and interaction with kinetin, 1: soaking seeds with kinetin, 2: foliar spray with kinetin on the H_2O_2 content (μmol/g) of *Mentha spicata* L. plant.

the effects of kinetin in facing salinity stresses and the reality of the chemical changes that occur in the plant when facing salt stresses, showing tolerance to salinity within specific ranges. *Mentha* plant is one of the moderate-tolerant plants to salinity at levels less than 6.2 dS m^{-1}, and an increase in proline causes an upsurge in the activity of the enzymes responsible for manufacturing proline, such as ornithine aminotransferase (Ahmed *et al*., 2020).

However, kinetin interaction with two salinity treatments showed a significant proline accumulation decline in the salt treatment of 6.2 dS m^{-1} in the two plant groups, while at 2.3 dS m-1, the less proline accumulation may be within the plants' tolerance level for salinity. This kinetin contributes to the protection of the plant by proline buildup to maintain osmosis and cellular balance, and this outcome aligned with observations of Afzal *et al*. (2006) in wheat crops. It was also evident through the study that an increase in the content of H_2O_2 occurs when raising saline treatments, with the salt treatment 6.2 dS m^{-1} giving a significant rise in the accumulation of H_2O_2. It positively correlated with the increase of salt elements (Na+ and Cl-), and an upsurge in the content of H_2O_2 coincided with increasing MDA content in the leaves of the *M. spicata* plant (Figure 7). It indicates an escalation in the permeability of cell membranes due to the accumulation of H_2O_2, causing lipid oxidation in the cell membrane. These results were consistent with the past findings in maize (Helena *et al*., 2019).

In the presented study, a relevant increase emerged in the MDA at 6.2 dS m^{-1} in both plant groups, showing the superiority of Group 2 in MDA accumulation (Figure 8). However, a lower MDA of 30.3% in Group 1 and 20.9% in Group 2 resulted in a salinity treatment of 2.3 dS $m\text{-}^{1}$ compared with 6.2 dS m^{-1} in both groups. The sensitivity of plants toward the stresses also appears through MDA assessment, which caused damage to the cellular membranes with a reduction in their stability in wheat (Tayyaba *et al*., 2018) and in the *Fenugreek* plant (Swati *et al*., 2021). In plants, the increase in salt elements causes damage to cell membranes, and enhancing ROS activity in stresses causes lipid oxidation, and the MDA increases. Interaction of kinetin with two salt treatments significantly reduced the content of H_2O_2 and MDA in both salt treatments (2.3 and 6.2 dS m^{-1}) in both groups of spearmint plants. However, the level of reduction in Group 2 was higher (38%) than in Group 1 with seed priming with kinetin, and these results appeared positively associated with an upsurge in antioxidant enzymes.

Generally, the stress conditions caused an increase in ROS as a mechanism of defense in plants against the stress factors to remove the toxicity of H_2O_2 and O^- (Ersalan *et al*., 2007; Swati *et al*., 2021). This study showed

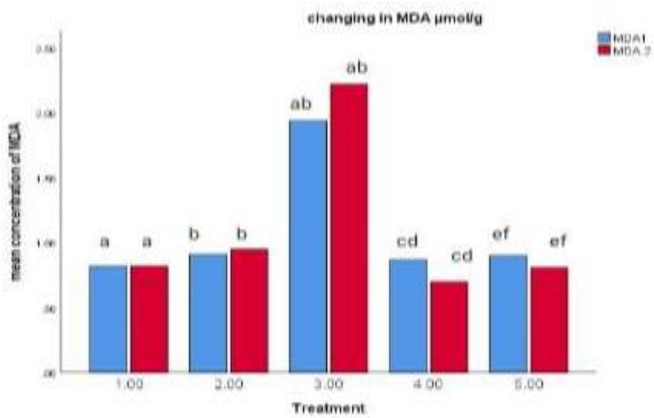

Figure 8. Effect of salinity and interaction with kinetin, 1: soaking seeds with kinetin, 2: foliar spray with kinetin on the MDA content (µmol/g) of *Mentha spicata* L. plant.

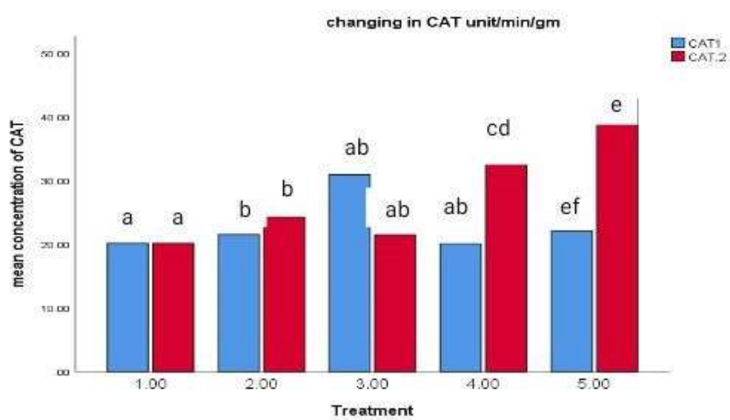

Figure 9. Effect of salinity and interaction with kinetin, 1: soaking seeds with kinetin, 2: foliar spray with kinetin on the CAT content (unit/min/g) of *Mentha spicata* L. plant.

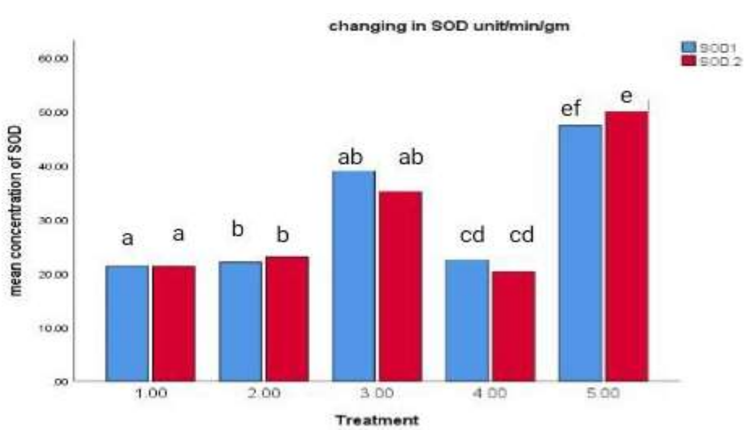

Figure 10. Effect of salinity and interaction with kinetin, 1: soaking seeds with kinetin, 2: foliar spray with kinetin on the SOD content (unit/min/g) of *Mentha spicata* L. plant.

the activity of CAT and SOD increasing significantly at $p < 0.05$ with 2.3 and 6.2 dS m^{-1} in both plant groups (Figures 9 and 10), which indicates that *M. Spicata* plants can heighten the activity of antioxidants when exposed to salinity stress conditions. These results were in harmony with the findings of Tayyaba *et al*. (2018) in wheat crops. The interaction of kinetin with salinity treatments causes substantial surges in CAT and SOD activity in both plant groups, with an increased level of enzyme activity in Group 2 compared with Group 1 plants by 38.2% of CAT enzyme activity and 44.7% of SOD activity. Libertad and Manuel (2014) stated that treating wheat plants with kinetin and saline treatments raised enzymatic antioxidant activity more than saline treatments without kinetin. Riti and Mirza (2020) mentioned modulation in antioxidant defense in the *Luffa acutangula* plant under salt stress interaction with kinetin.

CONCLUSIONS

The results indicated the effectiveness of kinetin in alleviating the adverse effect of irrigation water salinity on *M. spicata* plants. It reduced the level of salt elements and electron leakage percentage with the improvement in the potassium (K^+) absorption level, as well as, decreasing proline, H_2O_2, and MDA, with an increase in the level of enzymatic antioxidant activity observed with kinetin (5 mg L^{-1}). By treating the *M. spicata* plants with kinetin, using foliar application was better than soaking seeds with kinetin.

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