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Seed Biopriming- An Integrated Stress Management Strategy

Balasanthosh K.[1*] and Priyanka S.[2]

[1]Faculty of Agriculture, Annamalai University, Chidambaram-608 002.

[2] Faculty of Agriculture, Annamalai University, Chidambaram-608 002.

*Corresponding Author: balasanthosh2001@gmail.com

Abstract

Exposure of crops to stress is the most significant barrier to agricultural output and food security worldwide. Stress induces changes in plants' physiological functions, which leads to lower plant growth and agricultural yield. Plants undergo a variety of molecular, cellular, and physiological changes to combat various abiotic stresses. Plants suffer from increased osmotic pressure outside the root due to osmotic stresses like drought or salt stress that ultimately result in reduced water availability to plant roots. In addition to morphological modifications, physiological changes such as lower leaf osmotic potential, accumulation of Osmo protectants, increased antioxidant activities, and so on occur in response to such abiotic stresses. Seed priming is a novel yet simple technique that involves the use of beneficial and eco-friendly biological agents to improve the physiological functioning of seeds. This technique also plays a vital role in restoring agro-ecological balances through the improvement of soil fertility or by decreasing soil and water contamination. An understanding of the mechanisms involved in seed bio-priming with plant growth-promoting microbes is very crucial to efficiently utilise this technique towards agricultural sustainability. It is generally thought that the advancement of metabolic processes along with activation of repairing systems during the pre-germination stage are the central reasons behind growth promotion and acquired stress tolerance. The application of plant growth-promoting rhizobacteria in agriculture has been emerging to improve stress resilience. Bio-priming of seeds ensures early protein and DNA synthesis, and also helps in effective mitochondrial development. This review aims to summarise the current state of understanding of the mechanisms involved in this eco-friendly technique. (1)

Introduction

The latest advancement in seed treatment, known as "bio-priming," combines physiological (hydrating the seed) and biological (covering it with beneficial microorganisms) elements to prevent illness. By undergoing a number of structural, physiological, and biochemical changes within the plants, seed priming with advantageous microorganisms or biocontrol agents increases the availability of nutrients to the plants and induces systemic resistance against biotic and abiotic stresses in various ecological conditions. These microorganisms encompass a variety of bacterial and fungal agents that encourage plant development (2).

What is Biopriming and Its Importance?

This method involves hydrating seeds and treating them with a biocontrol agent, which is a beneficial bacteria or fungus. Bio-priming has lately been used as an alternate strategy for managing various seed-borne and soil-borne diseases. At moderate (23 °C) and humid circumstances, seeds are moistened followed by inoculation with a bio-control agent, which can be either beneficial bacteria or fungi, for approximately 20 hours. once then, seeds are harvested before roots form. Seed biopriming is a standard technique for getting a large population of beneficial micro-organisms into the soil, where biopriming can colonise the developing roots of crops. This method has been used effectively in the field for decades and produces better or comparable results to traditional harmful fungicides. Seed biopriming with microorganisms improves plant growth and development by regulating a variety of biochemical and physiological activities and providing plants with stress tolerance and resistance mechanisms. Biopriming is used to activate certain signalling pathways in the earlier stages of plant phenology, resulting in more rapid plant protection mechanisms. After infection, a second signalling pathway is initiated, which eventually leads to an increase in signal transduction. This results in a rapid and significant enhancement of the protective mechanisms that are already present. Also, seed biopriming has many benefits against chemical treatments, which include having economically viable, quick, sustainable, while offering beneficial features for primed seeds (3). This technology also allows farmers to maximum productivity with minimal resources, improving their economic position and helping to alleviate the global food crisis. Further studies on seed biopriming technology should be conducted and cantered on producing of microbial solutions that are more tailored to specific environmental circumstances. (4)

Priming agents (bio-agents)

Recruitment of primers is a key step in biological seed enhancements as the growth-promoting abilities of the priming agents are highly specific to certain species, cultivars, or genotypes of crops. Further, the success rate is mostly higher with the selection of indigenous microbes so as to avoid competition or antagonistic interaction. The eligible candidates used in seed treatment are mostly species of fungi and bacteria including Trichoderma, Pseudomonas, Bacillus, Glomus, Azospirillum, Azotobacter, Agrobacterium, Rhizobium, etc. Broadly, their relationship to the host may be classified into two types, viz., rhizospheric and endophytic. Rhizospheric microbes colonize the rhizosphere and rhizoplane (root surface), but the endophytes are able to colonize the inner tissues of plant parts. Therefore, It need to explore the competent seed endophytes that can establish beneficial plant-microbe associations (symbioses) by colonizing plant parts efficaciously and stimulating the physiological system of plants. Bacteria inhabiting the root zone and stimulating the growth and productivity of crops through different mechanisms are termed as plant growth-promoting rhizobacteria (PGPR). (5)

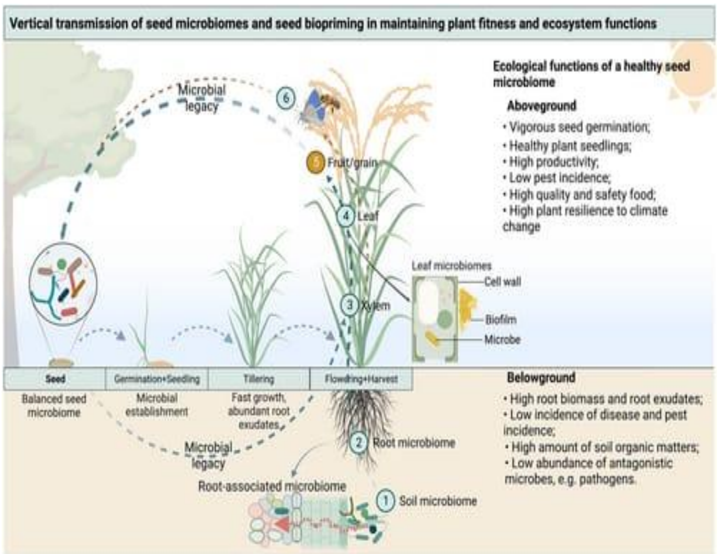

Fig.1 Vertical Transmission of Seed Microbiomes and Seed Biopriming (7)

Such group of microbes is screened from the soil on the basis of plant growth-promoting (PGP) traits such as nitrogen (N2) fixation, phytohormone production, phosphorus (P) solubilization, siderophore production, antifungal activity, 1-aminocyclopropane-1-carboxylate (ACC) deaminase and other enzyme activities, and production of other organic compounds. However, the efficacy of seed treatment is higher besides its low requirement of microbial doses or biomass. (6)

Biopriming as an approach to enhance nutrient use efficiency:

Biopriming is a potential approach involving plant growth-promoting bacteria (PGPB). It is not only effective in dealing with pathogens but also substantially improves the nutrient uptake efficiency after treatment. The process improves plant growth and establishment by releasing compounds involved in mineral solubilization. Most of the fertilizers added to the soil are not available to the plant as there are either run-off or leaching losses. This results in poor nutrient uptake and low nutrient use efficiency (8). To achieve this, microorganisms have a very important role to enhance nutrient mobilization and their uptake. For instance, phosphate solubilizing microorganisms such as Enterobacter, Bacillus and Pseudomonas release crystal dissolving compounds and phosphate-solubilizing enzymes that make phosphorus available to the plants. (9)

Role of Biopriming in Resistance Against Abiotic Stresses

Biopriming used two strains including *A. brasilense* and *B. amyloliquefaciens* and observed that biopriming with these strains increased drought tolerance in wheat plants through upregulation of genes related to stress. Role of biopriming has been studied in various crops using different PGPR as compiled in Table 1.

Role of Biopriming in Resistant Against Biotic Stresses

Biopriming has been applied in various crops for the biocontrol of several diseases (Table 2). Abuamsha, Salman and Ehlers applied *Serratia plymuthica* and *P. chlororaphis* to the different oilseed rape cultivars for the control of a pathogen *Leptosphaeria maculans* causing blackleg disease, and it was observed that disease extent was reduced up to 71.6% by *S. plymuthica* and 54% by *P. chlororaphis*(13). Seed biopriming gave the highest control over *Verticillium longisporum* as compared to coating the bacteria on the seeds. Biopriming has been reported to control damping-off disease in various crops such as cucumber, maize, pea and soybeans (14). Similarly, different biocontrol agents were applied to the seeds through biopriming, and better biocontrol was observed in radish, carrot, sweet corn and pearl millet. (15)

Conclusion

Improved quality of seed is an important component in the sustainability of crop production under changing climate. Adoption of environment-friendly strategies such as biopriming is required not only to reduce the input costs or load on natural resources rather ensures sustainable food production. Farmers should be encouraged to adopt this technology since it can improve soil quality, promote crop growth, provide better protection against various abiotic stresses and also increase yield without causing any environmental or health risks. Biopriming with plant-beneficial fungus and bacteria or with other organic chemicals can significantly improve seed germination and emergence, seedling establishment, crop development, and yield parameters under both normal as well as stressful circumstances. Various microbial strains have been reported to reduce the negative effects of abiotic stress by generating a different of metabolites such as phytohormones, exopolysaccharides, volatile organic chemicals, siderophores or antioxidative enzymes, and thereby improve plant's stress response that results in enhanced crop productivity even under extreme environmental conditions. The use of plant growth-promoting microorganisms in seed priming is an effective technique that is thought to be a key component of an integrated stress management strategy.

Therefore, an integration of seed biopriming and stress-memory-related research is essential as a way forward for improving priming mediated agricultural productivity worldwide. (16)

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Table 1. Role of biopriming in abiotic stress tolerance

Strains under study	Mechanism of action	Crop	Role in stress tolerance	PGP activities
Bacillus pumilus, B. furmus	ACC-deaminase activity, IAA production, phosphate solubilisation.	Potato	Salinity, drought, heavy metal stress tolerance	Increase in plant height, No. of leaves plant^{-1}, No. of tubers plant^{-1}. (10)
Bacillus cereus	Phosphate solubilization, IAA, catalase, protease, chitinase Production	Rice, mungbean, chickpea	Salinity tolerance	Increase in seedling height, number and length of leaves, root and shoot biomass (11)
Agrobacterium rubi, Burkholderia gladii, P. putida, B. subtilis, B. megaterium	–	Radish	Improved seed germination under saline conditions	Increase in seed germination (12)

Table 2. Role of biopriming in biotic stress tolerance

Strains under study	Crop	Role in stress tolerance
Trichoderma harzianum	Maize	*Fusarium verticillioides* and fumonisins tolerance
Pseudomonas fluorescens	Sunflower	*Alternaria blight* tolerance
Clonostachys rosea	Carrot	*Alternaria dauci* and *Al. radicina* tolerance
Pseudomonas fluorescens	Pearl millet	Downy mildew tolerance
Pseudomonas aureofaciens	Sweet corn	*Pythium ultimum* tolerance
Pseudomonas fluorescens	Sweet corn	Damping-off tolerance

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