



Effects of Seed Priming on Early Seedling Growth and Germination

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Manuscript details:

Received: 09.04.2026
Accepted: 20.05.2026
Published: 30.05.2026

Cite this article as:

Thombal Komal D and Tuwar AR (2026)
Effects of Seed Priming on Early Seedling Growth and Germination, *Int. J. of Life Sciences*, 14 (1A):359-362.
<https://doi.org/10.5281/zenodo.20685516>

Available online on <http://www.ijlsci.in>
ISSN: 2320-964X (Online)
ISSN: 2320-7817 (Print)



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ABSTRACT

By starting metabolic processes without radicle emergence, seed priming is a pre-sowing therapy that improves seed germination, vigor, and early seedling growth. Seed priming has become a successful method to boost crop performance and productivity when environmental conditions impact crop establishment. This study assesses how several seed priming methods - hydropriming, osmopriming, and biopriming - affect the early seedling growth and germination behavior of particular crop species. Germination percentage, mean germination time, seedling length, fresh and dry weight, and vigor index were among the characteristics that were measured while the seeds were treated under controlled conditions. According to the findings, primed seeds germinated more quickly and consistently than unprimed controls. While osmopriming greatly increased seedling vigor and biomass accumulation, hydropriming boosted water uptake and initial germination rates. The development of roots and shoots was further aided by biopriming with advantageous microbial inoculants, suggesting a synergistic influence on early growth. All priming treatments significantly improved germination and seedling growth parameters, according to statistical analysis, with osmopriming demonstrating the best overall efficacy. These results suggest that seed priming is a useful and affordable strategy to enhance crop establishment, especially in situations where soil moisture and temperature are below ideal. In agriculture, seed priming can result in uniform stands, quicker crop establishment, and possibly increased yields. It is advised that more study be done to clarify the physiological and molecular processes that underlie priming-induced stress tolerance and to improve procedures for extensive field use in a variety of crop species.

Keywords: Seed priming, Germination rate, Seedling vigor, Hydropriming, Osmopriming, Biopriming.

INTRODUCTION

Early seedling growth and seed germination are crucial phases for crop establishment and yield. Water absorption, enzyme activation, and metabolic processes that enable the embryo to grow into a viable seedling are all necessary for germination. Drought, salt, and severe

temperatures are examples of environmental stressors that have a detrimental impact on stand establishment, seedling vigor, and germination uniformity. To improve seed performance in both ideal and suboptimal circumstances, a number of seed priming methods have been developed, including as hydropriming, osmopriming, and biopriming. Using just water, hydropriming promotes better water absorption and starts early metabolism. While biopriming mixes advantageous microorganisms with priming solutions to encourage seedling growth and provide pathogen protection, osmopriming uses osmotic solutions to control water absorption and improve stress tolerance.

According to recent research, seed priming increases seedling vigor, root and shoot growth, and stress resilience in addition to improving germination rate and uniformity. Despite these developments, research is still ongoing to determine the relative benefits of various priming methods on the early growth of seedlings as well as the underlying physiological and molecular mechanisms. By being aware of these impacts, priming procedures for a variety of crop species can be improved, improving crop establishment and increasing agricultural output. In order to provide light on their potential uses in sustainable agriculture, this study intends to assess how various seed priming methods affect the germination traits and early seedling growth of particular crop species. A pre-sowing method called "seed priming" partially hydrates seeds to initiate metabolic processes without causing radical emergence.

This enhances stress tolerance, enzyme activity, and water absorption. Typical priming methods consist of: Soaking seeds in water to enhance water absorption and start metabolism is known as hydropriming. Osmopriming is the process of controlling water intake and improving stress resilience by using osmotic solutions, such as PEG or salts. Biopriming is the process of combining beneficial microorganisms with priming to promote development and provide pathogen protection. Prior research has demonstrated that primed seeds develop seedlings with superior root and shoot growth, have higher uniformity, and germinate more quickly. Comparative research on priming techniques across crops is still scarce, particularly when it comes to comprehending physiological and molecular mechanisms. The effects

of hydropriming, osmopriming, and biopriming on germination, seedling vigor, and early growth in a few chosen crops are assessed in this study. The findings are intended to offer useful information for enhancing crop establishment and yield in a range of environmental circumstances.

MATERIALS AND METHODS:

Seed Material: Certified suppliers provided the seeds for crops like soybean, maize, and wheat. The seeds had no obvious flaws and were all the same size.

Treatments for Seed Priming: Hydropriming : Soaking seeds for 12 hours in distilled water.

Osmopriming : Soak seeds for 12 hours in a 10% PEG 6000 solution.

Biopriming is the process of soaking seeds for 12 hours in a solution containing *Bacillus subtilis* (10^8 CFU/mL). Control: Seeds without priming.

Conditions for Germination and Seedling

Growth: Seeds were incubated at $25 \pm 2^\circ\text{C}$ in Petri dishes on moistened filter paper.

The following observations were made: Percentage of germination (%) Average time for germination (days) Seedling length (cm) and weight, both fresh and dry (g) Index of Vigor.

Experimental Design: Three replicates of each treatment in a completely randomized design (CRD). ANOVA was used to statistically evaluate the data.

All of the important parameters—germination percentage, mean germination time, seedling length, fresh weight, dry weight, and vigor index—are included in this table, which provides a clear comparison perspective of priming effects across several crops.

RESULT AND DISCUSSION

1. Compared to unprimed seeds, primed seeds germinated more quickly and consistently.
2. The greatest increase in seedling vigor and germination percentage was observed with osmopriming.
3. Hydropriming had a limited effect on seedling development but improved initial germination.

Table 1: Effect of Seed Priming on Germination and Early Seedling Growth

Crop Treatment	Germination (%)	Mean Germination Time (days)	Seedling Length (cm)	Fresh Weight (g)	Dry Weight (g)	Vigor Index
Soybean Control	82	6.5	7.2	0.48	0.12	590
Soybean Hydropriming	90	5.2	8.5	0.56	0.14	765
Soybean Osmopriming	94	4.8	9.3	0.61	0.15	874
Soybean Biopriming	92	5.0	9.0	0.58	0.14	828
Tomato Control	80	6.8	6.9	0.44	0.11	555
Tomato Hydropriming	88	5.5	8.1	0.53	0.13	713
Tomato Osmopriming	92	5.0	8.8	0.57	0.14	810
Tomato Biopriming	90	5.2	8.5	0.55	0.13	765
Wheat Control	78	7.0	6.5	0.42	0.10	507
Wheat Hydropriming	85	5.8	7.8	0.50	0.12	663
Wheat Osmopriming	91	5.1	8.5	0.56	0.13	774
Wheat Biopriming	89	5.3	8.2	0.54	0.13	730
Maize Control	75	7.2	6.2	0.40	0.09	465
Maize Hydropriming	83	6.0	7.5	0.48	0.11	623
Maize Osmopriming	90	5.2	8.2	0.53	0.12	738
Maize Biopriming	88	5.4	8.0	0.51	0.12	704

4. Biopriming enhanced the growth of roots and shoots, indicating a beneficial microbial effect.
5. All primed treatments had a consistently higher Vigor score than the control, suggesting more potential for early growth.
6. Differences were statistically substantial ($p < 0.05$), indicating that priming methods were successful.

Benefits of Seed Priming:

A straightforward but incredibly powerful pre-sowing method that improves seed performance and early plant growth is seed priming.

Increased Uniformity and Germination Rate Compared to unprimed seeds, primed seeds germinate more quickly and consistently. Fast crop establishment is ensured by a lower mean germination time.

1. Increased Vigor of Seedlings By promoting early metabolic activity, seed priming produces stronger seedlings, longer roots and shoots, and increased biomass. Stronger seedlings can endure environmental stressors and compete for nutrients more effectively.
2. The Ability to Handle Stress Primed seeds are more resilient to abiotic stressors such oxidative damage, drought, salt, and extreme temperatures. Seedlings are protected during early growth by osmopriming and biopriming, which activate stress-responsive genes and antioxidant enzymes.
3. Improved Crop Establishment and Production A more uniform stand in the field is the result of

faster and more consistent germination. Crop performance and potential yield are enhanced by robust seedlings.

4. A decrease in seed waste the amount of seeds needed to produce a desired plant population is decreased via seed priming, which enhances germination and early growth.
5. Harmony with the Principles of Sustainable Agriculture Beneficial bacteria are integrated through biopriming, which improves soil health and lessens the demand for artificial fertilizers. Economical and ecologically benign, making it appropriate for farmers with minimal resources.
6. Initiation of Physiological and Metabolic Mechanisms Priming initiates pre-germinative metabolic processes, including hormone signaling, DNA repair, and enzyme activation. Once sown, seeds are physiologically “prepared” for effective germination.

CONCLUSION

Early seedling development and germination efficiency are greatly increased by seed priming. Higher yields depend on improved crop establishment, which is ensured by faster germination and uniform emergence. Osmopriming was most successful in increasing biomass accumulation and vigor, perhaps as a result of induced stress tolerance and regulated hydration. The potential of biopriming to include

microbial inoculants into crop management is highlighted by its additional advantages in root and shoot growth. This study shows that seed priming is a realistic and affordable way to enhance crop production, especially in situations that are prone to stress. Using priming strategies can help ensure food security and sustainable agriculture. The physiological and molecular mechanisms behind priming-induced growth and stress tolerance should be investigated further.

Conflict of interest

The authors declare no competing interests.

Data Availability Statement: Not applicable.

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