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MICROBIAL TECHNOLOGY FOR SEED BIO-ENHANCEMENT IN STRESS CONDITION: AN ECO-FRIENDLY METHOD FOR CROP IMPROVEMENT IN SUSTAINABLE AGRICULTURE

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Since the 18th century, soil helpful microorganisms, also known as plant growth-boosting rhizobacteria, have been widely employed in the agricultural ecosystem. The term was coined by Kloepper and Schroth and also who also explored their role in soil and plant growth development (Kloepper and Schroth 1978). Crop seed is an important component of agricultural production, and seed has a high value in India and other countries where agriculture is a major source of employment and GDP (Tyagi 2012). Some seed-borne diseases, biotic and abiotic stress and climate change all contribute to crop yield destruction. As a result, the most recent method employs a seed pre-treatment technique that is environmentally friendly, cost-effective, and requires less land to yield more crops (Sanjeev 2012; Reddy 2013). The soil and water ecosystems are harmed by chemical priming or seed pre-treatment with chemicals. Furthermore, this procedure is expensive and hazardous to both plants and humans (Rahman et al. 2018). Due to the limitations of chemical seed priming, researchers created a soil beneficial microbe priming technique that ensures long-term production by increasing germination, seedling emergence, and early seedling development features (Forsberg et al. 2003). Treating seed with rhizospheric microbes mitigate biotic and abiotic stresses and also amplify the efficacy of different biological agents present in soil (Mastouri et al. 2010). Microbial population helps to proliferate crop plant growth by increased nutrient uptake, biological control to different biotic stress as well as production of different plant growth regulators (Glick 2003; Saravanakumar et al. 2008; Dobbelaere et al. 2003). Thus, agroindustry is investigating the method of organic farming or seed priming (Dey et al. 2004) which could release different plant growth regulators, enhance symbiotic or asymbiotic nitrogen fixation, solubilizing phosphorus, and other element required for plant growth. Bacterial priming promotes iron absorption via chelation by generating siderophores and increases ACC deaminase, which decreases ethylene levels, resulting in increased root and plant development (Banerjee and Yesmin 2002; Dobbelaere et al. 2003; Glick and Pasternak 2003).

Agricultural technology with microorganisms is now working to disrupt traditional farming techniques by increasing yield or productivity while also protecting our agro ecology.

Bio Priming Featured by Microbes as One of the Recent Practices in Agro Ecosystem

Plant growth-promoting bacteria (PGPB) or plant growth-promoting rhizobacteria are microbes that are associated with the root rhizosphere and soil and are involved in improved crop production, increased yield, disease resistance, improved soil structure, bioremediation of contaminated soil, and so on (Zaidi et al. 2006). Treating plant seeds with an osmotic solution containing plant growth-promoting rhizobacteria is a cost-effective and environmentally friendly application strategy (O'Callagham 2016).

Rhizospheric bacteria are an important element of the biogeochemical cycle because they develop symbiotic relationships with plants and act as free-living plant growth promoters (e.g. *Azospyrillum, Azotobactor, Providencia, Bacillus, Pseudomonas,* etc.) (Vessey 2003; Gray and Smith 2005). These bacteria also can apply via seed bio priming that enhances crops stress tolerance and increases plant growth (Dimkpa et al. 2009), increases water uptake capacity, and improves sugar and proline content in seedling conditions (Yan 2015) by enhancing metabolism (Farooq et al. 2006).*Azospyrillum*, a common plant growth-promoting bacteria found in a wide range of environments, has a significant impact on crop production and nitrogen production (Steenhoudt and Van-derleyden 2000). They also boost the rate of adventitious root formation and root elongation in crops (Fallik et al. 1994). *Azospyrillum* inoculated crop seed shown to exert a beneficial effect on plant- water relationship, mineral uptake, and root growth (Dobbelaere et al. 2001). Many studies have found that inoculating seed with live *Azospyrilum* has a substantial effect on reducing abiotic stress in agricultural plants. When subjected to waterlogging conditions, for example, maize and winter wheat seed primed with *Azosprillum* inoculum can considerably reduce water stress compared to control or nonprimed seed. (Casanovas et al. 2002).

Bio priming with *Pseudomonas fluorescens* inoculum stimulates plant growth and is tolerant against downy mildew in pearl millet (Raj et al. 2004). Germination rate is increased by priming with rhizobacteria in radish under saline stress (Kaymak et al. 2009). Maize is a major cereal crop that is afflicted by Fusarium, which causes ear rot and destroys 20% of grain storage. Fusarium in maize can be controlled by seed priming with *Trichoderma harzianum*. *Trichoderma* in a formulation of 1×10^8 spore/ml and 10 g/kg of seed is effective in treating maize ear rot and stimulating plant development by boosting germination percentage, yield, and vigor index, among other things (Nayaka et al. 2008). Priming with *Stenotrophomonas maltophila* present in the root rhizosphere of *Sorghum bicolor* significantly affected the wheat plant by ameliorating the salt stress and stimulate defense response against the *Fusarium sp*. (Singh and Jha 2017). Many studies suggested that the co-application of different microbes may also activate new plant growth promoters those also linked with soil prolificacy (Stringlis et al. 2018). To maintain soil fertility, biofertilizers might be employed as a complement to the pre-showing treatment of crops with plant growth-stimulating bacteria, either alone or in consortia.

Cross Protection for Alleviation of Stress in Bacterial Primed Seed

Plant-associated microbes have unique characteristics that help them deal with the negative effects of stress. Abiotic stress can also be reduced by microorganisms that induce systemic tolerance (IST) and influence physiological and biochemical changes. (Yang et al. 2009). Endogenous glycine and betaine synthesis have risen under water deficit conditions as a result of bio priming, and the plant is now protected from water stress, chilling, and salt stress. During abiotic stress, however, the upregulation of

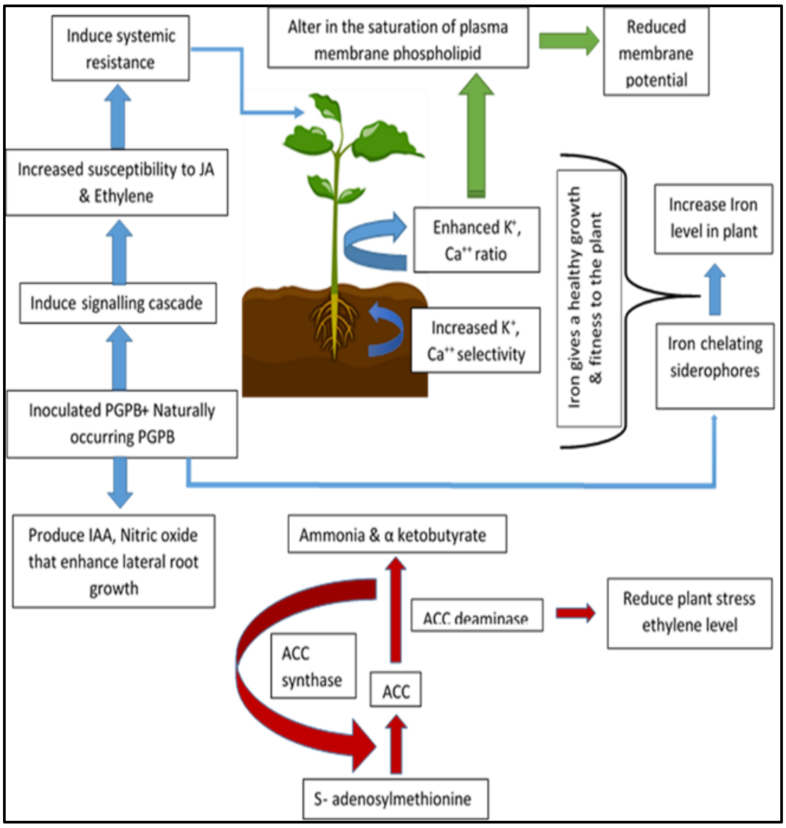

Fig1: Mechanism for alleviating biotic and abiotic stress in bio primed seed

superoxide dismutase (SODs) or the upregulation of other antioxidative enzymes causes a systemic reaction (Gratao et al. 2005). Several major studies have been conducted to elucidate the positive effect of inoculation or seed priming in overcoming various biotic and abiotic stresses. (Mayak et al. 2004a; Grichko and Glick 2001; Egamberdiyeva 2007). Inoculation of those microbes develops an induced systemic resistance which accelerates the resistance against the pathogen (Walters and Fountaine 2009). Some researcher showed that beta-glucuronidase have shown that the osmotin promoter low molecular weight proteins that assemble under salinity stress condition is very sensitive to ABA (Abscisic acid) and some other phytohormones also protect the plants against a pathogenic effect, physical effect, etc (Liu et al. 1995). This osmotin is also synthesized at the translation and posttranslational level (La et al. 1992) (Fig1).

Plants under stress conditions stimulate endogenous ethylene production which positively affects the plant vigor as well as all overgrowth of the plant (Jackson 1985). The biomolecule ACC is a precursor of ethylene production which is cleaved by the ACC deaminase (Saleem et al. 2007; Wang et al. 2001). Bacteria used for priming increase the level of ROS (Reactive Oxygen Species) scavenging antioxidant and upregulated the gene engage with this enzymatic synthesis. PGPB (Plant growth-promoting bacteria) significantly produced some phytohormones such as gibberellic acid, IAA, auxin, etc. which trigger plant root development also amplify shoot growth as well as increasing biomass of crop plants to alleviate abiotic and biotic stress conditions (Patten and Glick 2002). Bacteria generate exopolysaccharides, which are mostly made of humic substances and aid in soil aggregation, soil porosity, and plant root proximity under abiotic stress, particularly water stress. PGPB also helps the plant to nutrient uptake from unhealthy soil where micronutrients (such as potassium, zinc, copper, phosphorus, etc.) are not available due to fixation by increasing root adhering tissue and soil ratio (Oades and Waters 1991). This issue can also be caused by salinity stress. Increased salinity reduces the availability of nutrients in the soil ecosystem, but growth-promoting bacteria can aid by solubilizing nutrients from organic matter or allelopathic substances, as well as making the insoluble form of nutrients available to plants. (Richardson et al. 2009).Gene expression has also looked at the positive effects of stress on their environmental situation. According to certain studies, inoculation with Paenibacillus polymixa B2 in Arabidopsis thaliana increased drought stress tolerance in plants (Wang et al. 2009).

Conclusion and Future Scope of Research

Microbial technologies can give greater protection against many soil-borne diseases, therefore farmers should be encouraged to use this technology, which can improve soil health, increase yield, and raise agricultural plant development without posing any environmental or health risks. It might be a non-chemical or non-hazardous alternative to chemical priming. More study on the survivability, presence, mode of mechanism, and gene expression on the primed seed of plant growth-promoting microorganisms is urgently needed. Genetic modification of those rhizospheric bacteria investigated on seed for global food need and to safeguard the agro-ecosystem must also be changed in next-generation research. Under biotic and abiotic stress, these microorganisms function as a biostimulant for plant growth, nutrient absorption, and increased production. This article discusses about microbial technology for crop development to promote sustainable agriculture by minimizing the use of pesticides and chemical fertilizers at high rates. These priming technologies are becoming increasingly viable, low-cost, and simple ways to combat stress and soil-water pollution in underdeveloped countries

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