Archives of Current Research International

Volume 25, Issue 5, Page 296-301, 2025; Article no.ACRI.135110
ISSN: 2454-7077

Biostimulant Effects of Plant Extracts on Seed Germination and Storage Stability

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/acri/2025/v25i51209

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://pr.sdiarticle5.com/review-history/135110

Short Research Article

Received: 25/02/2025
Accepted: 30/04/2025
Published: 06/05/2025

ABSTRACT

Biostimulants derived from plant extracts have gained attention for their potential to enhance seed germination and improve storage stability. This study investigates the effects of various plant extracts (e.g., moringa, neem, aloe vera) on seed germination rates and storage longevity in selected crops. Experiments were conducted under controlled conditions, evaluating germination percentage, seedling vigor, and post-storage viability. Results indicate that certain plant extracts significantly improve germination rates and seed shelf life compared to untreated controls. The findings suggest that plant-based biostimulants could serve as eco-friendly alternatives to synthetic treatments in agriculture.

Keywords: Biostimulants; plant extracts; seed germination; storage stability; moringa; neem; aloe vera; seedling vigor; eco-friendly agriculture.

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Cite as: *Jyoti, and Harish Kumar. 2025. "Biostimulant Effects of Plant Extracts on Seed Germination and Storage Stability". Archives of Current Research International 25 (5):296-301. https://doi.org/10.9734/acri/2025/v25i51209.*

1. INTRODUCTION

Seed germination and storage stability are fundamental determinants of agricultural productivity, influencing crop establishment, yield potential, and food security (Bewley *et al.*, 2013). The ability of seeds to germinate efficiently and remain viable during storage is crucial for farmers, seed banks, and the agricultural industry at large. However, several factors-such as environmental stress, seed aging, and microbial contamination-can impair germination rates and reduce storage longevity (Rajjou *et al.*, 2012). To mitigate these challenges, synthetic growth enhancers and chemical preservatives have been extensively employed. While these agents can improve germination and prolong shelf life, their prolonged use raises concerns regarding environmental toxicity, soil degradation, and potential health hazards for consumers (Arora *et al.*, 2010). Consequently, there is a growing demand for sustainable, eco-friendly alternatives that can enhance seed performance without adverse effects.

Plant extracts have emerged as promising candidates due to their rich composition of bioactive compounds, including phytohormones (e.g., gibberellins, cytokinins), antioxidants (e.g., flavonoids, phenolics), and antimicrobial agents (e.g., alkaloids, terpenoids) (Basra & Lovatt, 2016). These natural compounds can stimulate metabolic activity in seeds, enhance stress resistance, and suppress pathogenic microorganisms that compromise seed viability. Among the most studied botanical extracts are those derived from moringa (Moringa oleifera), neem (*Azadirachta indica*), and aloe vera (*Aloe barbadensis*), each demonstrating unique biostimulant and preservative properties.

Moringa leaf extract, for instance, is rich in cytokinins, zeatin, and antioxidants, which have been shown to improve germination vigor and seedling growth in crops such as maize, wheat, and soybeans (Mbakogu & Ugwuoke, 2018). Similarly, neem extracts possess broad-spectrum antimicrobial and antifungal properties, attributed to bioactive constituents like azadirachtin, nimbin, and salannin (Schmutterer, 1990). These compounds help protect seeds from fungal and bacterial infections during storage, thereby extending viability. Aloe vera gel, on the other hand, contains polysaccharides, auxins, and gibberellin-like substances that enhance water uptake and stimulate enzymatic activity during germination (Ahlawat & Khatkar, 2011).

Despite the documented benefits of these plant extracts, their efficacy can vary depending on factors such as extraction methods, concentration, seed type, and storage conditions (Srivastava *et al.,* 2016). Furthermore, comparative studies evaluating their combined or individual effects under different environmental stresses (e.g., temperature fluctuations, humidity variations) remain limited. Addressing these gaps is essential for optimizing the use of plant-based treatments in agriculture. This study aims to evaluate the effectiveness of moringa, neem, and aloe vera extracts in enhancing seed germination and improving storage stability under varying conditions.

2. MATERIALS AND METHODS

The study utilized three medicinal plants—Moringa (*Moringa oleifera*) leaves, neem (*Azadirachta indica*) leaves, and aloe vera (*Aloe barbadensis*) gel—for extract preparation. Aqueous and ethanolic (70%) extracts were obtained through maceration, where plant materials were soaked in solvents for 72 hours with occasional shaking, followed by filtration and evaporation (Harborne, 1998). The extracts were tested at 5%, 10%, and 15% (v/v) concentrations to evaluate their effects on seed germination.

Seeds of wheat (*Triticum aestivum*), tomato (*Solanum lycopersicum*), and soybean (*Glycine max*) were selected for the experiment. Prior to treatment, seeds were surface-sterilized with 1% sodium hypochlorite for 5 minutes and rinsed with distilled water (ISTA, 2020). The seeds were then soaked in plant extracts for 12 hours, while control seeds were treated with distilled water.

For the germination assay, seeds were placed in Petri dishes lined with moist filter paper (n=50 seeds per treatment) and maintained under controlled conditions (25±2°C, 12/12 h light/dark cycle) (Bewley *et al.*, 2013). Germination was monitored daily for 7 days, and the germination percentage was calculated based on radicle emergence (≥2 mm).

To assess storage stability, treated and untreated seeds were stored under room temperature (25°C) and cold storage (4°C). Germination viability was evaluated after 1, 3, and 6 months to determine the long-term effects of plant extracts (Ellis & Roberts, 1981). Data analysis included calculating the germination percentage, vigor index, and mean germination

time (MGT). The vigor index was determined as (germination percentage × seedling length) (Abdul-Baki & Anderson, 1973). Statistical significance was assessed using one-way ANOVA ($p<0.05$) followed by Tukey's post-hoc test (IBM SPSS v.26).

3. RESULTS AND DISCUSSION

The effects of different plant extracts on seed germination and storage stability were evaluated for wheat, tomato, and soybean seeds. The results are summarized in Table 1 and Table 2.

3.1 Effect on Seed Germination

As shown in Table 1, all tested plant extracts significantly improved seed germination compared to the control ($p < 0.05$). Moringa extract (10%) exhibited the most pronounced effect, increasing germination to 92% (wheat), 85% (tomato), and 88% (soybean). This enhancement may be attributed to its high cytokinin content, which promotes cell division and growth (Basra *et al.*, 2005). Neem extract (10%) moderately improved germination (78% in tomato, 82% in soybean), likely due to its secondary metabolites that protect seeds from pathogens. Aloe Vera extract (10%) also showed significant improvement (88% in wheat, 80% in tomato, 84% in soybean), possibly due to its growth-promoting hormones and moisture-retention properties.

3.2 Effect on Seed Storage Stability

After six months of storage (Table 2), seeds treated with plant extracts maintained higher germination rates than the control, particularly under cold storage (4°C). Moringa extract again performed best, maintaining 90% germination at 4°C and 80% at 25°C, suggesting its role in preserving seed vigor. Neem extract showed strong storage stability (85% at 4°C, 70% at 25°C), likely due to its antimicrobial properties that reduce fungal and bacterial degradation (Schmutterer, 1990). Aloe Vera-treated seeds retained 88% viability at 4°C and 75% at 25°C, possibly due to its polysaccharides that reduce oxidative stress.

3.3 Temperature Influence on Seed Longevity

Cold storage (4°C) consistently outperformed room temperature (25°C) in preserving seed viability. This aligns with previous studies indicating that lower temperatures slow metabolic activity and reduce seed deterioration (Walters *et al.*, 2005).

Table 1. Effect of Plant Extracts on Seed Germination (%)

Treatment	Wheat	Tomato	Soybean
Control	75	68	72
Moringa (10%)	92*	85*	88*
Neem (10%)	80	78*	82*
Aloe Vera (10%)	88*	80*	84*

*(*Significantly higher than control, $p<0.05$)*

Table 2. Seed Storage Stability after 6 Months

Treatment	Germination (%) at 25°C	Germination (%) at 4°C
Control	55	70
Moringa (10%)	80*	90*
Neem (10%)	70*	85*
Aloe Vera (10%)	75*	88*

4. CONCLUSION

Moringa extract emerges as the most effective treatment for enhancing both seed germination and storage longevity, likely due to its rich nutrient profile and bioactive compounds. Neem extract also plays a valuable role in maintaining seed viability during storage, primarily attributed to its strong antimicrobial properties that protect seeds from deterioration. Meanwhile, Aloe Vera provides a balanced improvement, moderately supporting germination while also contributing to storage stability, possibly owing to its hydrating and protective gel components. Additionally, cold storage at 4°C proves significantly more effective than ambient conditions in prolonging seed viability, as lower temperatures slow metabolic activity and reduce seed aging. Together, these findings highlight the potential of natural extracts and controlled storage conditions in optimizing seed performance and shelf life.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
https://pr.sdiarticle5.com/review-history/135110