



SEED PRIMING: THE FIRST STEP TOWARD HEALTHY CROPS

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Introduction

Seed priming, first introduced by Heydecker in 1973, involves precise and controlled wetting of seeds. It is a pre-sowing technique that enhances seed physiology by partially hydrating seeds to start early metabolic processes before the radicle emerges. After this, seeds are re-dried to their initial moisture level and stored until planting. This process leads to faster and more uniform seed germination. In general, seed priming is waking the seed before sowing. Seed priming is practised using a wide range of agents and techniques, which can be tailored according to crop type and anticipated stress conditions.

The significant types of priming are:

Hydropriming:

Healthy uniform seeds were soaked in water for a duration depending on the respective crop species. Remove the seed and shade dry them to their original moisture levels. The most popular and economical way of priming.

- Uses water for controlled hydration.
- Water uptake activates:
 - DNA repair
 - RNA and protein synthesis
 - Enzyme activation

Over-soaking can lead to seed rot and oxygen deficiency, and it can shorten seed life after priming. Less effective for seeds with hard seed coats.

Osmo priming

- Employs osmotic solutions such as sodium chloride (NaCl), calcium chloride (CaCl₂), potassium nitrate (KNO₃), polyethylene glycol and sugars like mannitol and sorbitol to regulate water potential and improve germination and stress tolerance.
- Improves antioxidant activity
- DNA and membrane repair
- Costlier than hydropriming

Hormonal priming

- Employs plant hormones to regulate germination-related metabolism
- Commonly used hormones include gibberellic acid (stimulates α -amylase synthesis), indole-3-acetic acid and indole-3-butyric acid (enhance cell elongation and root growth), cytokinins (promote cell division), and salicylic acid (enhances antioxidant defence and stress tolerance). Abscisic acid is rarely used in stress studies.
- Costlier, requiring precision and careful handling.

Nutri priming

- Seeds are soaked in nutrient solutions to supply essential macronutrients or micronutrients during early germination, thereby improving seedling vigour and nutrient use efficiency.

- Commonly used macronutrients:
 - Nitrogen (Potassium nitrate: KNO_3 , Urea)
 - Phosphorous
 - Potassium (Potassium chloride: KCl , Potassium sulphate: K_2SO_4)
- Micronutrients:
 - Zinc (Zinc sulphate: ZnSO_4)
 - Iron (Iron sulphate: FeSO_4)
 - Boron (Boric acid)
 - Manganese (Manganese sulphate: MnSO_4)
- Colonise the seed surface and rhizosphere, producing growth-promoting substances, solubilising nutrients, and inducing systemic resistance.

Biopriming

- Inoculation of beneficial organisms to stimulate seed defence mechanisms.
- Common bioagents are: *Trichoderma spp.*, *Pseudomonas fluorescens*, *Bacillus subtilis*, Azospirillum, Rhizobium and phosphate-solubilising bacteria.
- Short shelf life of treated seeds
- Effectiveness is influenced by soil and environment.

Redox priming

- Advances in seed priming technique, in which seeds are treated with mild oxidising or reducing agents to modulate the cellular redox balance.
- Oxidants: hydrogen peroxide (commonly used), ozone
- Reductants: Nitric oxide, ascorbic acid and glutathione.
- Activates antioxidant enzymes and improves membrane integrity.

Nano priming

- Seeds treated with engineered nanoparticles
 - Metal and metal oxide nanoparticles and carbon-based nanoparticles are commonly used
 - Effective at ultra-low doses
 - Enhances multiple traits simultaneously
- Limitations:
- Environment and food safety concerns
 - Requires specialised materials and facilities
 - Not yet widely recommended for farmers

Polymer-based priming

- seeds are treated with hydrophilic polymers (natural or synthetic)
- Synthetic polymers
 - Polyethylene glycol (PEG) (also used in osmo priming)
 - Polyvinyl alcohol (PVA)
 - Polyacrylamide
- Natural/ biodegradable polymers
 - Starch-based polymers
 - Alginate
 - Chitosan (also has a biostimulant effect)

Effect of priming on seed:

- Faster and synchronised germination: early establishment enhances nutrient uptake efficiency,
- Improved seedling vigour index
- Enhanced antioxidant activity (Superoxide dismutase, catalase, peroxidase)
- Better membrane integrity and reserve mobilisation

- Improved tolerance to drought, salinity and temperature stress

Importance of priming under drought stress:

First and foremost, the most crucial stage in establishing plants to raise healthy crops, achieve good yields, and maintain high nutritional value is seed germination. Hence, priming the seeds before germination plays a vital role in good crop establishment.

- Improves water use efficiency at early growth stages
- Enhances root growth and early establishment
- Reduces seedling mortality under moisture stress
- Often reflected in higher stress tolerance indices

Conclusion

Seed priming enhances seed germination speed and uniformity, encouraging early flowering and maturity. It helps break seed dormancy and boosts tolerance to stress and soil-borne diseases. Numerous studies across various crops demonstrate that seed priming enhances growth and yield, especially in challenging conditions. While different priming techniques are effective, proper standardisation is necessary for the best outcomes. Biopriming with beneficial microbes supports plant development and soil health. Recently, Nano priming has attracted interest due to its efficient, targeted nutrient delivery. Integrating beneficial microbes with nanomaterials for seed priming presents a promising strategy to boost crop productivity.

References

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