

Investigating the Impact of Salinity on Coriander Growth, Germination, and Stress Responses to Develop Sustainable Cultivation Practices in Saline Conditions

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Abstract

Coriander (*Coriandrum sativum* L.) is a widely used herb in culinary, medicinal, and industrial applications. It is essential to understand how salinity, a common agricultural issue, impacts its growth. This study examines the effects of different salt concentrations on coriander's germination, growth, and overall health. Using sodium chloride (NaCl) treatments ranging from 0 to 4000 ppm, the research evaluates key growth parameters such as germination rate, plant length, number of leaves, root development, and shoot tip necrosis. Results indicate a significant negative correlation between salinity levels and plant health. As NaCl concentration increased, the germination rate decreased sharply, with no germination observed at 4000 ppm. Similarly, plant length, number of leaves, and root development were significantly hindered by higher salinity levels. Shoot tip necrosis, an indicator of stress, became more prevalent with increasing NaCl concentrations. The findings underscore coriander's sensitivity to salinity, highlighting the need for effective soil and irrigation management practices to mitigate salinity's adverse effects. This study contributes to the broader understanding of salinity resilience in crops and underscores the importance of developing salt-tolerant varieties or adopting cultivation techniques to ensure sustainable coriander production in saline-prone areas.

Keywords: Coriander (*Coriandrum sativum* L.), Salinity, Germination, Crop resilience

I. INTRODUCTION

Coriander is a plant that people use in cooking, medicine [1], and as a decoration because it has a special taste and smell. It originally comes from places like Southern Europe and Western Asia and has been grown for a long time because it's important in many cultures' food. But sometimes, coriander faces problems from things like too much salt in the soil or water, which we call salinity. This happens a lot in areas where farmers use a lot of water to grow crops. When too much salt builds up, it can harm the coriander plants and make it hard for them to grow well. This is a big problem for farmers and even for people who grow coriander at home. To help with this issue, it's important to understand how salt affects coriander. By knowing this, farmers and researchers can figure out ways to protect coriander from the harmful effects of salt. In this study, we look at how salt affects coriander's growth [2], how much coriander it produces, its nutritional value, and how good it tastes. We also explore different ways to reduce the damage salt can cause to coriander plants. Overall, the goal is to find ways to help coriander grow well even when there's too much salt around. This helps make sure we can keep enjoying coriander in our food and keep it as an important plant in agriculture [3].

1.1 Importance of Studying Salinity Effects on Coriander

Understanding how salinity affects coriander is very important for several reasons. Coriander is not only widely used as a herb in cooking and medicine but also has industrial applications. Its leaves, seeds, and roots

are used in many cuisines worldwide, adding special flavors to dishes. Additionally, coriander has medicinal properties, like being antioxidants and fighting off microbes and inflammation. So, it's crucial to make sure we can grow high-quality coriander sustainably to meet the needs of consumers and industries. In places where the soil and water have a lot of salt, growing traditional crops can be hard because they don't handle salt well. But coriander is somewhat okay with salt, which means it could be a good alternative crop for areas with lots of salt. By studying how coriander deals with salt, scientists can figure out ways to make it even better at growing in salty places. This not only gives farmers more options but also helps protect traditional crops from the harmful effects of salt. Growing crops like coriander that can handle salt can also help us make use of land that's not good for regular farming because of too much salt. By growing coriander on these lands, farmers can improve the soil [4] and make it better for farming other things. Moreover, studying how salt affects coriander can teach us more about how plants deal with tough situations in general. This knowledge can help us make crops more resilient to things like climate change, which is making salt problems worse in many places. As salt becomes a bigger issue in farming, it's really important to find and grow crops that can handle it. This helps make sure we have enough food and that farming can continue even when the environment is changing. In summary, studying how salt affects coriander is crucial for making the most of its economic value, expanding farming into salty areas, improving degraded lands, and ensuring we have enough food despite environmental challenges. By figuring out how coriander can deal with salt and using smart farming techniques, scientists can help farming communities all over the world.

1.2 Scope and Limitations of the Research

Scope: This research explores how different salt levels affect coriander plants' growth, focusing on germination rate, plant height, leaf area, and yield. It examines the accumulation of salt ions and osmolytes in coriander under saline conditions, providing insights into the plant's salt tolerance mechanisms. The study also evaluates methods to mitigate salt's adverse effects on coriander development and yield, aiming to enhance agricultural practices in salt-affected areas. The findings contribute to the broader understanding of salinity resilience in coriander.

Limitations: The study's depth and breadth might be limited by resource constraints and time availability. Focusing on specific coriander cultivars could reduce the generalizability of the results to other varieties. Variability in environmental factors like humidity, temperature, and light intensity may affect plant responses to salt, complicating consistent results. Practical limitations in the scale of experimentation, including plot size and specialized equipment, could restrict comprehensive analyses. The study might not address long-term salinity effects on soil and microbial communities, which can indirectly influence coriander growth.

II.RELATED WORK

This comprehensive review emphasizes the importance of sustainable practices and targeted interventions to improve coriander's growth and yield in saline environments, contributing to a more sustainable agricultural future.

Sánchez-Navarro et al. (2024) Incorporating green manure and mitigating Na^+ and NO_3^- levels led to a notable 12.5% increase in soil organic carbon, demonstrating the effectiveness of sustainable practices in soil management. In LS soils, total biomass reached 35.9 tm ha^{-1} , surpassing the 31.9 tm ha^{-1} in S soils, showcasing the impact of soil type on biomass production, influenced further by salinity levels. Optimal irrigation dosages yielded 29 tm ha^{-1} of coriander, underlining the critical role of irrigation in maximizing crop yields. However, insufficient irrigation resulted in decreased productivity, emphasizing the necessity for precise irrigation management to prevent production losses and environmental pollution. This study highlights the importance of adopting tailored agricultural practices that not only enhance soil health and biomass

production but also mitigate environmental impacts, emphasizing the need for careful irrigation adjustments to sustainably meet agricultural demands.

Hassanein et al. (2022). The study delved into the utilization of biostimulants to bolster coriander's resilience and adaptation to salt-induced stress, imperative in addressing both biotic and abiotic adversities. It underscored the significance of comprehending the molecular, morphological, and physiological reactions to biostimulants to harness their advantages through seed priming. Notably, the amalgamation of humic acid and potassium silicate emerged as the most potent strategy, signifying their promise in safeguarding coriander yields amidst saline environments via seed priming techniques. This finding holds profound implications for sustainable agricultural practices, as it offers a targeted solution to mitigate the detrimental impacts of salinity on coriander cultivation, thereby fostering food security and agricultural sustainability.

Wang et al. (2022). This study delved into the protective properties of coriander (*Coriandrum sativum* L.) against hypertension resulting from a high-fructose, high-salt diet (HFSD) in Sprague-Dawley (SD) rats. Coriander exhibited notable improvements in glucolipid profiles, decreased sodium retention, and lowered serum uric acid levels. Moreover, it elevated the levels of vasodilator factors in the bloodstream. LC-MS/MS analysis unveiled the presence of flavonoids such as rutin and quercetin in coriander. These findings collectively indicate coriander's potential in mitigating HFSD-induced hypertension through multifaceted physiological mechanisms.

Amiripour et al. (2021). This study investigates the effects of silicon (Si) and salinity on coriander leaves, shedding light on their physiochemical characteristics under salt stress. However, the application of 100 and 200 mg/L Si mitigated the adverse effects of salt stress on growth parameters. Salinity decreased chlorophyll and relative water content, yet Si spray enhanced both. Interestingly, total phenol and flavonoid content increased at 100 mM NaCl but declined at 200 mM. Catalase and superoxide dismutase activity rose under salt stress but decreased with high Si saturation. The optimal treatment for maximizing essential oil production was 100 mM NaCl and 100 mg/L Si, suggesting the potential of Si in enhancing plant development and oil yield under moderate to severe salinity.

Amiripour et al. (2021). By treating coriander plants with varying concentrations of silicon and sodium chloride via foliar spray, the researchers uncovered intriguing insights. Higher EO output was noted in plants subjected to moderate salt stress and supplemented with lower concentrations of silicon. Moreover, the primary components of the EO exhibited varying levels across treatments, suggesting a complex interplay between salt stress and silicon supplementation. Fatty acid profiles also exhibited significant alterations under salt stress, with saturated fatty acids increasing while unsaturated fatty acids decreased. Heat map and principal component analyses provided further clarity on treatment effects. Overall, the findings underscore the nuanced relationship between salt stress, silicon supplementation, and coriander EO and FA composition, offering valuable insights for optimizing plant growth conditions.

Rabiei et al. (2020). Dual inoculation resulted in notable enhancements across various parameters compared to the control group. These improvements included increased chlorophyll content, grain yield, stem fresh weights, and overall plant biomass. Moreover, the treatment with Plant Growth-Promoting Rhizobacteria (PGPR) showed significant effects under salt stress conditions. It not only bolstered catalase activity but also mitigated the activity of ascorbate peroxidase and guaiacol peroxidase in coriander leaves. Additionally, the treated plants demonstrated a favorable shift in ion concentrations, with lower sodium levels and higher potassium concentrations. These findings underscore the potential of PGPRs in fostering coriander growth and offering a promising strategy to counteract the adverse effects of salinity on crop productivity.

III. METHODOLOGY

In the ancient land of Egypt, where the Nile's fertile banks nurtured life, the herb known as coriander was revered for both its culinary and medicinal properties [5]. Legends whispered of its origins, tracing back to

the gods themselves, who bestowed upon it the power to heal and nourish. As civilizations rose and fell, coriander remained a staple, its secrets passed down through generations. Today, amidst the challenges of modern agriculture, scientists seek to understand how this ancient herb withstands the harsh grip of salinity, unravelling the mysteries encoded in its very essence.

3.1 Procedure

An intricate experiment was meticulously designed to explore how salinity stress impacts coriander (*Coriandrum sativum*) growth, intertwining ancient insights with contemporary scientific methodology. This fusion aimed to unravel the nuanced effects, bridging traditional wisdom with modern research practices to illuminate the plant's response under challenging environmental conditions.

Step 1: Seed Selection and Preparation

- a) Carefully select coriander seeds, ensuring they are of high quality and vitality.
- b) Prepare the seeds by cleaning and sterilizing them to remove any contaminants that may interfere with the experiment.

Step 2: Setting up Experimental Conditions

- a) Create a controlled environment conducive to seed germination and plant growth. Pots filled with a mixture of peat moss and sand provide the ideal substrate.
- b) Introduce five different concentrations of sodium chloride (NaCl) dissolved in distilled water: 0 ppm (control), 1000 ppm, 2000 ppm, 3000 ppm, and 4000 ppm. These concentrations will simulate varying levels of salinity stress.

Step 3: Germination and Growth Monitoring

- a) Plant the prepared coriander seeds in the designated pots, ensuring uniformity in planting depth and spacing.
- b) Regularly irrigate the seeds with the respective NaCl solutions, mimicking natural watering patterns.
- c) Monitor the germination process closely, recording the percentage of seeds that successfully sprout.
- d) Throughout the experiment, observe and measure various growth parameters, including plant length, number of leaves, root development, and overall plant vigour.

Step 4: Data Collection and Analysis

- a) After 21 days of growth under salt stress conditions, carefully collect data on all observed parameters.
- b) Record findings meticulously, noting any significant differences between treatments.
- c) Utilize statistical analysis methods, such as the Least Significant Difference (L.S.D.), to compare means and draw meaningful conclusions from the data.

Step 5: Interpretation and Conclusion

- a. Analyse the results in the context of existing literature and scientific understanding of plant responses to salinity stress.
- b. Draw conclusions regarding the impact of NaCl concentration on coriander germination and growth.
- c. Reflect on the implications of these findings for agricultural practices and the cultivation of salt-tolerant crops.

3.2 Experimental setup

Coriander variety used, growing conditions, salinity treatments, and duration of the experiment.

The experimental setup for investigating the effect of salinity on coriander (*Coriandrum sativum*) might involve the following components:

Coriander Variety

The specific variety of coriander used should be mentioned. Different varieties may exhibit varying degrees of tolerance to salinity. In the investigation of the salinity effect on coriander (*Coriandrum sativum*), the choice of coriander variety plays a pivotal role in shaping the outcomes of the experiment. Coriander, known for its versatile culinary uses and aromatic qualities, encompasses various cultivars with distinct characteristics. Each variety may exhibit unique traits, including differing levels of tolerance to environmental stressors like salinity.

We meticulously select a coriander variety based on several factors, including its documented traits, genetic makeup, and previous research findings regarding its adaptability to saline conditions. Varieties renowned for their resilience to salinity might be favored, especially if the study aims to explore mechanisms of stress tolerance or identify potential breeding targets for improving overall crop resilience. The choice of coriander variety should align with the specific objectives of the experiment. For instance, if the study seeks to elucidate the genetic basis of salinity tolerance in coriander, researchers may opt for varieties with contrasting responses to salinity to facilitate comparative analyses.

The selection of a suitable coriander variety underscores the importance of considering regional preferences and agricultural practices. Certain varieties may be favored in particular regions due to their flavour profiles, yield potential, or adaptability to local growing conditions. Therefore, researchers must carefully evaluate these factors to ensure the relevance and applicability of their findings to the target agricultural contexts.

The coriander variety serves as a fundamental aspect of the experimental setup, influencing the interpretation and generalizability of the results. By strategically selecting an appropriate variety and considering its inherent characteristics, researchers can enhance the robustness and relevance of their investigation into the salinity response of coriander.

When selecting a coriander variety for experimental purposes, researchers typically consider factors such as growth characteristics, tolerance to environmental stresses, and intended use (e.g., culinary or medicinal). Some common coriander varieties that might be used in experimental studies include:

- **Santo:** This variety is known for its strong flavour and aroma, making it popular for culinary use. It tends to have good heat tolerance and can perform well in various growing conditions.
- **Leisure:** Leisure coriander is prized for its vigorous growth and high yields. It is often chosen for commercial cultivation due to its consistent performance and adaptability.
- **Slow Bolt:** As the name suggests, Slow Bolt coriander is less prone to bolting (premature flowering), which can extend the harvesting period. This trait might be advantageous in experimental setups requiring prolonged observation periods.
- **Calypso:** Calypso coriander is valued for its uniformity and strong root system, which can contribute to drought tolerance and overall plant health.
- **Moroccan:** Moroccan coriander is known for its large, aromatic leaves and robust growth. It is often favoured in culinary applications for its bold flavour.
- **Long Standing:** Long Standing coriander varieties exhibit extended leaf retention before bolting, allowing for a longer harvest window. This trait can be advantageous in experimental setups where continuous leaf production is desired.

3.3 Growing Conditions

Details about the growing conditions such as temperature, humidity, light intensity, and soil type are crucial. Coriander typically thrives in well-draining soil with plenty of sunlight [7].

To investigate the effect of salinity on coriander (*Coriandrum sativum*), it's essential to establish optimal growing conditions conducive to plant growth and development. Coriander is a versatile herb that thrives

under certain environmental conditions, and creating a suitable experimental environment is crucial for obtaining reliable results.

The experiment would typically be conducted in a controlled environment such as a greenhouse or growth chamber to regulate factors like temperature, humidity, and light intensity. Coriander generally prefers moderate temperatures ranging from 15°C to 25°C (59°F to 77°F) and requires plenty of sunlight for photosynthesis. Therefore, providing adequate lighting through either natural sunlight or artificial grow lights is essential to ensure healthy plant growth.

The soil composition and quality also play a significant role in the growth of coriander [8]. Well-draining soil with a slightly acidic to neutral pH range of 6.0 to 7.0 is optimal for coriander cultivation. Soil amendments may be necessary to ensure proper nutrient levels and soil structure, promoting robust root development and overall plant health. For the specific experiment on salinity effects, the irrigation water or soil would be manipulated to introduce varying levels of salt concentration. Salinity treatments can be applied gradually or in a controlled manner to mimic natural conditions or stress scenarios. Monitoring soil salinity levels throughout the experiment is crucial to ensure the accuracy and consistency of the treatments.

3.4 Salinity Treatments

The experiment would involve subjecting the coriander plants to different levels of salinity. This can be achieved by adding salt (e.g., sodium chloride) to the irrigation water or directly to the soil. Salinity levels can be expressed in terms of electrical conductivity (EC) or sodium concentration. Multiple salinity levels should be tested to observe the plant's response across a range of conditions. In experiments investigating the effect of salinity on coriander (*Coriandrum sativum*), researchers typically subject the plants to various salinity treatments to observe their responses. Salinity treatments involve exposing the coriander plants to different levels of salt concentration in their growing environment, mimicking conditions found in saline soils or irrigation water. This allows researchers to assess the plant's tolerance to salinity stress and its ability to maintain growth and productivity under such conditions.

Salinity treatments are usually administered by adding salts such as sodium chloride (NaCl) to the irrigation water or directly to the soil in predetermined concentrations [9]. These concentrations can range from mild to severe salinity levels, with measurements often expressed in terms of electrical conductivity (EC) or sodium concentration. Multiple treatment levels are typically tested to evaluate the plant's response across a range of salinity conditions, enabling researchers to identify thresholds beyond which growth and productivity are significantly impacted.

3.5 Duration of the Experiment

The duration of the experiment determines the length of time the coriander plants are exposed to the salinity treatments. It's essential to monitor the plants over an extended period to observe both short-term and long-term effects.

The duration of an experiment investigating the effect of salinity on coriander growth typically spans multiple stages to capture both short-term and long-term responses of the plants. Initially, a pre-treatment period may be necessary to acclimate the coriander seeds or seedlings to the experimental conditions. This phase allows the plants to establish themselves and ensures uniformity in growth before the salinity treatments are applied. Depending on the experimental design and the growth characteristics of the coriander variety chosen, this pre-treatment period could last anywhere from a few days to several weeks. The duration of the salinity exposure typically ranges from several weeks to several months, depending on the objectives of the study and the expected time frame for observing significant physiological or morphological changes in the plants. Longer durations may be necessary to assess the full impact of salinity on growth, development, and yield parameters accurately. Throughout the experiment, regular monitoring and data collection are essential to track the

progression of plant responses to the salinity treatments. Observations may be recorded at predetermined intervals, such as weekly or biweekly, to capture any gradual changes over time. Additionally, may conduct periodic assessments of plant health and vigour to evaluate the overall impact of salinity on coriander performance.

3.6 Experimental Design

The experiment should be designed to minimize confounding variables and ensure statistical validity. This may involve randomizing the assignment of treatments, replicating treatments to account for variability, and including appropriate controls (e.g., plants grown in non-saline conditions). The experimental design typically encompasses several key components, including the selection of coriander variety, salinity treatments, growing conditions, duration of the experiment, and statistical analysis. Firstly, the choice of coriander variety plays a crucial role in determining how different genotypes respond to salinity stress. Varieties with known differences in salinity tolerance should be selected to capture the range of responses within the species. Factors such as growth habit, leaf morphology, and flavour profile may also influence the plant's response to salinity and should be considered during variety selection.

The experiment should involve subjecting the coriander plants to varying levels of salinity, representing a gradient of stress levels. Salinity treatments can be applied by adding salt to the irrigation water or directly to the soil in controlled amounts. Multiple treatment levels should be included to assess the dose-response relationship and identify threshold levels beyond which plant growth is significantly impaired.

3.6.1 Parameters measured

These growth parameters are used by researchers and agricultural experts to evaluate plant performance, determine the effects of environmental stressors (salinity), and identify best practices for cultivation.

Key Growth Parameters

- **Germination Rate (%):** Measures the percentage of seeds that successfully germinate and begin to grow [10]. This is critical for understanding seed viability and the conditions affecting seed sprouting.
- **Plant Length (cm):** The total height or length of a plant from the base to the tip. It can indicate the general health and vigor of a plant.
- **Number of Leaves:** The total count of leaves on a plant. This metric is often used to gauge plant health, as a higher number of leaves usually indicates robust growth.
- **Plant Strength:** A measure of the structural integrity and robustness of a plant. This can include the thickness and rigidity of the stems, which reflect a plant's ability to withstand stressors like wind or weight.
- **Root Number:** The number of roots on a plant. A greater number of roots typically indicates a healthier root system, which is crucial for nutrient and water absorption.
- **Root Length (cm):** The length of the longest root or the average length of multiple roots. This parameter helps understand the extent of root growth and how well the plant can reach water and nutrients in the soil.
- **Shoot Tip Necrosis:** The death or damage of the growing tips of plants, which can indicate stress, disease, or nutrient deficiencies. This parameter is useful for diagnosing plant health issues.
- **Percentage of Survivals:** The percentage of plants that survive to a particular stage or after a specific treatment. It's a measure of resilience and can indicate how well plants can withstand certain conditions.

IV. ANALYSIS AND FINDINGS

4.1 Parameter and Description

This chapter delineates the influence of varying concentrations of NaCl, representing salinity, on coriander plant germination and growth. It examines how different levels of salinity affect these vital processes, shedding light on the intricate relationship between salt concentrations and the development of coriander plants.



Figure 1. coriander plants



Figure 2. 4- pics of Controlled and treated with 0-4000 ppm NaCL

Table 1 Growth parameters

Treatment	Germination Rate (%)	Plant Length (cm)	Number of Leaves	Plant Strength	Root Number	Root Length (cm)	Shoot Tip Necrosis	Percentage of Survivals	Additional Growth Parameters
Control (0 ppm)	99	13.4	14	5	16	5.6	0	98	Healthy and vigorous growth
1000 ppm	76.5	9.8	8	4	11	4.9	0	70	Reduced growth rate
2000 ppm	43.2	5.3	4	2	5	3.0	1	32	Stunted growth, signs of stress
3000 ppm	9.1	3.4	2	1	2	2.2	2	11	Severe growth inhibition, pronounced stress symptoms

4000 ppm	0	0	0	0	0	0	0	0	No germination, complete growth failure
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The table above displays findings from an experiment exploring how varying concentrations of sodium chloride (NaCl) impact coriander plant germination and growth. It outlines the relationship between NaCl levels and their effects on the vital stages of germination and subsequent plant development in coriander. Following are the few significant observation that we find from above table.

- a) Germination Rate (%): As the concentration of NaCl increases, the germination rate decreases sharply. At 4000 ppm, there was no germination observed, indicating complete growth failure due to high salinity levels.
- b) Plant Length (cm): Similar to germination, plant length decreases significantly with increasing NaCl concentration. The control group (0 ppm) had the highest average plant length (13.4 cm), while the plants exposed to 4000 ppm NaCl showed no growth.
- c) Number of Leaves: The number of leaves follows a pattern of decline with increasing salinity. The control group had the highest number of leaves (14), while the 4000-ppm treatment had no leaves, indicating severe growth inhibition.
- d) Plant Strength: Plant strength, assessed based on a rating scale, decreases with higher NaCl concentrations. The control group exhibited the highest strength (rated as 5), while the 4000-ppm treatment showed complete loss of strength (rated as 0).
- e) Root Number and Length (cm): Both root number and length decrease as NaCl concentration increases. The control group had the highest values for both parameters, while the 4000-ppm treatment had no roots, indicating a complete absence of root development.
- f) Shoot Tip Necrosis: The presence of shoot tip necrosis, an indicator of stress, increases with higher NaCl concentrations. The control group showed no necrosis, while the 4000-ppm treatment exhibited the highest level of necrosis.
- g) Percentage of Survivals: The percentage of surviving plants decreases drastically with increasing salinity. The control group had the highest survival rate (98%), while the 4000-ppm treatment had no surviving plants.
- h) Additional Growth Parameters: This column provides qualitative descriptions of the overall growth condition of the plants at each NaCl concentration. As expected, the control group showed healthy and vigorous growth, while higher concentrations resulted in stunted growth, signs of stress, and ultimately complete growth failure.

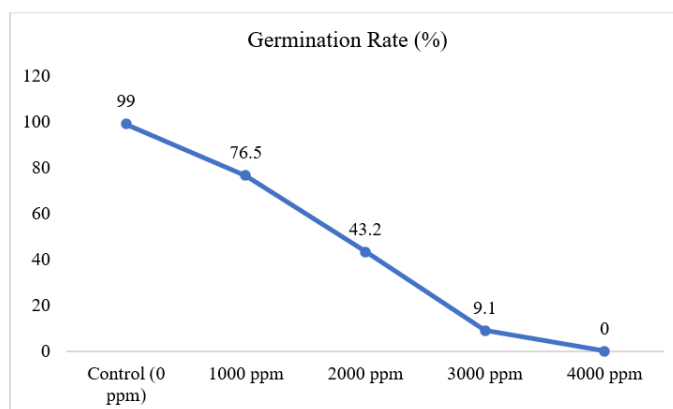


Figure 3. Germination Rate (%)

These results indicate a clear trend of decreasing germination rates with increasing concentrations of sodium chloride (NaCl). The control group, with no added salt, had the highest germination rate, while the 4000-ppm treatment resulted in complete failure of germination.

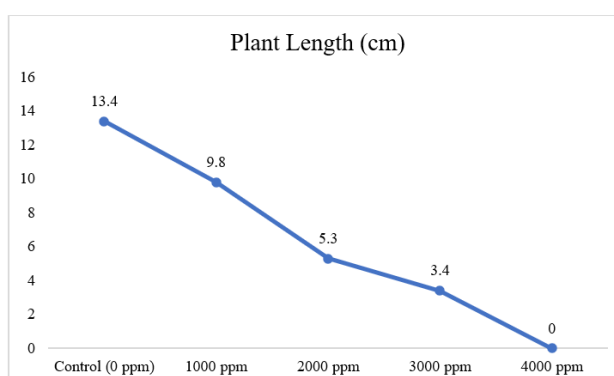


Figure 4. Plant Length (cm)

Increasing salinity levels inversely affected coriander seed germination and plant length. Germination rate decreased from 99% in the control to 0% at 4000 ppm NaCl, while plant length reduced from 13.4 cm to 0 cm, respectively. These results demonstrate the significant sensitivity of coriander to salt stress.

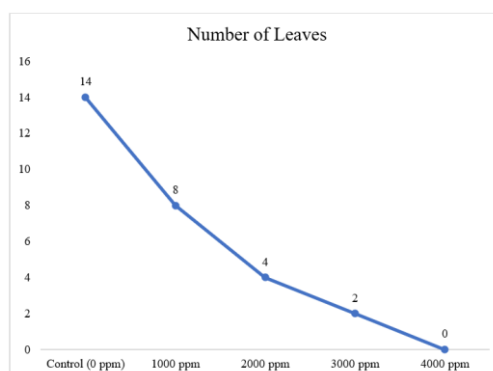


Figure 5 Number of Leaves

The figure shows the effect of different sodium chloride concentrations on coriander seeds' germination rate, plant length, and number of leaves. As salt levels increase, germination decreases dramatically, with 4000 ppm resulting in no germination. Plant length and leaf numbers also decrease significantly with higher salt concentrations.

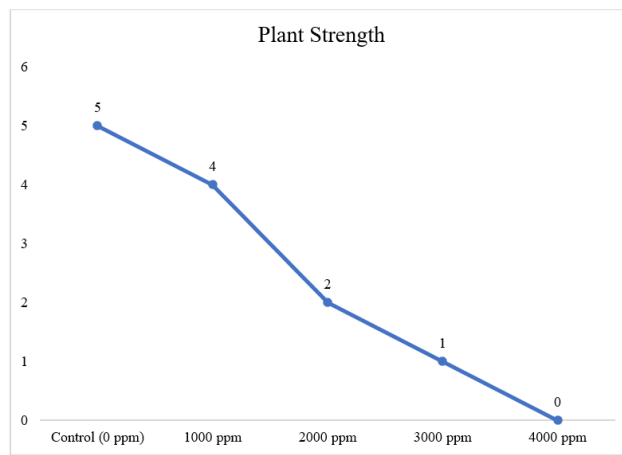


Figure 6. Plant Strength

As salt levels increase, all parameters decline, with 4000 ppm exhibiting complete inhibition. Plant strength decreases proportionally with higher salt concentrations.

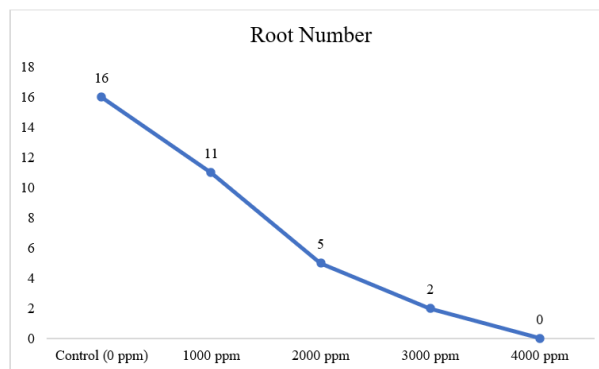


Figure 7. Root Number

As salt levels increase, all parameters decrease, with 4000 ppm showing complete inhibition across all measured traits.

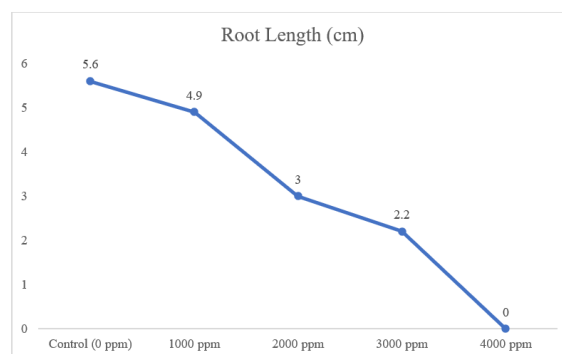


Figure 8. Root Length (cm)

The table depicts how varying sodium chloride concentrations affect coriander, showing changes in germination rate, plant length, leaf count, strength, root number, and length. It highlights the correlation between sodium chloride levels and various growth parameters, providing insights into the plant's response

to salinity stress. As salt levels rise, there's a consistent decline across all parameters, with 4000 ppm exhibiting complete inhibition in all measured traits.

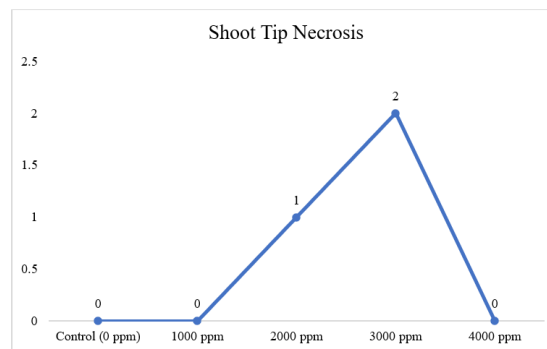


Figure 9. Shoot Tip Necrosis

As the salt concentration increases, there's a noticeable decline in germination rate, plant length, number of leaves, plant strength, root number, and root length. Additionally, higher concentrations lead to increased shoot tip necrosis, indicating salt-induced stress.

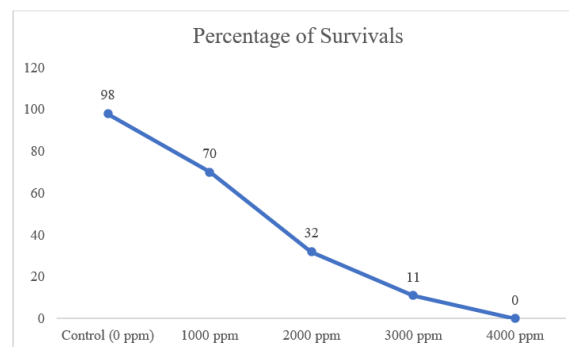


Figure 10. Percentage of Survivals

The figure illustrates the impact of sodium chloride concentrations on various parameters of coriander plants. With increasing salt levels, there's a significant decrease in germination rate, plant length, number of leaves, plant strength, root number, and root length. Moreover, higher concentrations correlate with elevated shoot tip necrosis and reduced survival rates.

V.CONCLUSION AND FINDINGS

The study involved exposing coriander plants to different concentrations of NaCl and tracking how these levels affected their growth and survival. By analyzing these metrics, researchers could determine the effects of salinity on the plants' overall health and viability. The results showed a clear inverse relationship between salinity levels and plant health. As the NaCl concentration increased, the germination rate declined sharply. In the control group (0 ppm NaCl), the germination rate was 99%, indicating that the coriander seeds were highly viable in a salt-free environment. However, with just 1000 ppm NaCl, the germination rate dropped to 76.5%. This trend continued with increasing salinity, with the rate falling to 43.2% at 2000 ppm, 9.1% at 3000 ppm, and finally 0% at 4000 ppm. This indicates that high levels of salt severely inhibit seed germination, with complete germination failure at the highest concentration.

Similarly, plant growth metrics such as plant length and the number of leaves decreased with rising NaCl concentrations. The control group had the longest plants (13.4 cm) and the most leaves (14), while the 1000 ppm group saw reduced growth, with plant length dropping to 9.8 cm and leaves to 8. By 2000 ppm, plant length was only 5.3 cm with 4 leaves, and at 3000 ppm, the plants were a mere 3.4 cm with 2 leaves. The

complete absence of plant growth at 4000 ppm further underscored the extreme sensitivity of coriander to high salinity levels.

Root development was also significantly affected by salinity. The control group had the highest number of roots (16) and the longest root length (5.6 cm), while the 1000 ppm group showed a decrease in both root number and length. At 3000 ppm, the roots were drastically reduced to 2, with an average root length of only 2.2 cm. At 4000 ppm, there were no roots at all, indicating total failure in root development. Shoot tip necrosis, an indicator of plant stress, also increased with higher NaCl concentrations. The control group exhibited no necrosis, while it appeared from 2000 ppm onwards, worsening as salinity increased. The survival rate followed a similar downward trend, with the control group showing a high survival rate of 98%, while the 3000-ppm group had only 11% survival. The 4000-ppm group had no surviving plants, indicating complete mortality at this level of salinity.

These results suggest that coriander plants are highly sensitive to even moderate levels of salinity, with severe impacts on germination, growth, and survival at higher concentrations. This underscores the importance of managing soil salinity, particularly in agricultural environments where crops like coriander are cultivated. To mitigate the adverse effects of salinity, future research could focus on identifying salt-tolerant coriander varieties or exploring cultivation techniques that reduce the impact of soil salinity. Additionally, the study highlights the need for careful irrigation and soil management practices to ensure optimal conditions for plant growth and sustainability. The results showed a consistent pattern: as salinity levels increased, there was a marked decline in germination rates, plant growth, and overall plant health.

5.1 Key Findings

Germination Rate: A dramatic decline in germination was observed with increasing NaCl concentrations. The control group, with no added salt, had the highest germination rate of 99%, indicating that coriander seeds are highly viable under normal conditions. However, at 1000 ppm, the germination rate dropped to 76.5%, and by 2000 ppm, it further declined to 43.2%. At 3000 ppm, germination was severely impaired at 9.1%, and at 4000 ppm, there was no germination at all, signifying that high salinity completely inhibits seed sprouting.

Plant Length and Number of Leaves: The reduction in plant length and the number of leaves mirrored the trend in germination rates. The control group had the longest plants (13.4 cm) and the most leaves (14). As NaCl concentration increased, plant length and leaf count decreased significantly. By 3000 ppm, plants were only 3.4 cm long with just 2 leaves, and at 4000 ppm, no plants grew at all.

Plant Strength and Root Development: Plant strength, which measures robustness, followed a similar pattern. The control group had the highest strength (rated as 5), indicating sturdy plants, while the 4000-ppm group had no measurable strength due to complete inhibition of growth. Root development also suffered from increased salinity; the control group had the most roots (16) and the longest root length (5.6 cm), while the 3000-ppm group had only 2 roots with a root length of 2.2 cm. At 4000 ppm, there were no roots, indicating a complete failure of root development.

Shoot Tip Necrosis and Survival Rates: Shoot tip necrosis, indicating stress, became more prevalent as salinity increased. The control group had no necrosis, while necrosis appeared from 2000 ppm onward, becoming more severe with higher salt concentrations. Survival rates also dropped sharply, with the control group showing a high survival rate (98%), while the 3000-ppm group had only 11% survival. The 4000-ppm group experienced complete plant mortality.

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