Seed Treatment, Seed Priming and Biopriming: Innovative Approaches for Sustainable Crop Production

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Abstract

Seed quality plays a critical role in determining crop establishment, growth, and productivity. Various environmental stresses such as drought, salinity, temperature fluctuations, and soil-borne diseases adversely affect seed germination and seedling development. Seed enhancement technologies including seed treatment, seed priming, and biopriming have emerged as effective strategies to improve seed performance and crop productivity. Seed treatment involves the application of chemical, physical, nutritional, or biological agents to protect seeds from pathogens and pests. Seed priming is a controlled hydration process that activates pre-germinative metabolic activities, resulting in rapid and uniform germination. Biopriming combines seed hydration with beneficial microorganisms to enhance disease resistance and plant growth. These techniques contribute significantly to sustainable agriculture by improving stress tolerance, reducing chemical dependency, and enhancing nutrient use efficiency. The present article discusses the principles, methods, advantages, and agricultural significance of seed treatment, seed priming, and biopriming in modern crop production systems.

Keywords: Seed treatment, Seed priming, Biopriming, Seed enhancement, Sustainable agriculture, Bioagents

Introduction

Seeds are the foundation of agriculture and serve as the starting point for crop production. The quality and vigour of seeds directly influence germination, plant establishment, crop growth, and final yield. However, seeds are often exposed to adverse environmental conditions such as drought, salinity, temperature stress, and pathogen attack, which reduce their germination potential and field performance. In recent years, climate variability and declining soil health have further intensified challenges in crop establishment.

To overcome these problems, several seed enhancement technologies have been developed to improve seed quality and seedling vigour. Among these technologies, seed treatment, seed priming, and biopriming have gained considerable importance due to their simplicity, low cost, and effectiveness. These techniques improve germination, protect seedlings from diseases, and enhance tolerance to environmental stresses.

Seed treatment is one of the oldest and most widely practiced methods of protecting seeds from seed-borne and soil-borne pathogens. Seed priming enhances the physiological performance of seeds through controlled hydration, while biopriming integrates beneficial microorganisms with seed priming to improve plant health and productivity.

These technologies are increasingly being recognized as important tools for sustainable and climate-resilient agriculture. They help farmers achieve better crop establishment, reduce dependence on chemical pesticides, and improve overall agricultural productivity.

Seed Treatment

Seed treatment refers to the application of chemical, physical, biological, or nutritional agents to seeds before sowing in order to improve seed health and protect against diseases and pests.

Objectives of Seed Treatment

- Protection against seed-borne and soil-borne pathogens
- Improvement of germination and seedling vigour
- Prevention of insect damage
- Enhancement of nutrient availability
- Improvement in crop establishment and yield

Types of Seed Treatment

Chemical Seed Treatment

Chemical fungicides and insecticides are commonly used to protect seeds during germination and early growth stages. Chemicals such as carbendazim, thiram, captan, and imidacloprid are widely used in agricultural crops.

Physical Seed Treatment

Physical methods involve the use of heat, hot water, solarization, or irradiation to eliminate pathogens present on seed surfaces.

Nutrient Seed Treatment

Micronutrients such as zinc, boron, molybdenum, and iron are applied to seeds to improve early seedling nutrition and growth.

Biological Seed Treatment

Biological seed treatment involves the use of beneficial microorganisms to suppress pathogens and promote plant growth. Common bioagents include:

- Trichoderma
- Pseudomonas fluorescens
- Rhizobium

Seed Priming

Seed priming is a pre-sowing technique in which seeds are partially hydrated under controlled conditions to initiate metabolic activities necessary for germination without allowing radicle emergence.

After priming, seeds are dried back to their original moisture content before sowing.

Advantages of Seed Priming

- Faster and uniform germination
- Improved seedling emergence
- Enhanced stress tolerance
- Better root and shoot development
- Increased crop productivity

Types of Seed Priming

Hydropriming: Seeds are soaked in water for a specific duration and then dried before sowing. It is the simplest and most economical priming method.

Osmopriming: Seeds are soaked in osmotic solutions such as polyethylene glycol (PEG) or potassium nitrate to regulate water uptake.

Halopriming: Seeds are treated with inorganic salts such as sodium chloride or calcium chloride to improve salinity tolerance.

Hormonal Priming: Plant growth regulators like gibberellic acid and salicylic acid are used to stimulate seed germination and vigour.

Nutripriming: Seeds are soaked in nutrient solutions to enhance nutrient uptake and seedling growth.

Biopriming

Biopriming is an advanced seed enhancement technology that combines seed priming with beneficial microorganisms. During biopriming, seeds are inoculated with bioagents and incubated under controlled conditions to allow microbial colonization on the seed surface. Biopriming provides the combined advantages of physiological seed activation and biological disease protection.

Benefits of Biopriming

- Improved germination and seedling vigour
- Enhanced protection against pathogens
- Increased nutrient uptake
- Improved tolerance to abiotic stresses
- Reduction in chemical pesticide usage
- Promotion of sustainable agriculture

Common Bioagents Used in Biopriming

Fungal Bioagents

- Trichoderma harzianum
- Trichoderma viride

Bacterial Bioagents

- Bacillus subtilis
- Azospirillum
- Pseudomonas fluorescens

These microorganisms improve plant growth through mechanisms such as antibiosis, nutrient solubilization, induced systemic resistance, and phytohormone production.

Importance in Sustainable Agriculture

Sustainable agriculture aims to increase productivity while minimizing environmental impacts. Seed enhancement technologies contribute significantly to sustainable crop production by reducing chemical inputs and improving resource use efficiency. Primed and bioprimed seeds show improved tolerance to drought, salinity, and temperature stress. These methods also help reduce seedling mortality and improve crop stand under adverse field conditions. Biopriming is particularly important in eco-friendly farming systems because it reduces reliance on synthetic pesticides and promotes beneficial microbial activity in the rhizosphere.

Applications in Agricultural Crops

Cereals: Seed priming improves germination and stand establishment in crops such as rice, wheat, and maize.

Pulses: Biological seed treatment with Rhizobium improves nodulation and nitrogen fixation in pulse crops.

Oilseeds: Seed treatment protects oilseed crops from fungal infections and improves early growth.

Vegetables: Priming and biopriming enhance germination, seedling vigour, and transplant success in vegetable crops.

Future Prospects

Recent advances in seed science are leading to the development of innovative technologies such as nano-priming, microbial consortia-based biopriming, and stress-specific seed enhancement formulations. Integration of biotechnology, microbiology, and precision agriculture is expected to improve the efficiency and adoption of these technologies. Research is also focusing on developing crop-specific and climate-resilient seed enhancement strategies to support sustainable food production.

Conclusion

Seed treatment, seed priming, and biopriming are important seed enhancement technologies that improve germination, seedling vigour, disease resistance, and crop productivity. These techniques help seeds overcome biotic and abiotic stresses and ensure better crop establishment under diverse environmental conditions. Seed treatment provides protection against pathogens and pests, while seed priming enhances physiological preparedness for germination. Biopriming combines the advantages of both approaches by integrating beneficial microorganisms with seed hydration techniques. With increasing concerns regarding climate change, soil degradation, and excessive use of agrochemicals, these technologies offer sustainable and environmentally friendly solutions for modern agriculture. Wider adoption of seed enhancement practices can contribute significantly to food security, sustainable crop production, and climate-resilient farming systems.

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