

# Harnessing the Potential of Plant Probiotics for Sustainable Agriculture

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## Abstract

Plant probiotics, beneficial bacteria, play a crucial role in enhancing plant growth, improving yield, and elevating the quality of vegetable produce. These microorganisms aid in nutrient absorption, water retention, and supplement uptake from the soil, thereby promoting soil fertility and augmenting crop productivity. Compared to chemical fertilizers, plant probiotics offer a nature-friendly alternative, fostering sustainable agricultural practices. Key probiotic strains such as *Bifidobacterium longum* subsp., *Lactobacillus*, and *Pseudomonas* have been extensively studied for their efficacy in promoting plant growth and fitness. Notably, research has identified *Streptomyces* strains capable of enhancing plant growth and resistance to infections, showcasing their potential as biofertilizers. Furthermore, investigations into seed-borne bacterial flora in rice varieties have revealed their role in seedling colonization, nitrogen fixation, and antagonism against fungal infections. Endophytic bacteria like *Acinobacter* and *Enterobacter* contribute to plant growth throughout various growth stages, from germination to reproductive phases. As agriculture faces challenges from urbanization and climate change, the significance of plant probiotics in mitigating plant stress and improving resilience is increasingly recognized. Plant growth-promoting bacteria exemplify the potential of plant probiotics to enhance soil health, nutrient acquisition, and plant defence mechanisms. The integration of probiotics into agricultural practices not only enhances productivity but also reduces reliance on chemical inputs, promoting environmental sustainability. Future research is expected to further elucidate the mechanisms underlying the beneficial effects of plant probiotics and their potential applications in sustainable agriculture.

**Keywords:** Plant probiotics, Agricultural sustainability, Crop productivity, Soil health, Microbial biofertilizers

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## Introduction

“Probiotics are live microorganisms that, once administered in adequate amounts, Confer a health impact on the host.” each the Food and of the eubacterium (e.g., together with however not restricted to strains of the subsequent species: *Eubacterium rhamnosus*, *Eubacterium acidophilus*, *Eubacterium plantarum*, *Eubacterium*

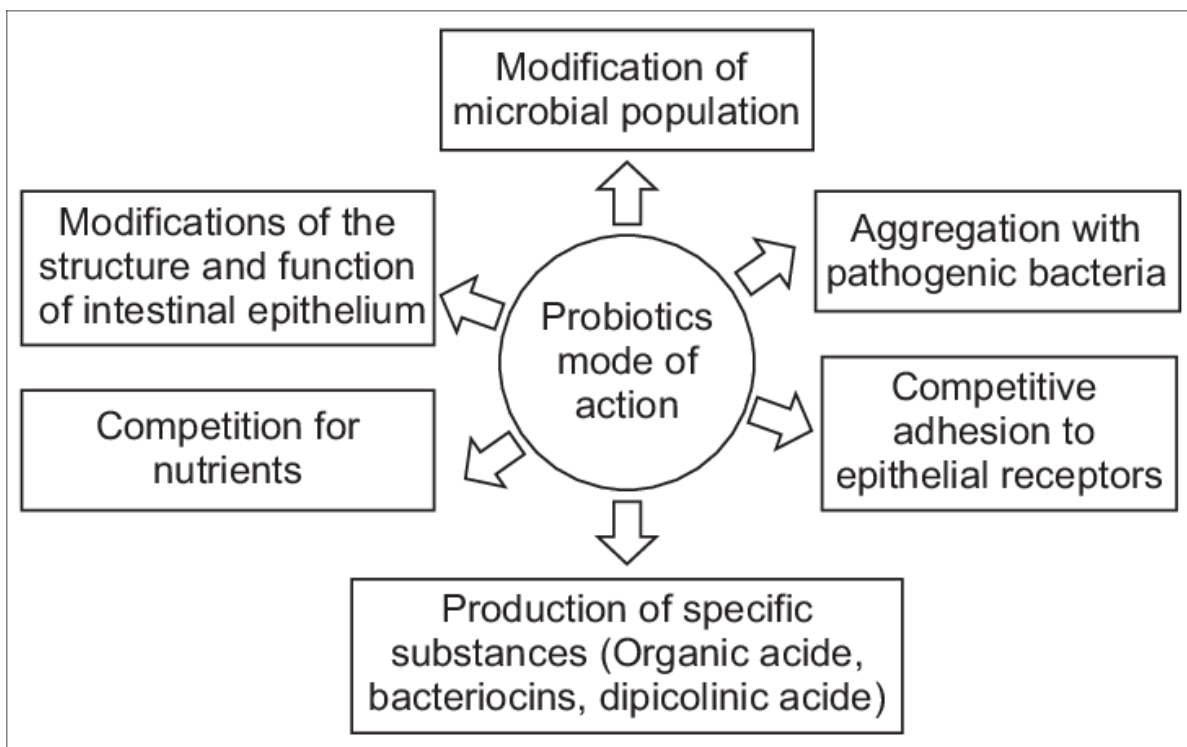
*casei*, and *Eubacterium delbrueckii* subsp. *Bulgaricus*) and *Bifidobacterium* genera (e.g., *Bifidobacterium infantis*, *Bifidobacterium animalis* subsp. *lactis*, and *Bifidobacterium longum*). Also, strains from different microorganism species (e.g., *Propionibacterium acidilactici*, *Lactococcus lactis*, *Leuconostoc mesenteroides*, *Bacillus subtilis*, *Enterococcus faecium*, true bacteria *Thermophilus*, and *Enterics coli*) and sure yeasts

(e.g., genus *Saccharomyces boulardii*) qualify as probiotics [Fijan et al,2014]. With increasing data regarding the essential role of gut microbiome within the human health, the gut microbiome is currently thought-about a vital ally, interacting with most Human cells [Cani et al,2018]. Probiotics have a large vary of applications in poultry, livestock, cultivation, and conjointly in humans for the interference and treatment of disorders, ailments and infectious and non-infectious diseases (e.g., microorganism infectious agent, parasitic, or flora diseases, systema nervosum disorders, obesity, cancer, and allergic problems), in addition as surgical and operative processes. Nowadays, probiotics are associate degree inevitable a part of human nutrition with elevated consumption levels through naturally and microbially soured merchandise with huge amounts of viable useful microbes, like soured animal merchandise, soured fruits and their juices, and varied different food merchandise [Fijan et

al,2014]. Stress, in spite of its origin (physical, mental, or Social), activates the hypothalamic-pituitary-adrenal (HPA) axis [Nicolaidis et al,2014].

### Activity of plant probiotic

Plant probiotics are mainly used to increase pathogens resistances [York et al,2018]. Probiotics improve yields by reducing and eliminating chemical fertilizers [Menendez et al,2017]. There is various type of information about the mechanisms in action of probiotics [Lebeer et al,2008., Siezen et al,2010., Carro et al,2017., Ghattargi et al,2018] (Figure: -1) some types of mechanisms that sometimes overlap relate to both the direct effects and the effects of probiotics' metabolites consumers' demand for high-quality grown functional food has increased [Lingua et al, 2013]



**Figure 1** Mechanism of action of probiotics

This is true for products such as fruits, and vegetables etc. A large proportion of which are consumed fresh. Therefore, methods of promoting plant growth for agricultural sustainability are being studied worldwide [Rahman et al,2018] It is known that plant nutrition and secondary metabolic pathways can be affected by beneficial microorganisms [Lingua et al,2013., Ali et al ,2011. Thakur et al,2019] It should be noted that dry weight of secondary production is less than 1% [Oksman-Caldentey et al,2004]. Some data are in agreement with the results study's others plant probiotic bacteria on strawberry growth and yield [Esitken,et al,2010., Rahman et al , 2018., Bona et al , 2015,Flores-Félix et al 2015, Pırlak et al.,2009., Mukta et al,2017]. The weight of the tested strawberry fruits was lower than the same variety grown under intensive cultivation conditions. It's consistent with other studies where strawberry crops reduced under fertilization [Bona et al, 2015].

### **Probiotics and Food Products**

The vary of food merchandise containing probiotic strains is wide and still growing. the most merchandise existing within the market square measure dairy-based ones as well as hard milks, cheese, ice cream, buttermilk, dried milk, and yogurts, the latter accounting for the most important share of sales [Stanton et al,2001]. Non-dairy food applications embody soy based mostly merchandise, nutrition bars, cereals, and a spread of juices as applicable means that of probiotic delivery to the buyer [Ewe et al,2010, Sheehan et al,2007]. The factors that has to be self-addressed in evaluating the effectiveness of the incorporation of the probiotic strains into such merchandise square measure, besides safety, the compatibility of the merchandise with the organism and therefore the maintenance of its viability through food process, packaging, and storage conditions. The product's pH for example may be an important issue determinative the incorporated probiotic's

survival and growth, and this can be one in all the explanations why soft cheeses appear to own variety of benefits over yogurt as delivery systems for viable probiotics to the digestive tube [Medina et al,1994., Gardiner et al,1998., Kehagias et al,2006]. Current technological innovations give ways that to beat probiotic stability and viability problems giving new choices for his or her incorporation in new media and ulterior satisfaction of the increasing shopper demand. Microencapsulation technologies are developed to safeguard the microorganism from injury caused by external atmosphere. By the introduction of a straw delivery system containing a dry sort of the probiotic microorganism liquid makers will currently give it to the buyer. additionally, viable reproductive structures of a spore forming probiotic square measure obtainable within the market giving benefits throughout process. within the same time, the potential of antibiotics'—substances with antimicrobial properties—production by bifidobacterial is being explored so as to be applied within the food space [Pszczola et al,2012., O'Sullivan et al,2012]

### **Application of Plant Probiotics**

Plant probiotic can be formed a single microbial culture or consortium of more than one beneficial microbe with plant growth-promoting potential. Plant growth-promoting rhizobacteria (PGPR) are well established and studied in agricultural microbiology and plant pathology. Its different aspects like ability of colonization and survival in plant rhizosphere, nature of the compound produced and involved in plant growth promotion, competition with natural microbial population, packing and formulation, survival during storage and transportation, etc was done by the immense amount of work (Herrmann and Lesueur et al, 2013).

Many industries have been involved in production, marketing and dissemination of microbe-based fertilizers or growth enhancers at both large and

small scales. In such conditions, the expense of biofertilizers with the risk and responses will be weighed with those of chemical fertilizers, and promotion of technology for environmental reasons (Willer et al, 2011).

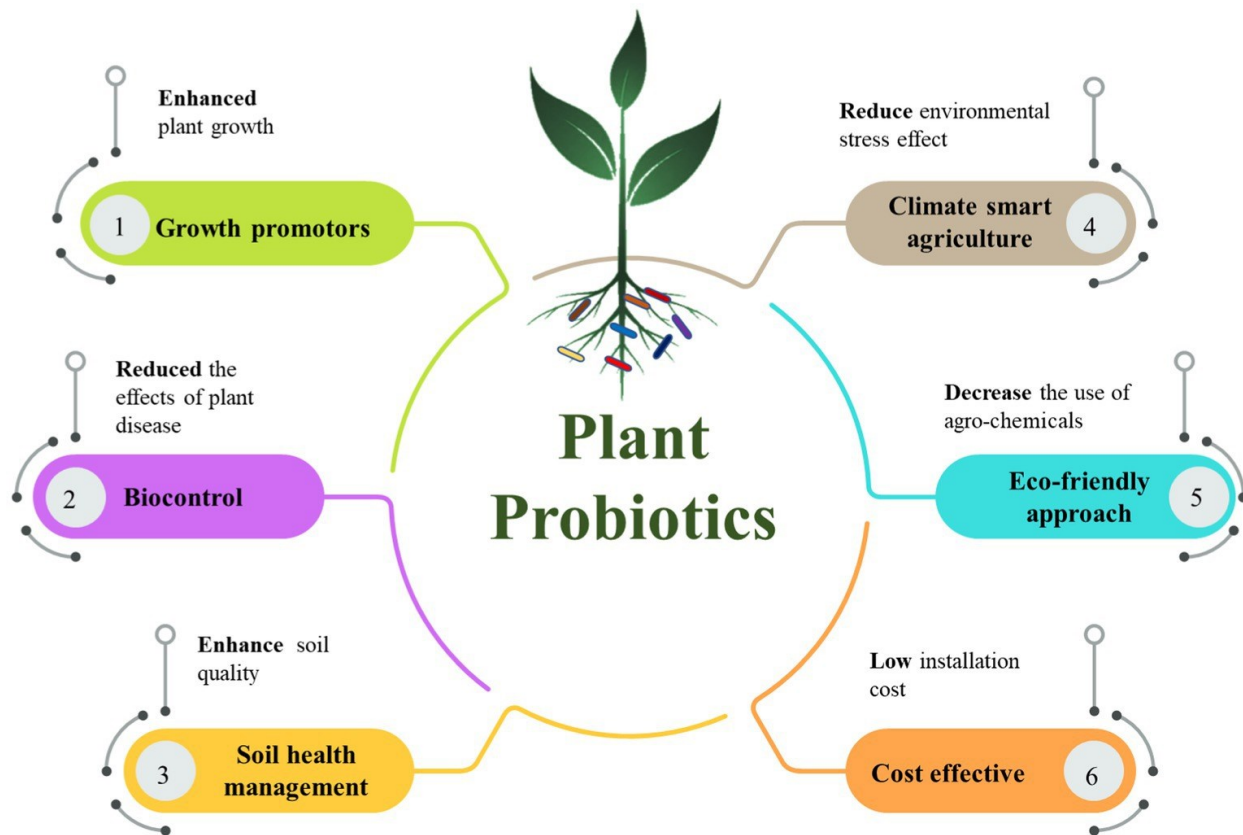
Application of plant probiotics, may be increase crop production, chemical fertilizers and pesticides and, moreover, allowing the obtention of better-quality products. (Garcia et al, 2012., Flores-Felix et al,2015) Plant probiotics were used for plant health, growth and better productivity with an environmental-friendly alternative of chemical fertilizers which maintain soil health and promote the concept of organic farming. we are mainly focusing on the issues associated with problems related to formulations and applications of plant probiotic.

## Review of Literature

Plant probiotics are such a good bacterium which are helps to grow the plant including yield also increase the vegetable food quality. Plant probiotics are helping the plants to absorb nutrients, water and additional supplement from soil. Plant probiotics are not just help in plant growth they also increase soil fertility and helps improve crops productivity. Plant probiotics are nature friendly than chemical fertilizers. Some good plant probiotics are *Bifidobacterium longum* sub sp, *Lactobacillus*, *Pseudomonas* etc. Lots of work had been done on this topic. Investigation are done that there is a sequenced of *Streptomyces* strains that can promote the growth of a plant and increase the fitness. This is established that infection of root assays in any types of seeds were actually coated with suspension of pregerminated *Streptomyces* spores. The strains are tagging with enhanced green fluorescent protein (eGFP) and the resistance of apramycin (Sarah F Worsley et al. *Appl Environ Microbiol*. 2020.) There are many seeds those carry endophytes, as a result it is a good source of seedling colonization. So here we

actually want to describe about seed borne bacterial flora in different rice varieties that are cultivated in the Argentina (northeast). After Microbiological and other molecular characterization of a set it was isolated that from the CT6919 seeds plays an important role as seed-borne mesophiles and also as a plant probiotic, involved diazotrophy and also antagonism of fungal infections. So, the seed-borne bacterial flora which is protected against *Curvularia* sp Infection for the rice seedlings. There is the root colonizing pattern of 2 *Pantoea* was isolated from the seeds that was inoculated axenic rice seedlings and which was actually studied by fluorescence microscopy. According to the description we can suggest that by bacterial species rice plants are allow grain that they can may act as natural fertilizer or biofertilizers early from seed germination (Dante Ruiz et al. *J Microbiol*. 2011 Dec.) There are so many endophytes like acinobacter, enterobacter that are help plant growth at germination, seedlings and in reproductive stage (Snygdha Rani Das et al. *Arch Microbiol*. 2022). Working on the plant probiotics researchers are expected that plant probiotics will gain much more attention in the coming years. Because in this era agriculture productivity is rapidly decreased because urbanisation, climate change etc. So, in that situation plant probiotics will helps to reduce plant stress, saline stress, for better growth. Plant probiotics are microorganisms or group of microorganisms which by virtue of their potential role in improved nutrient acquisition and/or biocontrol activities can promote soil health, plant growth and enhance plant tolerance or immunity against various abiotic and biotic stresses. Plant growth-promoting bacteria (PGPBs) are good examples of plant probiotics. The fruits of plants treated with probiotics contained a higher amount of antioxidants, especially ascorbic acid. Alternation approach for plan growth promotion and pest management are explored for sustainable agriculture productivity in world wide. Putting so much chemicals (fertilizer and pesticides) in plants creates more risk for environmental health.

## Attribute of Plant Probiotics



**Figure 2** Schematic flow chart representing the prolific attributes of using plant probiotics (PPs).

## Effect of Plant Probiotics on Germinating Seedlings

One of the important plant growths promoting probiotic is Lactic acid bacteria which includes wide variety of bacteria with lactic acid production capacity including many industrial applications. LAB bacteria are Gram positive and non-motile organisms. They show indole, Methyl red and nitrate reduction tests as positive and Vogues Proskauer, Catalase and Oxidase production and Citrus utilization tests as negative. The LAB strains that are used as probiotics are isolated from the human gastrointestinal tract and commonly belong to the species of genera *Lactobacillus* and *bifidobacterium*. In our study, *Lactobacillus* was isolated from curd to study the effect on different seed Germination to assess the potentiality of

isolated *Lactobacillus* for improving the growth and activity of local crops. The *Lactobacillus* sp which was isolated from curd was grown in MRS medium at 37°C after spread and streak plate techniques. The isolated organism was *Lactobacillus acidophilus* which was identified further using gram's staining. Good microbes (probiotics) that help to Biofertilizer s and biopesticide Nitrogen fixaton Phosphate Solubilizatio n Siderosphor e Contains PGP to stimulate Exopolysacc harides production Phylohormone. The different seeds mainly Bengal Gram, peas, mustard seeds were coated with *Lactobacillus* culture, highest seed was obtained in the test. The isolated bacterium was proved as *Lactobacillus* on the basis of their cultural, morphological and Biochemical characteristics. Seeds which are soaked in *Lactobacillus* and plants

which was grown showed high seed Germination and a stimulatory growth over control. Hence, we can conclude that *Lactobacillus* which is a probiotic that can be effectively used as a biofertilizer to enhance the yield of crops.

## Conclusions and Future Perspectives

The process of germination causes the embryonic axis of a seed to lengthen, allowing succeeding seedlings to grow emergence. It involves hydrating the dormant seed. Phase I of the entire process is imbibition, and in the accomplishment of numerous metabolic and molecular processes while the plant is at the phase known as germination phase, which happens at a fixed seed MC (phase II).

Currently, agriculture across the globe faces a number of difficulties: Utilizing finite resources (such as rich soils), producing enough sustainable food and feed to meet the growing need of an increasing human population with an increased demand for animal products, caring about the environment environmental issues brought on the conventional intensive farming methods, and achieving the market demands for food quality in developed nations.

In this study, we compiled a large number of recently published papers that demonstrate the potential of plant probiotic bacteria to benefit plants in various ways. Phyto stimulation, nutrient mobilisation, and biocontrol of plant diseases are some of these advantages. Furthermore, a collection of helpful bacteria could help reduce the stress caused by a variety of circumstances, including salinity or the build-up of heavy metals are two examples. These microbes have also been demonstrated to supporters of healthy vegetable food.

Evidently plant probiotic bacteria, implemented as biofertilizers formulated with single lines or with a

consortium of isolates combining distinct useful effects, may want to function a possible technique to feed the arena whilst defensive ecosystems and enhancing meals quality. Consequently, a talk amongst scientists, politicians and farmers in addition to the lifestyles of studies applications and guidelines must be going on more often for the improvement of powerful and secure merchandise primarily based totally on PPB, that allows you to deliver blessings now no longer simply for producers, however for the entire individual in addition to for the complete Planet.

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