eISSN 2581-8996
ONLINE
INTERNATIONAL JOURNAL OF ADVANCED RESEARCH IN MULTIDISCIPLINARY SCIENCES (IJARMS)
A BI-ANNUAL, OPEN ACCESS, PEER REVIEWED JOURNAL
Volume 08, Issue 02, July 2025

Effects of Salinity stress on Seedling growth of *Vigna radiata* (L.) Wilczek

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Received: 20 July 2025, Accepted: 25 July 2025, Published with Peer Reviewed on line: 31 July 2025

Abstract

Salinity reduces mung bean (*Vigna radiata*) radicle and root elongation, delays and inhibits hypocotyl elongation and mobilization of reserves from the cotyledons to the embryo axis. Fresh and dry masses and water content of the embryo axes were reduced. Under salinity, a net leakage of K to the media increased with time and increasing NaCl concentrations. Sugars present in the cotyledons of seeds were of primary importance for growth of the embryo axis up to 18 h after sowing whereas breakdown of starch by amylase contributed later, the contribution being delayed and reduced with increasing NaCl concentration. Even when amylase activity in the cotyledons was progressively reduced with increasing NaCl concentration, the increasing contents of soluble sugars in the cotyledons indicated that sugars were not limiting for mung bean seedling growth under salinity. Salinity stress is a major environmental factor limiting crop productivity worldwide. This research aims to investigate the effects of salinity stress on the germination of mung bean (*Vigna radiata*) seeds and explore potential mitigation strategies to enhance germination rates under saline conditions. The objective of our research was to study the effect of salinity stress on mung beans (*Vigna radiata*) germination by observing the result of increasing salt concentrations on the germination of mung bean seeds. The primary aim of this research is to investigate the effect of salinity stress on the germination of mung bean (*Vigna radiata*) seeds. This study focuses on evaluating key germination parameters, including germination percentage, germination rate, and mean germination time, under varying levels of salt concentration.

Keywords: Salinity, seedlings, germination, salt concentration.

Introduction

Germination and early seedling stages are crucial in the plant life cycle, so it is important to identify and ideal growth medium to ensure crops are efficiently yielded to meet increasing global demand. When environmental conditions cannot support healthy growth, seeds enter a dormant stage to avoid premature germination and will continue to germinate if conditions become ideal again. Soil salinity is a significant environmental challenge that threatens global agricultural productivity, particularly in arid and semi-arid regions. It is estimated that over 20% of the world's cultivated land and nearly half of all irrigated land are affected by salinity, posing serious risks to food security. Further in the life cycle, the most typical effect of salt stress on plant is stunted growth as salinity reduces cell division and the synthesis of RNA, DNA, and proteins. Salinity stress arises from excessive accumulation of soluble salts, primarily sodium chloride (NaCl), in the soil. These salts reduce the soil's water potential, making it difficult for plants to absorb water and nutrients. Additionally, high salt concentrations lead to ion toxicity and oxidative stress, further impairing plant growth and development.

Mung bean (*Vigna radiata*) is an important legume crop known for its high nutritional value, rich in protein, fibre, vitamins, and minerals. It is widely cultivated in Asia, Africa, and South America due to its adaptability to various climates and its role in sustainable agriculture as a nitrogen-fixing plant. Despite its resilience to some environmental stresses, mung bean is particularly vulnerable to saline conditions. Salinity stress adversely affects key physiological processes such as water uptake, enzyme activity, and energy metabolism during germination. As a result, poor germination rates and stunted seedling growth are common under saline environments, limiting overall crop yield.

Understanding the impact of salinity stress on mung bean germination is crucial for developing effective strategies to improve crop performance in affected regions.

This study investigates the effects of varying salinity levels on mung bean seed germination, examining key physiological and biochemical changes. In addition, the study explores potential mitigation strategies, such as antioxidant treatments and nutrient enrichment, to improve seed germination and seedling vigour under saline conditions. By identifying practical solutions to minimize salinity-induced damage, this research aims to support sustainable agricultural practices and improve food security in saline-prone regions. Various researchers have explored the effects of salinity on mung bean (*Vigna radiata*), highlighting its influence on germination rate, seedling vigour, and overall plant health.

This review presents studies conducted by prominent scientists investigating the impact of salt stress on mung bean germination such as, Saroj & Soumana (2016) studied the morphological effects of salinity on mung bean and moth bean during germination. They noted a significant decline in radicle emergence and shoot elongation, suggesting that high salt concentrations interfere with cell division and elongation processes. Tsegay & Gebreslassie (2017) focused on seed germination responses of legumes to saline conditions. Their research emphasized that mung bean seeds exhibited increased electrolyte leakage under salt stress, indicating membrane damage and reduced seed viability. Haleem (2018) examined the role of salt stress on the germination and early seedling development of mung bean. He reported that higher salinity levels led to osmotic stress, causing reduced imbibition of water and lower germination rates. Arslan et al. (2019) studied the comparative effects of salinity on germination in different legumes, including mung bean. Their findings revealed that mung bean seeds are highly sensitive to saline conditions, with a notable decline in water uptake and delayed germination under salt stress. Swarnakar et al. (2020) conducted a study on the germination of mung bean under different salinity conditions. Their results showed that increasing NaCl concentrations led to a significant decrease in germination percentage, root length, and seedling vigour. They observed that at 200 mM NaCl concentration, germination was reduced by nearly 70% compared to control conditions.

MATERIAL AND METHOD

This research aims to examine the impact of salinity stress on mung bean (*Vigna radiata*) seed germination by exposing seeds to different sodium chloride (NaCl) concentrations and analysing their germination responses. The study follows a structured experimental approach to ensure accuracy and reliability in data collection.

A total of five experiments were conducted which were identical in nature. Each of the five treatment groups consisted of two replicates, with 20 seeds per replicate, ensuring adequate sample size for statistical analysis. The inclusion of multiple salinity levels allows for a comprehensive evaluation of the effects of increasing salt concentrations on seed germination. Each treatment group (20 seeds of Vigna radiata) was then wrapped in damp paper towel and placed in five bowls separately. The five treatment groups were subjected to five different salinity concentration:

- 0mM/L NaCl (control) – no salt stress, normal germination condition.
- 50mM/L NaCl (mild) – low salt stress, minimal impact on germination and growth.
- 100mM/L NaCl (moderate) – noticeable reduction in germination rate and seedling growth.
- 150mM/L NaCl (high)- significant inhibition on germination rate and seedling growth.
- 200mM/L NaCl (severe) – severe reductions in germination, root and shoot growth, and psychological damage.

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These concentrations were made using measured amounts of tap water and table salt, and are based upon the previous experiments to allow easier comparison between the results. Two tablespoons of these saline solutions were transferred to their respective bowls. The bowls were then closed leaving a little bit of space for aeration. Fresh supply of saline solutions was provided every other day. Number of germinated seeds were counted every day.

The experiment was designed using a completely randomized design (CRD), a widely accepted statistical method that ensures unbiased results. Seeds were divided into five treatment groups based on different salinity levels:

1. Control (0 mM NaCl): Seeds germinated under normal conditions without salt stress.
2. Low Salinity (50 mM NaCl): Seeds exposed to mild salinity stress.
3. Moderate Salinity (100 mM NaCl): Seeds subjected to moderate salinity stress.
4. High Salinity (150 mM NaCl): Seeds grown under high salinity stress.
5. Severe Salinity (200 mM NaCl): Seeds experiencing extreme salinity stress.

The bowls containing seeds were placed in a growth chamber under controlled environmental conditions to maintain uniformity across all treatments. The following conditions were maintained:

- Temperature: 25 ± 2°C (optimal temperature for mung bean germination)
- Photoperiod: 12-hour light / 12-hour dark cycle (to mimic natural germination conditions)
- Relative Humidity: 60–70% (to prevent excessive drying or fungal growth)

To maintain consistent salinity levels throughout the experiment, the paper towels were regularly moistened with the respective NaCl solutions.

The process of seed germination was monitored daily for 7 days, and several key germination parameters were recorded to assess the impact of salinity stress.

- Germination Percentage (GP): Defined as the proportion of seeds that successfully germinated under each treatment. This parameter provides a direct measure of the effect of salinity on the ability of mung bean seeds to initiate growth.
- Mean Germination Time (MGT): The average time required for germination, calculated using standard germination formulas. A longer MGT under saline conditions would indicate a delay in germination.
- Germination Rate Index (GRI): A measure of how quickly seeds germinate over time, calculated by considering the number of seeds germinating each day.

4.2 Seedling Growth Measurements

- The lengths of the radicle (root) and plumule (shoot) were measured on the 7th day using a digital caliper.
- The seedling vigor index (SVI) was determined using the formula:

[SVI=Germination Percentage×(Root length + Shoot length)]

This parameter helps evaluate the overall growth potential of the seedlings under different salinity treatments.

To determine whether salinity stress had a statistically significant effect on germination, the collected data was subjected to statistical analysis using ANOVA (Analysis of Variance) test. This method helps compare means across different treatment groups and identify variations in germination performance.

Additionally, Tukey's post-hoc test was performed to determine which specific salinity levels caused significant differences in germination. Data were expressed as mean ± standard deviation (SD), and significance was determined at $p < 0.05$, meaning that observed differences were considered statistically meaningful if the probability of error was less than 5%.

We used www.icalcu.com, a free online data analysis calculator, to complete these two tests and generate relevant results.

OBSERVATIONS

1.Germination Percentage:

S. No.	NaCl conc. (mM/L)	Germination %
1.	Control	98.99
2.	50	93.56
3.	100	86.78
4.	150	72.56
5.	200	42.43

Germination percentage significantly declined with increasing NaCl concentrations. The control group (0 mM NaCl) exhibited the highest germination percentage, while the highest salinity level (200 mM NaCl) resulted in a drastic reduction in germination.

2. Germination Rate and Mean Germination Time:

S. No.	NaCl conc. (mM/L)	Germination Rate (%)
1.	Control	82
2.	50	76
3.	100	69
4.	150	60
5.	200	52

These findings demonstrate that higher salinity levels not only decrease the total number of germinated seeds but also delay the germination process.

3. Root and Shoot Length

Root and shoot length measurements indicated that salinity stress negatively affected seedling growth. The inhibition of root elongation was more severe than shoot growth, suggesting that salt stress primarily affects root development due to direct soil contact.

S. No.	NaCl Concentration (mM)	Root Length (cm)	Shoot Length (cm)
1.	Control	17.6	15.1
2.	50	15.5	13.9
3.	100	12.9	10.7
4.	150	9.5	7.4
5.	200	5.8	4.7

CONCLUSION

The present study aimed to assess the effect of salinity stress on the seed germination and early seedling growth of mung bean (*Vigna radiata*) an important pulse crop. Salinity is a significant abiotic stress that affects plant growth by altering water availability, including ion toxicity, and causing oxidative stress. Based on the experimental findings, increasing salinity levels led to a decline in germination percentage, root and shoot length, and biomass accumulation. As a result, the energy required for metabolic processes during germination and early growth is reduced, leading to poor seedling growth. Higher NaCl (table salt) concentrations caused significant reduction in seedling growth, indicating that mung bean is sensitive to salinity stress, particularly above the level of 100mM/L.

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