



## Role of Seed Priming in Enhancing Germination and Seedling Vigour

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Seed germination and early seedling growth are crucial phases in a plant's life cycle and directly influence the final crop yield. Germination failure, delayed emergence, and weak seedlings often result from poor seed quality or adverse environmental conditions. Seed priming is a pre-sowing technique that enhances seed performance by initiating early biochemical and physiological processes without allowing radical protrusion. This controlled hydration prepares seeds for rapid germination and efficient seedling establishment once they are sown. Seed priming has become widely accepted due to its **simplicity, low cost, and high effectiveness**. It is used in cereals, pulses, vegetables, spices, flowers, medicinal and plantation crops.



### Definition of Seed Priming

Seed priming is a **pre-sowing hydration treatment** that allows limited imbibition to activate metabolic processes required for germination but prevents radicle emergence. After priming, the seeds are redried to their initial moisture content to maintain storability and ease of handling.

### Need and Importance of Seed Priming

- Many seeds suffer from **low germination** due to poor quality or dormancy.
- Seeds often fail to germinate uniformly due to **environmental stresses**.
- Germination is sensitive to **soil moisture, temperature, salinity, and oxygen availability**.
- Modern high-density planting and mechanization require **uniform field emergence**.
- Priming reduces the time between sowing and emergence, thereby avoiding early-season hazards.

Seed priming ensures faster, uniform, and synchronized germination, which is essential for achieving **high crop yields**.

## Seed Priming Methods (With Deep Explanation)

### Hydropriming

Hydrating seeds in water for a controlled period.

**Mechanism:** Water initiates early germination metabolism, improves membrane reorganization, and enhances enzyme activation.

### Advantages

- Cheapest method
- No chemicals required
- Suitable for cereals and pulses
- **Limitations:** Requires strict control of duration to avoid over-imbibition

### Osmopriming

Seed soaking in osmotic solutions (PEG, mannitol, sorbitol) which control water uptake.

**Mechanism:** Slow hydration allows seeds to activate metabolism gradually, improving stress tolerance.

### Benefits:

- Highly effective under drought and salinity
- Improves germination uniformity

### Halopriming

Soaking seeds in salt solutions (KCl, CaCl<sub>2</sub>, MgSO<sub>4</sub>, NaCl).

**Mechanism:** Enhances ionic balance, improves nutrient uptake, and strengthens membrane integrity.

Useful for: Rice, pulses, oilseeds, vegetables.

### Hormonal Priming

Using plant hormones like GA<sub>3</sub>, IAA, kinetin, ABA inhibitors, ethylene releasers.

### Role:

- GA<sub>3</sub> stimulates embryo growth and breaks dormancy
- Auxins improve root growth
- Cytokinins enhance cell division
- **Common in:** Vegetables, spices, flowering crops.

### Biopriming

Coating or soaking seeds with beneficial microbes such as *Trichoderma*, *Pseudomonas*, *Rhizobium*, *Azotobacter*.

### Benefits:

- Increases seedling disease resistance
- Promotes root colonization
- Enhances nutrient solubilization

### Solid Matrix Priming (SMP)

Seed mixed with inert materials (vermiculite, peat, charcoal) + controlled water. Used for *vegetable nursery systems* and *flower seeds*.

## Mechanism of Action (Highly Detailed)

Seed priming activates multiple biochemical, physiological, and molecular pathways:

### Phase I: Imbibition and Membrane Repair

- Seeds rapidly absorb water and repair membrane damage caused during dehydration and storage.
- Reorganization of phospholipid layers reduces solute leakage.
- Enhanced cell membrane stability ensures rapid germination.

### Phase II: Metabolic Activation

During priming, seeds experience:

- Activation of hydrolytic enzymes ( $\alpha$ -amylase, protease, lipase)
- Breakdown of stored carbohydrates, proteins, and lipids
- Synthesis of mRNA and protein molecules
- Improved mitochondrial activity leading to higher ATP production

This metabolic readiness enables faster germination after sowing.

### Phase III: Hormonal Modulation

Seed priming alters hormonal balance:

- $\uparrow$  GA<sub>3</sub> promotes germination
- $\downarrow$  ABA overcomes seed dormancy
- $\uparrow$  Cytokinins enhance cell division
- $\uparrow$  Auxins promote root development

### Antioxidant System Enhancement

Priming increases the activity of antioxidant enzymes such as:

- Catalase (CAT)
- Superoxide dismutase (SOD)
- Peroxidase (POD)
- These enzymes protect the embryo from oxidative stress and enhance seed vigour.

### Gene Expression and Cell Cycle Activation

- Primed seeds show increased expression of genes responsible for germination.
- Cells enter the **G2 phase** of the cell cycle, enabling radicle emergence immediately after sowing.

## Effect of Seed Priming on Germination

### Improved Germination Percentage

Primed seeds germinate faster and more completely, ensuring a better crop stand.

### Increased Speed of Germination

Germination index, coefficient of velocity, and speed of germination are significantly improved.

### Reduced Mean Germination Time (MGT)

Primed seeds require less time to germinate because early metabolic steps are already completed during priming.

### Better Germination Under Stress Conditions

Primed seeds tolerate:

- Salinity
- Drought
- Temperature extremes
- Flooding
- Heavy metals

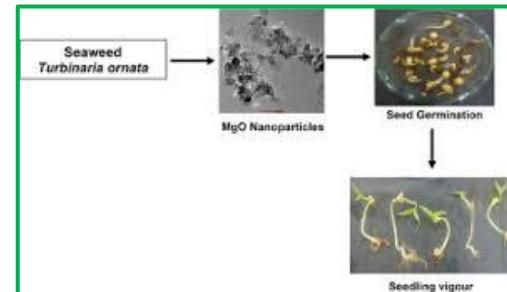
This is due to enhanced stress-responsive enzyme activity.

## Effect of Seed Priming on Seedling Vigour

### Improved Root System

- Longer radicle
- Increased lateral roots
- Higher root surface area
- Better root-shoot ratio

This enhances water and nutrient uptake.



### Increased Shoot Growth

- Higher chlorophyll content
- Faster leaf expansion
- Improved dry matter accumulation

### Higher Seedling Biomass

Due to efficient mobilization of food reserves and enhanced photosynthesis.

### Enhanced Physiological Strength

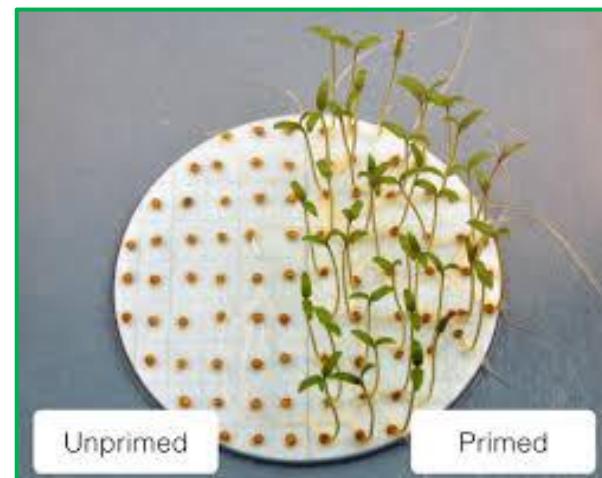
- Stronger early vigor
- Higher seedling survival rate
- Better early crop establishment

### Induced Resistance to Diseases

Bioprimed seeds show reduced incidence of damping-off, wilt, and root rot due to microbial colonization.

## Advantages of Seed Priming (Expanded)

- Cost-effective and easy method
- Improves germination and emergence
- Ensures uniform crop stand
- Enhances tolerance to abiotic and biotic stress
- Improves nutrient uptake and root architecture
- Reduces seed and seedling mortality
- Helps crops escape early-season drought
- Increases yield potential



### Limitations (Expanded)

- Risk of over-priming leading to loss of viability
- Primed seeds have lower storage life if not dried properly
- Standardization needed for each crop type and variety
- Requires careful control of water potential, temperature, and duration

## Conclusion

Seed priming is an effective, eco-friendly, and practical technique to enhance seed performance and seedling vigour. It improves germination rate, uniform emergence, physiological strength, stress tolerance, and yield potential. With increasing climatic uncertainties, seed priming is an essential tool to ensure climate-smart and sustainable agriculture.