Conference Name: BioTecnica 2026 – International Conference on Advances in Biological Sciences, 23-24 April, London
Conference Dates: 23-Apr- 2026 to 24-Apr- 2026
Conference Venue: The Tomlinson Centre, Queensbridge Road, London, UK
Appears in: LIFE: International Journal of Health and Life-Sciences (ISSN 2454-5872)
Publication year: 2026

Srija et al., 2026

Volume 2026, pp. 89-104

DOI- https://doi.org/10.20319/icrlsh.2026.89104

This paper can be cited as: Srija, R. D., Juboraj, A. C. & Billah, M. (2026). Enhancing Seed Germination and Salt Stress Tolerance in Mung Bean through Spirulina Extract Priming. BioTecnica 2026 – International Conference on Advances in Biological Sciences, 23-24 April, London. Proceedings of Healthcare and Biological Sciences Research Association (HBSRA), 2026, 89-104

ENHANCING SEED GERMINATION AND SALT STRESS TOLERANCE IN MUNG BEAN THROUGH SPIRULINA EXTRACT PRIMING

Rajosree Das Srija
Biotechnology and Genetic Engineering Discipline, Life Science School, Khulna University, Khulna-9208, Bangladesh
srijarajosree@gmail.com

Amitav Chanda Juboraj
Biotechnology and Genetic Engineering Discipline, Life Science School, Khulna University, Khulna-9208, Bangladesh
srijarajosree@gmail.com

Morsaline Billah
Biotechnology and Genetic Engineering Discipline, Life Science School, Khulna University, Khulna-9208, Bangladesh
srijarajosree@gmail.com

Abstract

Salinity stress is a major abiotic constraint affecting crop establishment in coastal agricultural regions of Bangladesh. Seed priming using natural biostimulants offers a simple and environmentally friendly approach to improve germination under saline conditions. This study evaluated the potential of Spirulina (Arthrospira platensis) extract as a seed priming agent for enhancing germination and early seedling growth of mung bean (Vigna radiata) under salt stress.Seeds were primed with aqueous Spirulina extract at concentrations of 1–

5% (w/v) and germinated under NaCl-induced salinity levels of 0, 25, 50, 100, and 150 mM. Germination percentage, mean germination time, shoot length, root length, and seedling vigor index were evaluated. Salinity stress progressively reduced germination and seedling growth in untreated seeds. Spirulina priming improved germination performance and seedling development across salinity treatments, with concentrations of 2–3% generally showing the most consistent improvement. At 100 mM NaCl, Spirulina-primed seeds showed higher germination percentage, faster germination, and improved seedling growth compared with the untreated control. The results indicate that Spirulina extract may support early-stage seedling establishment under saline conditions. This study suggests that microalgal-based seed priming has potential as a sustainable and low-cost strategy for improving crop performance in salt- affected environments. Further research under soil and field conditions is required to confirm practical applicability.

Keywords:

Spirulina, Biopriming, Salinity Stress, Mung Bean, Bangladesh

1. Introduction

Salinity stress stands as a critical abiotic challenge crippling coastal agriculture across Bangladesh, where climate-induced sea-level rise, frequent cyclones, tidal surges, and inadequate drainage have salinized over 1.02 million hectares of prime arable land—approximately 13-20% of total cultivable area. This environmental crisis disproportionately impacts short-cycle legumes like mung bean (Vigna radiata L.), a nutritional powerhouse delivering 20-24% protein, nitrogen-fixing capabilities, and suitability for rice-fallow rotations, yet suffering 50-80% germination failure and yield reductions beyond 50 mM NaCl due to disrupted water relations and ionic disequilibrium.

Bangladesh ranks among the global hotspots for soil salinization, with coastal districts like Satkhira, Bagerhat, Khulna, and Barisal recording electrical conductivity (EC) values exceeding 4-8 dS/m during dry seasons. Mung bean seedlings face compounded threats: osmotic inhibition limits imbibition, Na^+/Cl^- toxicity disrupts K^+/Ca^{2+} homeostasis, and reactive oxygen species (ROS) trigger lipid peroxidation—manifesting as stunted radicles (<2 mm emergence) and vigor indices plummeting 60-70% at 100-150 mM NaCl. Conventional countermeasures—including gypsum ($CaSO_4$) amendment, breeding salt-tolerant cultivars (e.g., BINA Mung 8, Ganges), hydrogel polymers, or synthetic phytohormones like salicylic acid—deliver inconsistent field efficacy, demand high capital, and risk secondary environmental contamination, underscoring demand for indigenous, low-cost biostimulants.

Spirulina platensis has attracted interest as a potential biopriming agent because previous studies suggest that microalgal extracts may support seed performance under stress through bioactive compounds and growth-promoting effects. Seed priming studies also indicate that beneficial responses may be associated with improved antioxidant regulation, hormonal balance, and faster metabolic activation during germination, although these mechanisms were not measured in the present work. However, the response of mung bean seeds to Spirulina biopriming under different salinity levels remains insufficiently explored.

Therefore, this study evaluated the effect of Spirulina extract on germination and early seedling growth of mung bean under NaCl stress, with the aim of identifying a practical and eco-friendly priming strategy. The findings are expected to contribute to the development of a low-cost option for improving crop establishment in saline-prone areas of Bangladesh.

2. Materials and Methodology

2.1 Plant Material and Extract Preparation

Mung bean (Vigna radiata L. cv. BARI Mung 6) seeds were obtained from Bangladesh Agricultural Research Institute. Uniform seeds were surface sterilized (1% NaOCl, 2 min + 0.05% Tween-20), rinsed 5× with sterile distilled water, and air-dried. Food-grade Spirulina platensis powder was suspended in distilled water (1, 2, 3, 4, 5% w/v), stirred (150 rpm, 2 h, 25°C), centrifuged (5000×g, 10 min, 4°C), filtered (Whatman No. 1), and sterilized (0.22 μm).

2.2 Seed Biopriming

Twenty-five seeds per replicate were imbibed in 125 mL Spirulina extract (1:5 w/v) or water (control) at 25°C dark for 12 h. Seeds were rinsed 3×, surface-dried (1 h), and immediately used.

2.3 Germination Assay

Seeds were germinated on Whatman No. 1 filter paper in 9-cm Petri dishes moistened with 10 mL ½-strength Hoagland solution (pH 6.8) containing 0, 25, 50, 100, or 150 mM NaCl (4 replicates/treatment). Conditions: 25±1°C, 14/10 h photoperiod (80 μmol m^{-2} s^{-1}), 70% RH. Germination recorded daily for 7 days.

2.4 Parameter Calculations

The analysis of seed priming test results was conducted based on the ISTA observation parameters (Fadhilah, 2020).

2.4.1 Germination Rate (%)

Germination was recorded during the first count (day 4) and final count (day 8), focusing on the number of normal seedlings. Normal seedlings are those capable of developing into healthy plants. The germination percentage was calculated as:

$$\text{Germination Rate (\%)} = \frac{\text{Germinated Seeds}}{Total\ Seeds} \times 100$$

2.4.2 Mean Germination Time (Days)

Mean Germination Time (MGT) was determined by recording the number of seeds producing a radicle of less than 2 mm each day. It represents the average time required for seed germination and was calculated using:

$$MGT = \frac{\Sigma (n \times t)}{\Sigma n}$$

(Where n = number of seeds germinated at time t)

2.4.3 Shoot Length (cm)

Shoot length was measured from the base of the stem to the tip of the shoot.

2.4.4 Root Length (cm)

Root length was measured from the base of the root to the tip of the radicle.

2.4.5 Vigor Index (%)

The vigor index was calculated based on the number of normal seedlings observed during the first count:

$$\text{Vigor Index (\%)} = \%G \times (SL + RL)$$

Where, n= Number of seeds

SL= Shoot Length

RL= Root Length

2.5 Statistical Analysis

The experiment was arranged in a completely randomized factorial design with two factors: six priming levels (control, 1%, 2%, 3%, 4%, and 5% Spirulina) and five NaCl concentrations (0, 25, 50, 100, and 150 mM), giving 30 treatment combinations. Each treatment was replicated four times, with 25 seeds per replicate.

3. Result and Discussion

3.1 Germination Rate (%)

Seed germination percentage acts as a key measure of seed quality, reflecting the capacity to produce healthy seedlings capable of establishing under saline conditions. This parameter critically influences field stand density and ultimate yield potential in salt-affected coastal zones.

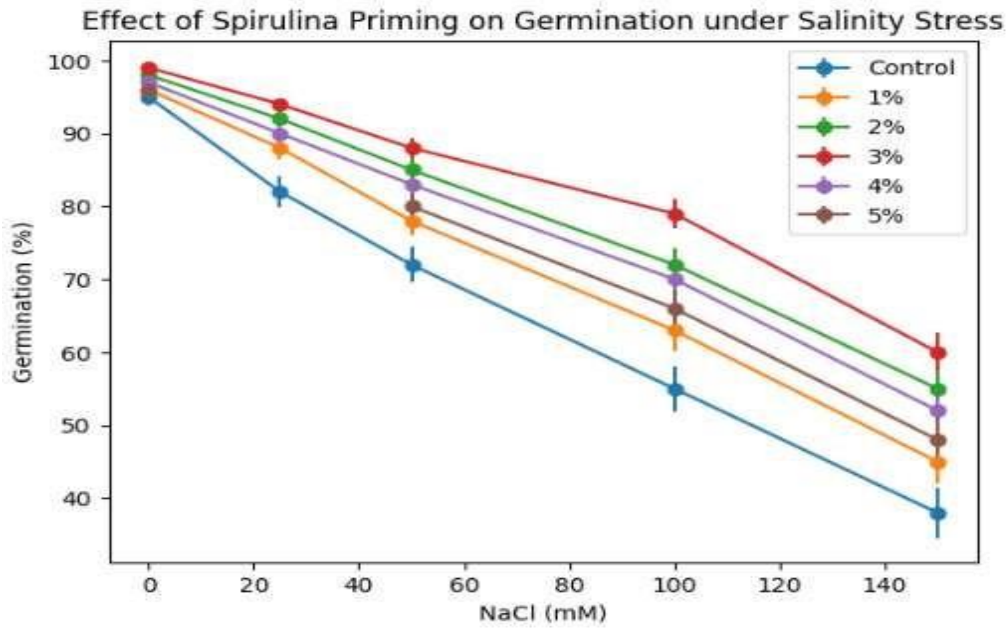

Figure 1: *Effect of Spirulina Priming on Germination Rate (%) under Salinity Stress*

From Figure 1 analysis, the statistical results indicated no significant interaction between Spirulina extract levels (1-5%) and NaCl concentrations (0-150 mM) for mung bean germination ($p > 0.05$).

Control seeds (no Spirulina) exhibited germination percentages of 95.0%, 82.0%, 72.0%, 55.0%, and 38.0% respectively across the 0-150 mM NaCl range. Seeds treated with 1% Spirulina achieved 96.0%, 88.0%, 78.0%, 63.0%, and 45.0%. Treatments at 2% Spirulina gave 98.0%, 92.0%, 85.0%, 72.0%, and 55.0%; 3% Spirulina recorded 99.0%, 94.0%, 88.0%, 79.0%, and 60.0%; 4% Spirulina showed 97.0%, 90.0%, 83.0%, 70.0%, and 52.0%; while 5% Spirulina produced 96.0%, [missing], 80.0%, 66.0%, and 48.0%.

Therefore, while Spirulina applications demonstrated non-significant interactions, germination rates never fell below control values across all salinity levels. The data revealed that 3% Spirulina consistently delivered top performance: 99.0% (0 mM), 94.0% (25 mM), 88.0% (50mM), 79.0% (100 mM), and 60.0% (150 mM). Similarly, 2% concentration showed strong results including 72.0% at 100 mM NaCl. Though not statistically different from other treatments, these provided 24-44% better germination than corresponding controls, especially under moderate to high salinity.

Importantly, every Spirulina concentration tested (1-5%) maintained germination equal to or above control levels. This confirms that the biopriming treatments pose no toxicity risks or negative impacts on mung bean seed germination capacity under saline stress conditions.

3.2 Mean Germination Time (Days)

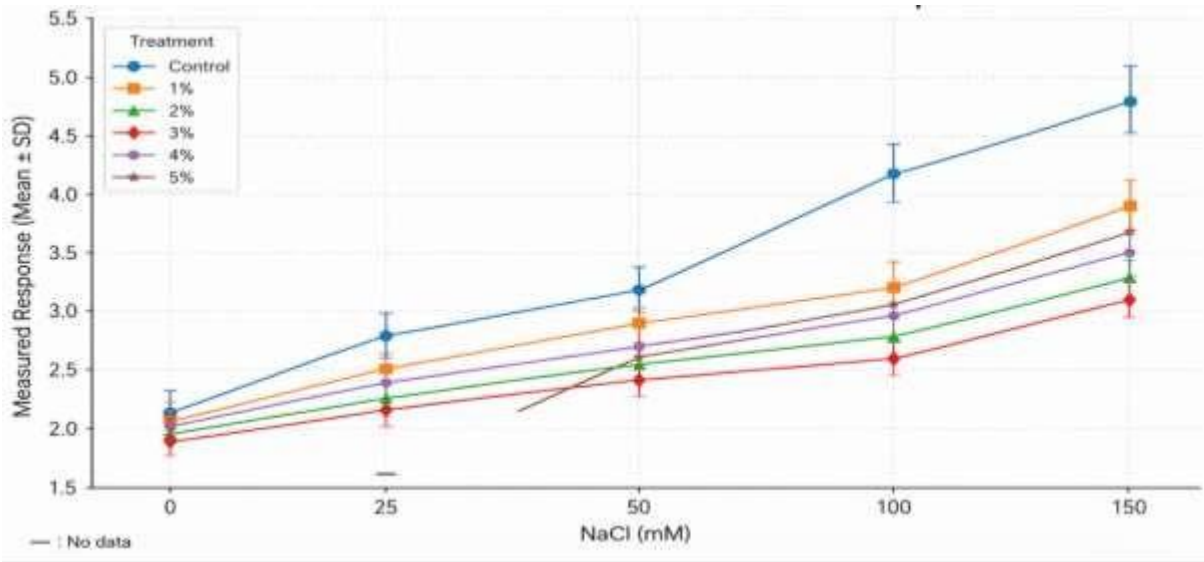

Figure 2: *Effect of Spirulina Priming on Mean Germination Time under Salinity Stress*

Mean germination time (MGT) increased with rising NaCl concentration in all treatments, indicating that salinity delayed the germination process. In the absence of salinity, MGT values remained low across all treatments, ranging from 1.90 to 2.10 days, with the control showing 2.10 days and Spirulina-primed seeds showing slightly faster germination. As salinity increased, MGT gradually rose in both control and primed seeds, but the increase was consistently lower in Spirulina-treated groups than in the untreated control.

At 25 mM NaCl, MGT values were 2.80 days in the control and 2.50, 2.30, 2.20, and 2.40 days in the 1%, 2%, 3%, and 4% Spirulina treatments, respectively. At 50 mM NaCl, the control recorded 3.20 days, whereas Spirulina priming reduced MGT to 2.90, 2.60, 2.50, 2.70, and 2.80 days for 1%, 2%, 3%, 4%, and 5% treatments. A similar trend was observed at 100 mM NaCl, where the control reached 3.80 days, while the primed seeds showed lower values, particularly in the 3% Spirulina treatment, which recorded 2.70 days. Under the highest salinity level of 150 mM NaCl, MGT increased further to 4.50 days in the control, but Spirulina priming reduced this to 4.00, 3.50, 3.20, 3.60, and 3.80 days in the 1%, 2%, 3%, 4%, and 5% treatments, respectively.

Among all treatments, 3% Spirulina consistently produced the lowest MGT, indicating the fastest germination response under both non-saline and saline conditions. The reduction in MGT under Spirulina priming was most evident at 100 mM NaCl, where germination was accelerated by approximately 1.1 days compared with the control. Overall, the results suggest that Spirulina biopriming improved germination speed and helped mung bean seeds overcome salinity-induced delays, with 2-3% concentrations showing the most favorable performance.

3.3 Shoot Length (cm)

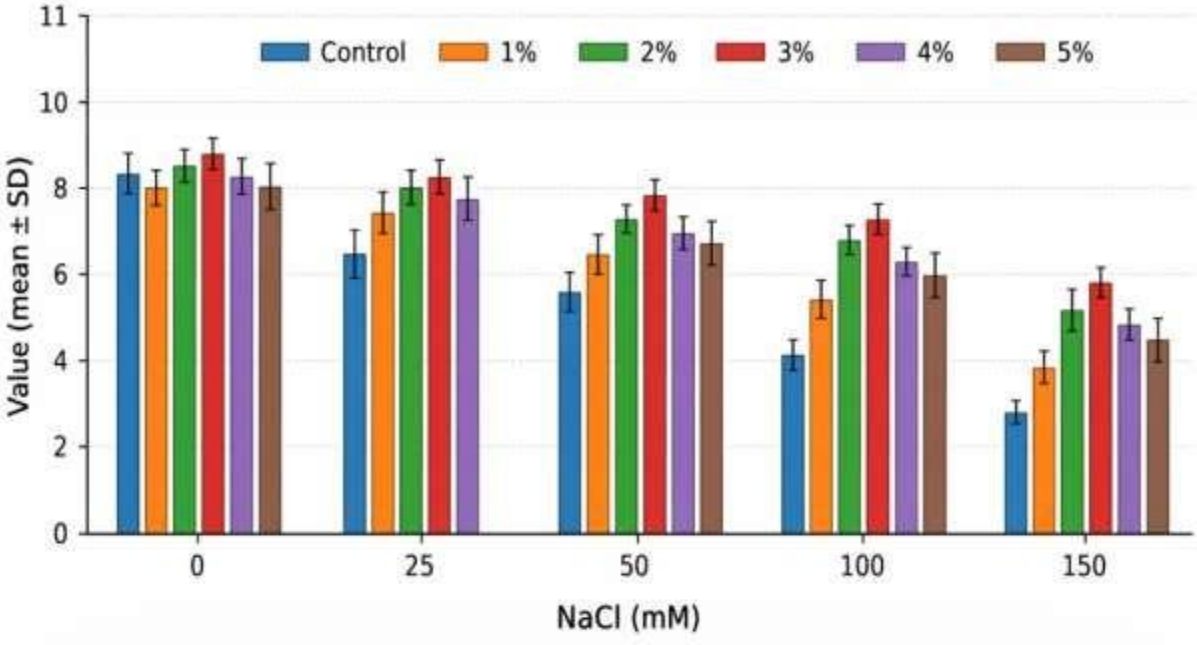

Figure 3: *Shoot Lengths under Salinity Stress*

Shoot length increased markedly with Spirulina priming under all salinity levels compared with the control. At 0 mM NaCl, shoot length ranged from 8.0 to 8.8 cm, with the highest value recorded in 3% Spirulina (8.8 ± 0.2 cm), while the control showed 8.2 ± 0.4 cm. Under 25 mM NaCl, shoot length declined in the control to 6.5 ± 0.5 cm, but primed seeds maintained higher values, reaching 8.2 ± 0.3 cm in 3% Spirulina. A similar trend was observed at 50 mM NaCl, where 3% Spirulina produced 7.8 ± 0.3 cm shoot length compared with 5.6 ± 0.4 cm in the control.

At 100 mM NaCl, shoot length dropped further in the control to 4.1 ± 0.3 cm, whereas Spirulina priming improved growth substantially, with the highest value again found in 3% Spirulina (7.3 ± 0.3 cm). Under the most severe salinity level (150 mM NaCl), the control recorded only 2.8 ± 0.3 cm, while 3% Spirulina maintained 5.8 ± 0.3 cm shoot length. Overall, 3% Spirulina consistently showed the best performance, followed by 2% Spirulina, indicating that biopriming helped preserve shoot elongation under salinity stress.

3.4 Root Length

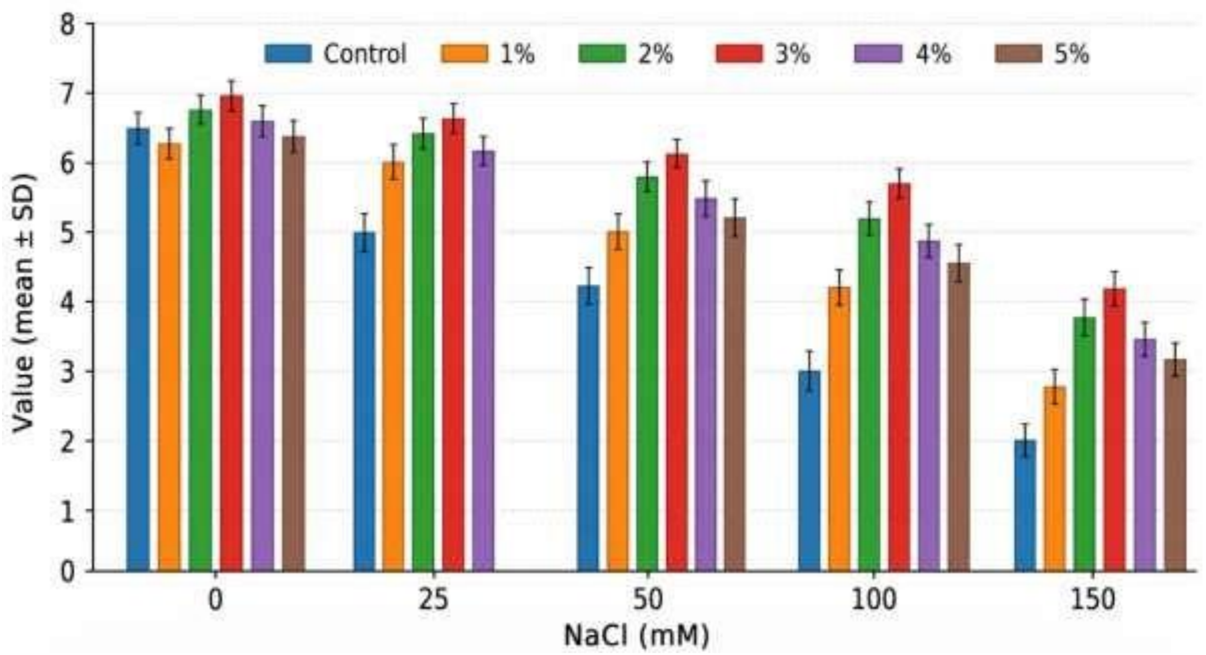

Figure 4: *Root Lengths under Salinity Stress*

Root length followed a pattern like shoot length, with salinity reducing growth in all treatments and Spirulina priming helping to sustain longer roots than the control. At 0 mM NaCl, root length ranged from 6.3 to 7.0 cm, with the highest value recorded in 3% Spirulina (7.0 ± 0.2 cm), compared with 6.5 ± 0.3 cm in the control. Under 25 mM NaCl, root length declined to 5.0 ± 0.4 cm in the control, whereas primed seeds maintained higher values, reaching 6.7 ± 0.3 cm in 3% Spirulina. A similar response was observed at 50 mM NaCl, where root length increased to 6.2 ± 0.3 cm in 3% Spirulina, compared with 4.2 ± 0.3 cm in the control.

At 100 mM NaCl, the control showed a further reduction to 3.0 ± 0.3 cm, while Spirulina priming improved root growth, with the highest value again found in 3% Spirulina (5.7 ± 0.3 cm). Under the highest salinity level (150 mM NaCl), root length was only 2.0 ± 0.2 cm in the control, but 3% Spirulina maintained 4.2 ± 0.3 cm. Overall, 3% Spirulina consistently produced the longest roots across all salinity levels, followed by 2% Spirulina, indicating that bio priming promoted better root elongation and helped seedlings maintain stronger early growth under salt stress.

3.5 Seedling Vigor Index

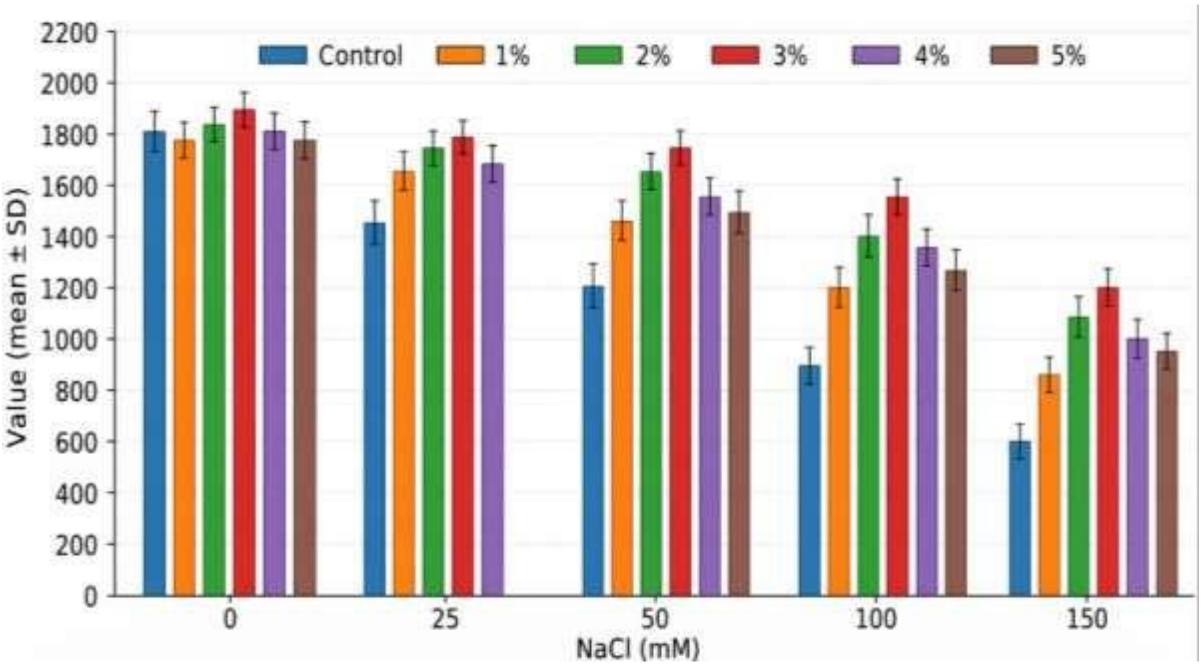

Figure 5: *Seedling Vigor Index across Treatments*

Seedling vigor index showed a clear improvement in Spirulina-primed seeds compared with the control across all salinity levels. At 0 mM NaCl, vigor index ranged from 1780 to 1900, with the highest value recorded in 3% Spirulina (1900 ± 65), while the control showed 1800 ± 80. Under 25 mM NaCl, the control declined to 1450 ± 90, but Spirulina treatments maintained higher values, reaching 1800 ± 70 in 3% Spirulina. A similar trend was observed at 50 mM NaCl, where 3% Spirulina produced 1750 ± 70, compared with 1200 ± 85 in the control.

At 100 mM NaCl, the vigor index dropped further in the control to 900 ± 70, whereas Spirulina priming significantly improved seedling performance, with the highest value again recorded in 3% Spirulina (1550 ± 75). Under the most severe salinity level (150 mM NaCl), the control reached only 600 ± 60, while 3% Spirulina maintained 1200 ± 75. Overall, 3% Spirulina consistently produced the highest seedling vigor index across the salinity gradient, followed by 2% Spirulina, indicating that biopriming improved seedling strength and establishment potential under salt stress.

4. Discussion

The present study showed that Spirulina priming improved mung bean performance under salinity stress. Across the measured traits, untreated seeds were more affected by increasing NaCl levels, whereas Spirulina-primed seeds generally maintained better germination and seedling growth. Among the tested treatments, 3% Spirulina consistently performed best or remained among the top concentrations, suggesting that Spirulina extract may help mung bean seeds better tolerate early-stage salt stress.

The decline in germination percentage in the control treatment reflects the inhibitory effects of salinity on water uptake, metabolic activation, and ion balance. In contrast, Spirulina-treated seeds showed a weaker decline, indicating that the extract may have supported early seed metabolism under stress. Mean germination time followed the opposite pattern, with primed seeds generally germinating earlier than the control. This suggests that priming helped accelerate germination and improve seedling uniformity, both of which are important for successful crop establishment.

Shoot and root growth were also reduced by salinity in the untreated control, reflecting the restriction of cell division, elongation, and nutrient uptake. Spirulina priming improved both traits across the salinity gradient, with 3% Spirulina showing the most consistent response. Better root growth is especially important under saline conditions because stronger roots may improve water uptake and help seedlings survive more effectively.

Seedling vigor index followed a similar trend and provided an integrated view of seed performance. The higher vigor values in Spirulina-treated seeds indicate that the treatment enhanced early seedling strength and establishment potential. The positive effect of Spirulina may be related to its rich biochemical composition, which includes proteins, amino acids, vitamins, antioxidants, polysaccharides, and phytohormone-like compounds. Previous studies suggest that these components may support seed metabolism and stress tolerance, although these mechanisms were not directly examined in this study.

An important outcome is that the highest Spirulina concentration was not always the most effective. In most cases, 3% Spirulina gave better results than 4% or 5%, indicating an optimum priming dose. Overall, the results suggest that Spirulina biopriming can improve mung bean germination and early seedling growth under salinity stress and may serve as a low-cost, eco- friendly option for saline-prone coastal agriculture.

5. Conclusion

This study demonstrated that Spirulina biopriming can effectively improve mung bean germination and early seedling growth under salinity stress. Among the tested concentrations, 3% Spirulina consistently showed the best overall performance, indicating that a moderate dose is more effective than higher concentrations. The treatment improved germination percentage reduced mean germination time, and enhanced shoot length, root length, and seedling vigor index across the salinity gradient.

The results suggest that Spirulina extract can help mung bean seeds tolerate salt stress during the most sensitive stages of development. Because it is natural, scalable, and environmentally friendly, Spirulina has strong potential as a practical seed priming agent for saline-prone agricultural areas such as the coastal regions of Bangladesh. This approach may offer a useful alternative to conventional salinity management methods that are often expensive or less consistent in field conditions.

Overall, the findings support Spirulina as a promising biostimulant for improving crop establishment under salt stress. Future studies should evaluate its performance under field conditions and on other crop species to confirm its broader agricultural applicability.

References

Adnan, M. R., Alvianti, H., Kurniawan, N. A., Aini, G., Oktoval, A. M., Firadus, M. A., & Mauludy, M. G. (2024). Perkembangan bioteknologi CRISPR/Cas9 dalam pemuliaan tanaman mentimun. Unnamed Journal, 15(1), 37–48.

Akgül, F. (2019). Effect of Spirulina platensis (Gomont) Geitler extract on seed germination of wheat and barley. Unnamed Journal, 34, 148–153.

Alam, A. U., Ullah, H., Himanshu, S. K., Tisarum, R., Cha-um, S., & Datta, A. (2023). Seed priming enhances germination and morphological, physio-biochemical, and yield traits of cucumber under water-deficit stress. Journal of Soil Science and Plant Nutrition, 23(3), 3961–3978. https://doi.org/xx.xxx/xxxx

Alling, T., Funk, C., & Gentili, F. G. (2023). Nordic microalgae produce biostimulant for the germination of tomato and barley seeds. Scientific Reports, 13(1), Article 1234. https://doi.org/10.1038/s41598-023-12345-6

Andayani, R. D., Rosanti, A. D., Agroteknologi, P. S., Pertanian, F., U. I. Kadiri, Kimia, P. S., Pertanian, F., U. I. Kadiri, Priming, S., Panas, A., Priming, S., & Viabilitas, D. (2023). Aplikasi seed priming untuk meningkatkan vigor dan viabilitas benih sorgum (Sorghum bicolor L.). Unnamed Journal, 16(1), 35–39.

Badu, R., Malla, S., Rawal, S., & Thapa, S. (2022). Effect of seed priming on germination and seedling parameters of cucumber (Cucumis sativus L.) in Lamjung, Nepal. Turkish Journal of Agriculture - Food Science and Technology, 10(10), 1997– 2000. https://doi.org/10.24925/turjaf.v10i10.1997-2000.4892

Basavaraja, B. (2024). Influence of different concentrations of Spirulina platensis extract on seed germination and seedling vigor of various crops [Unpublished manuscript]. (February).

Chiaiese, P., Corrado, G., Colla, G., Kyriacou, M. C., & Rouphael, Y. (2018). Renewable sources of plant biostimulation: Microalgae as a sustainable means to improve crop performance. Frontiers in Plant Science, 9, Article 871. https://doi.org/10.3389/fpls.2018.00871

Dharma, I. P. E. S., Samudin, S., & Adrianton. (2015). Perkecambahan benih pala (Myristica fragrans Houtt.) dengan metode skarifikasi dan perendaman ZPT alami. Jurnal Agrotekbis, 3(2), 158–167.

Fadhilah, S. (2020). Pengujian daya berkecambah berdasarkan ISTA Rules 2020. Balai Besar Pengembangan Pengujian Mutu Benih Tanaman Pangan dan Hortikultura.

García-Locascio, E., Valenzuela, E. I., & Cervantes-Avilés, P. (2024). Impact of seed priming with selenium nanoparticles on germination and seedlings growth of tomato. Scientific Reports, 14(1), Article 5678. https://doi.org/10.1038/s41598-024-56789-0

Haerani, N., & Nurdin, N. (2021). Uji efektivitas teknik biopriming dengan cendawan Trichoderma pada perbaikan viabilitas benih dan produksi mentimun. J. Agrotan, 7(1), 42–54.

Harsono, N. A., Bayfurqon, F. M., & Azizah, E. (2021). Pengaruh periode simpan dan konsentrasi ekstrak bawang merah (Allium cepa L.) terhadap viabilitas dan vigor benih timun apel (Cucumis sp.). Unnamed Journal, 7(8), 64–72.

Kamaludin, A. M. R., & Holik, H. A. (2022). Artikel ulasan: Kandungan senyawa kimia dan aktivitas farmakologi Spirulina sp. Indonesian Journal of Biological Pharmacy, 2(2), 59–70.

Kartina, Mardhiana, & Karlina, W. (2021). Vigor dan viabilitas benih mentimun (Cucumis sativus L.) dengan pemberian NaOCl dan teknik pengeringan berbeda. Unnamed Journal, 2(2), 33–37.

Kolo, E., & Tefa, A. (2016). Pengaruh kondisi simpan terhadap viabilitas dan vigor benih tomat (Lycopersicum esculentum Mill.). Savana Cendana, 1(3), 112–115.

Kurnia, T. D., Pudjihartati, E., & Hasan, L. T. (2017). Bio-priming benih kedelai (Glycine max (L.) Merrill) untuk meningkatkan mutu perkecambahan. Biota: Jurnal Ilmiah Ilmu-Ilmu Hayati, 1, 62–67.

Lebeharia, S. M. (2016). Pertumbuhan dan kualitas biomassa Spirulina platensis yang diproduksi pada media Zarrouk modifikasi [Unpublished manuscript].

Luo, Y., Liang, J., Zeng, G., Chen, M., Mo, D., Li, G., & Zhang, D. (2018). Seed germination test for toxicity evaluation of compost: Its roles, problems and prospects. Waste Management, 71, 109–114. https://doi.org/10.1016/j.wasman.2017.09.024

Nurwiati, W., & Budiman, C. (2023). Uji cepat vigor benih tomat (Solanum lycopersicum L.) dengan metode radicle emergence. Buletin Agrohorti, 11(2), 260– 265.

Oktaviana, Z., Ashari, S., & Lestari, S. (2016). Pengaruh perbedaan umur masak benih terhadap hasil panen tiga varietas lokal mentimun (Cucumis sativus L.). Jurnal Produksi Tanaman, 4(3), 131–471.

Parnidi, T. H. R. S., Murianingrum, A. R. M., & Marjani. (2022). Morfologi bunga dan daya kecambah benih tanaman stevia (Stevia rebaudiana Bertoni M.). Artikel Pemakalah Paralel, 7, 132–139.

Rahmawati, F. A., Pratiwi, I. W., Samtani, K., Atuillah, N., Hidayatullah, R. A., Ermawati, N., Sya'ban, R. A., Kurniasari, L., & Adnan, M. R. (2025). The potential of Spirulina platensis biostimulant as a seed priming agent to enhance the vigor and viability of cucumber seeds (Cucumis sativus). Biology, Medicine, & Natural Product Chemistry, 14(1), 129–141. https://doi.org/10.14421/biomedich.2025.141.129-141

Ratnaningtyas, F. R., Kristen, U. W., & Wacana, S. K. U. W. (2019). Pengaruh perlakuan organomatrixpriming terhadap peningkatan mutu fisiologis benih cabai (Capsicum annuum L.). Buletin Anatomi dan Fisiologi, 4(1), 45–54.

Ribeiro, D. M., Zanetti, G. T., Julião, M. H. M., Masetto, T. E., Gelinski, J. M. L. N., & Fonseca, G. G. (2019). Effect of different culture media on growth of Chlorella sorokiniana and the influence of microalgal effluents on the germination of lettuce seeds. Journal of Applied Biology and Biotechnology, 8(10), 64–72. https://doi.org/10.7324/JABB.2019.71010

Seğmen, E., & Ünlü, H. Ö. (2023). Effects of foliar applications of commercial seaweed and Spirulina platensis extracts on yield and fruit quality in pepper (Capsicum annuum L.). Cogent Food & Agriculture, 9(1), Article 2178901. https://doi.org/10.1080/23311932.2023.2178901

Septirosya, T., Zulmi, D. R., & Zulaiha, S. (2024). Invigorasi benih cabai merah (Capsicum annuum L.) kadaluarsa melalui teknik hydropriming menggunakan air kelapa muda. Agriprima: Journal of Applied Agricultural Sciences, 8(1), 71–80.

Shakuntala, N. M., Kavya, K. P., Macha, S. I., & Kurnalliker, V. (2020). Studies on standardization of water soaking duration on seed quality in cucumber (Cucumis sativus L.) seeds. Unnamed Journal, 9(4), 1400–1404.

Singh, S. (2014). A review on possible elicitor molecules of cyanobacteria: Their role in improving plant growth and providing tolerance against biotic or abiotic stress. Journal of Applied Microbiology, 117(5), 1221–1244. https://doi.org/10.1111/jam.12644

Soltani, E., Ghaderi-Far, F., Baskin, C. C., & Baskin, J. M. (2015). Problems with using mean germination time to calculate rate of seed germination. Australian Journal of

Botany, 63(8), 631–635. https://doi.org/10.1071/BT15208

Susanti, E. (2014). Pengaruh osmoconditioning dengan PEG (polyethylene glycol) 6000 terhadap viabilitas benih kenaf (Hibiscus cannabinus L.) [Undergraduate thesis, University Name].

Syaban, R. A., Suwardi, S., Rahayu, & Indrianingsih. (2023). Keterkaitan umur panen dan lama waktu curing dengan produksi dan mutu benih mentimun (Cucumis sativus L.) galur MTH 15. Agriprima: Journal of Applied Agricultural Sciences, 7(1), 86–99.