

Enhancement of growth attributes of *Cajanus cajan* by the synergistic action of bioinoculants

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Abstract

The swift pace of urbanization and industrialization has subjected the ecosystem to harmful consequences encompassing the degradation of water, soil, air, and biodiversity. To address this issue, a greater emphasis has been placed on sustainable agriculture. The application of bioinoculants is one of the various methods employed for sustainable agriculture, owing to their environment friendly characteristics. However, despite the numerous advantages associated with the use of plant growth promoting rhizobacteria (PGPR) as bioinoculants, there are limitations like reduced efficacy and persistence under field conditions. This is due to limited knowledge of the interactions of these microorganisms as members of the consortium, and with the native microflora, especially under real-time environmental conditions.

The present study focused on the characterization of three bacterial strains for their plant growth promoting (PGP) properties, individually and as multiple inoculants (dual and triple). This study compared their efficacy on fitness of *Cajanus cajan* (pigeonpea) under controlled and natural conditions. After establishing the synergistic impact of these bacterial strains on plant growth, the mechanism of synergism was studied by assessing the metabolome of the bacterial strains (individually and in different combinations) using High Resolution Liquid Chromatograph Mass Spectrometer and PGP attributes of bioinoculants were quantitatively determined. To enhance the shelf life of bioinoculants, solid and liquid bioformulations were developed after carrying out optimization studies for different additives, using Response Surface Methodology. Based on the better performance of liquid bioformulation, a pot experiment was conducted to study the impact of the formulation on plant growth, soil nutrient status, the resident bacterial community diversity, and markers of the phosphorus cycle.

The present work concluded that the strategic development of a consortium with three bioinoculant strains led to the synergistic enhancement of growth attributes in *C. cajan*. An efficient method for simultaneous monitoring of bacterial bioinoculant strains was devised to track their persistence during plant growth. The developed bioformulation exhibited a shelf life of six months and was found to be more stable at lower temperatures. The consortium also exhibited significant impacts on soil health by positively enhancing the soil nutrient status and bacterial diversity.

The study established a triple-membered bacterial consortium for enhancing growth and yield attributes of an economically important crop, *Cajanus cajan*. It reflected upon the plausible mechanism of synergism between bioinoculant strains used as a consortium. Further, to take the consortium into the application, stable bioformulations were developed. Finally, the positive impact of the application of the bioformulation was assessed in a holistic manner on plant and soil health. It, therefore, puts forth the systematic and sequential process of development of a robust and efficient bioformulation for ushering in agricultural sustainability.