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Seed Biopriming: A sustainable approach for stress tolerance and enhancement of seed quality

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Abstract

Priming is a pre-sowing technique used to improve seed vigour in terms of germination potential and various biotic as well as abiotic stress resistance. Different priming treatments can be used depending on the plant species, seed form and physiology, all of which facilitate the seed germination and so-called as "pre- germinative metabolism". Various priming methods such as hydropriming, osmo priming, chemo priming, nutri priming, hormo priming and biopriming can be used to enhance seed or plant performance. Of all the methods, biopriming is a realistic technique to improve seed performance in a variety of ways, such as, the increasing germination rates, improving plant growth, disease resistance, yield and eliminating seed as well as soilbornephytopathogens. Bio-priming is an adaptive agricultural method that is critical for food, nutritional and health security. This will assist us in ending poverty, ending hunger, improving health and well-being and so on. Current research work on biopriming continues to explore the potential of these Techniques in addressing agricultural challenges and Improving plant productivity.

Keywords: Biopriming, Biotic and abiotic resistance and Biocontrol agents

Introduction

In an agricultural world, scientists, researchers and farmers are constantly seeking innovative ways to boost agriculture production and productivity. Recently, most of the farming community has moved towards theorganic and sustainable agriculture, creating a need for an efficientbiological management of diseases as an alternative to existing chemicalfungicides. Biological seed treatments with suitable bioinoculants may provide an ecofriendly substitute to chemicalcontrol (Reddy et al., 2013). One such technique that has gained significant importance recently is seed bio-priming. Bio-priming is a technique of seed treatment that integrates biological (inoculation of seed with beneficial organism) and physiological activation (seed hydration) of disease control (Fig. 1.).

This technique is recently used as an alternative method for controlling many seed- and soil-borne pathogen. (Reddy et al., 2013). Biopriming, an advanced seed enhancement technique, involves immersing seeds in a microbial suspension for a specified period to enable microbial absorption (Callan et al., 1990). Like other priming methods, biopriming enhances germination rate, improves uniformity of germination, and increases seed vigour while also protecting seeds against soil and seed-borne pathogens.This pre-sowing treatment has gained significant attention, offering a wide range of benefits that can lead to improved seed yields and overall plant health. The attractiveness of seed bio-priming lies in its ability to activate the seed's 'pre-germinative metabolism' without allowing the emergence of the radicle, by penetrating the seed coat. One of the most promising techniques involve soaking seeds in a solution containing carefully selected beneficial microorganisms, such as bacterial or fungi biocontrol agents, that can penetrate the seed coat, colonize the seed surface and finally establish in the plant's root system. These biocontrol agents, which include plant growth-promoting rhizobacteria (PGPR), work in synchronization with the plant to enhance its seedling growth and protect it from various biotic as well as abiotic stresses. The mode of action of these biocontrol agents includes mycoparasitism, competition for space and nutrients, production of antibiotics and secondary metabolites, and induction of defense responses, including systemic resistance responses in the plant. In addition, they enhance plant growth and increase crop yields (Harman et al., 2004). Bioinoculants suppress diseasesthrough mechanisms such as siderophore production, secretion of antimicrobial secondarymetabolite and lytic enzymes (Keswani et al., 2014). Currently, biological control is gaining larger attention due to its low-cost and its ecofriendly application. The use of biocontrol agents presents a promising alternative for improving seed quality, enhancing plant growth, and minimizing disease incidence.

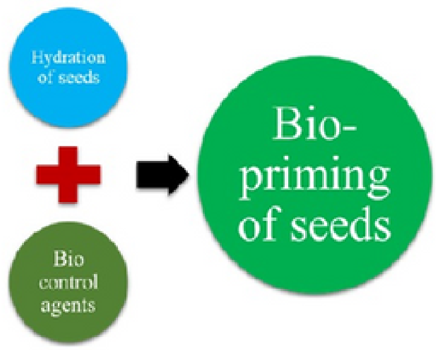

Fig. 1. Biopriming of seeds

Procedures involved in seed biopriming

Ø Selection of an appropriate Bio-inoculants - Beneficial microorganisms (bio-inoculants) are selected and cultured on suitable growth media

Ø Preparation of Suspension of Bio-Inoculants - The cultured bio-inoculants are transferred to a liquid medium to prepare a microbial suspension.

Ø Uniform Mixing of Bio-Inoculants The microbial suspension of bio-inoculants mixed uniformly to ensure even distribution of bio-inoculants

Ø Preparation of microbial Suspension with Different Concentrations - Seeds are soaked in microbial suspensions at different concentrations to determine the optimal treatment.

Ø Drying of Seeds to bring back original moisture content - After soaking, soaked solutions were drained out and the seeds are dried back to their original moisture content under controlled conditions.

Ø Kept for Germination or sowing and evaluation- The bioprimed seeds are placed in petri dishes or germination paper for germination tests to evaluate the effects of biopriming on seed quality and seedling growth.

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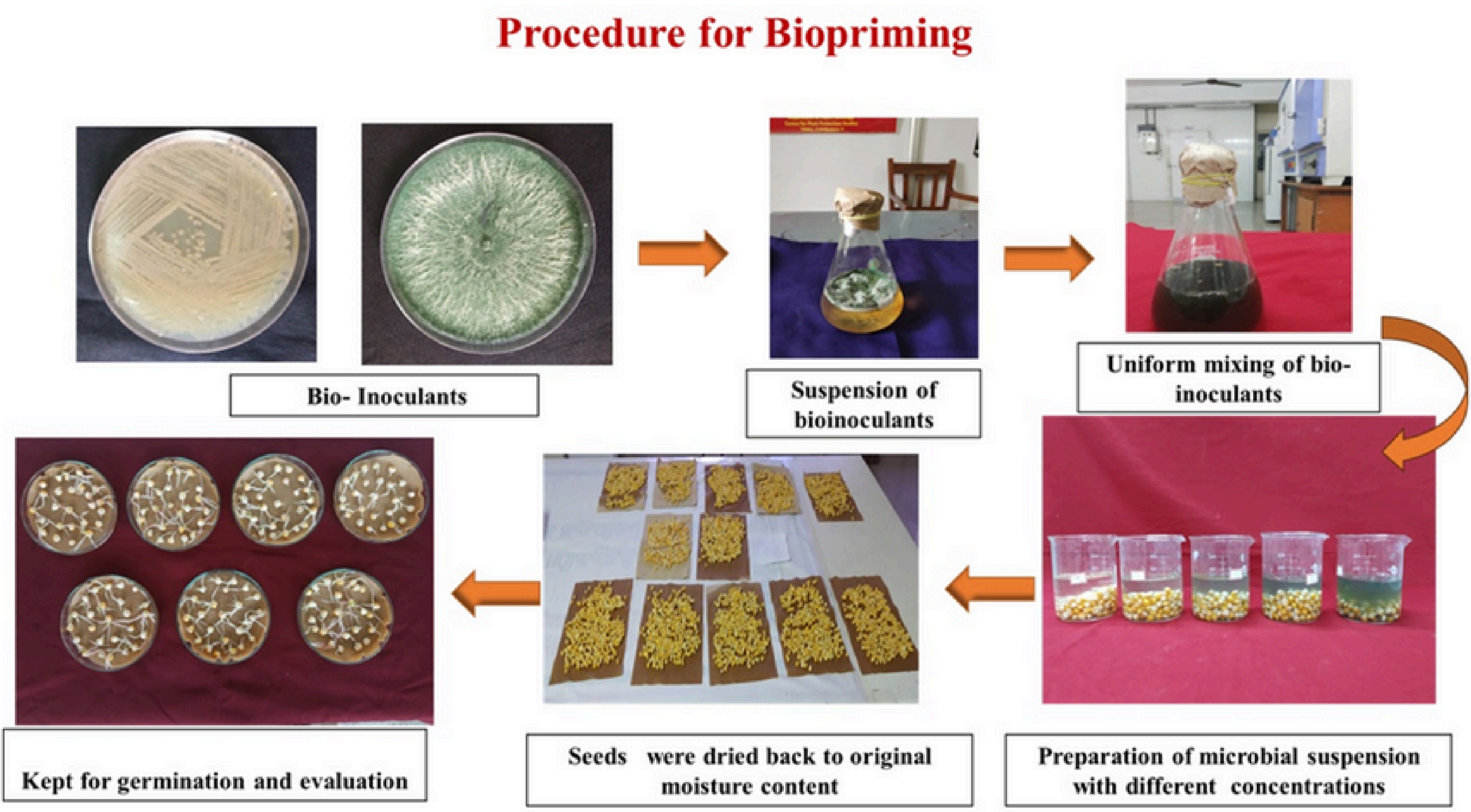

Fig. 2. Procedures involved in seed biopriming

Advantages of Bio-priming Over Other Techniques for Seed Priming

Bio-priming, like other priming techniques, increases the rate and uniformity of seed germination while simultaneously protecting seedlings from seed and soil-borne diseases. Hydration of pathogen-infected seeds during priming can accelerate pathogen growth, potentially reducing germination and seedling vigor. Nonetheless, incorporating biocontrol agents during priming offers a sustainable approach to managing seed-borne diseases (Reddy et al., 2013). Furthermore, certain bacteria that are employed as biocontrol agents can colonize the rhizosphere, promoting plant health both directly and indirectly beyond the germination stage (Callan et al., 1997). Compared to other methods like pelleting and film coating, seed biopriming has proven to be highly effective disease management strategy (Muller and Berg et al., 2008). While hydro priming, osmo-priming, hormo-priming, solid matrix priming, chemo-priming, and nutri-priming primarily targets abiotic stress, biopriming is effective in managing both biotic and abiotic stress. In the early stages of germination, bio-primed seeds outperform non-primed seeds due to their enhanced carbohydrate reserves, which support seedling survival under low oxygen stress in waterlogged conditions (Ella et al., 2011). Additionally, seed biopriming provides an environmentally beneficial alternative to chemical fungicides. As a result, biopriming is currently recognized as a highly effective biological strategy for sustainable agriculture.

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(Table .1) Bio-priming agents for enhancing biotic and abiotic stress tolerance in various crops

Sl.No	Crop	Bio-priming agents	Tolerance against	Reference
1	Rice	Bacillus amyloliquefaciens and Serratia marcescens	Magnaporthe oryzae	Amruta et al., (2019)
2	Soybean	Pseudomonas aeruginosa	Colletotrichum truncatum	Begum et al., (2010)
3	Garden pea	Bacillus velezensis, B. subtilis, B. mojavensis, B. amyloliquefaciens and B. halotolerans	Fusarium proliferatum and F. equiseti	Miljakovic et al., (2024)
4	Pearl millet	Pseudomonas fluorescens	Sclerospora graminicola	Raj et al., (2007)
5	Chilli	Trichoderma asperellum	Fusarium solani and Pythium ultimum	Chin et al., (2022)
6	Maize	Pseudomonas aeruginosa	Rhizoctonia solani	Singh et al., (2020)
7	Oil seed rape	Serratia plymuthica and Pseudomonas chlororaphis	Leptosphaeria maculans	Abuamsha et al., (2011)
8	French bean	Beauveria bassiana and Metarhizium anisopliae	Leaf miner insects	Akello et al., (2017)

Sl.No	Crop	Bio-priming agents	Tolerance against	Reference
9	Mungbean	Pseudomonas fluorescens and Trichoderma viride	Whitefly and Aphid	Dhar et al., (2020)
10	Mungbean	Mixture strains of Pseudomonas fluorescens + Rhizobium phaseoli	Drought stress	Nawaz et al., (2021)
11	Squash	Trichoderma harzianum and Bacillus subtilis	Salt stress	Tarchoun et al., (2024)
12	Cumin	Pseudomonas fluorescence	Drought stress	Piri et al., (2019)
13	Maize	Trichoderma harzianum	Cold stress	Afrouz et al., (2023)
14	Wheat	Trichoderma harzianum	Drought stress	Shukla et al., (2014)
15	Wheat and mungbean	Trichoderma hamatum and Paecilomyces lilacinus	Salt stress	Irshad et al., (2023)

Conclusion

Seed bio-priming is highly innovative technique that not only improves seed germination and seedling vigour but also helps plants overcome both biotic and abiotic stresses.A variety of bacterial or fungal bioagents, such as biopesticides or biofertilizers, may be effective as biopriming agents. Seed bio-priming offers benefits across agricultural, horticultural, and forestry crops. As a sustainable practice, it plays a vital role in boosting crop yields, minimize dependency on chemical inputs, and enhance food security. With the growing challenges of climate change and the increasing global population, continued research and development of seed bio-priming techniques will be essential for ensuring resilient and sustainable agricultural systems.

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