EXPLOITING BENEFICIAL BACTERIA AS PLANT PROBIOTICS FOR SUSTAINABLE CROP ENHANCEMENT

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INTRODUCTION

The use of microorganisms, especially bacteria with plant growth-promoting traits—the so-called plant probiotics—may serve as a potential solution to boost crop production. This approach can help avoid issues related to the use of chemical fertilizers and pesticides and lead to the production of higher-quality products (Garcia-Fraile et al., 2012; Flores-Felix et al., 2015).

The term Plant Probiotic Bacteria (PPB) was first introduced by Haas and Keel (2003) to describe a group of microorganisms that benefit plants, meeting three key criteria that together enhance plant protection: (i) effective and competitive colonization of the niche, (ii) ability to induce systemic resistance (ISR) in their hosts, and (iii) presence of direct antagonistic traits against pathogens. Additionally, bacteria capable of colonizing plant root systems and promoting plant growth are referred to as plant growth-promoting rhizobacteria (PGPR) (Kloepper and Schroth, 1978).

Developing plant probiotic microorganism (PPM)-based products offers an alternative to biofertilizers, biopesticides, and phytoremediation (Mayak et al. 2004)

MATERIAL AND METHOD

In the study, 30 soil bacteria were collected and isolated from healthy tomato plants on organic farms. The isolates were tested in vitro for plant growth-promoting properties, including potassium, phosphate and zinc solubility. Two strains of Bacillus sp. (strains Bv and Ba) were selected for greenhouse testing. Surface-sterilized tomato seeds were inoculated with bacterial suspensions (10^8 CFU mL^{-1}) and grown under controlled conditions for six weeks**.**

The parameters monitored in the study were plant growth, chlorophyll content and drought tolerance. Root colonization was also quantified.

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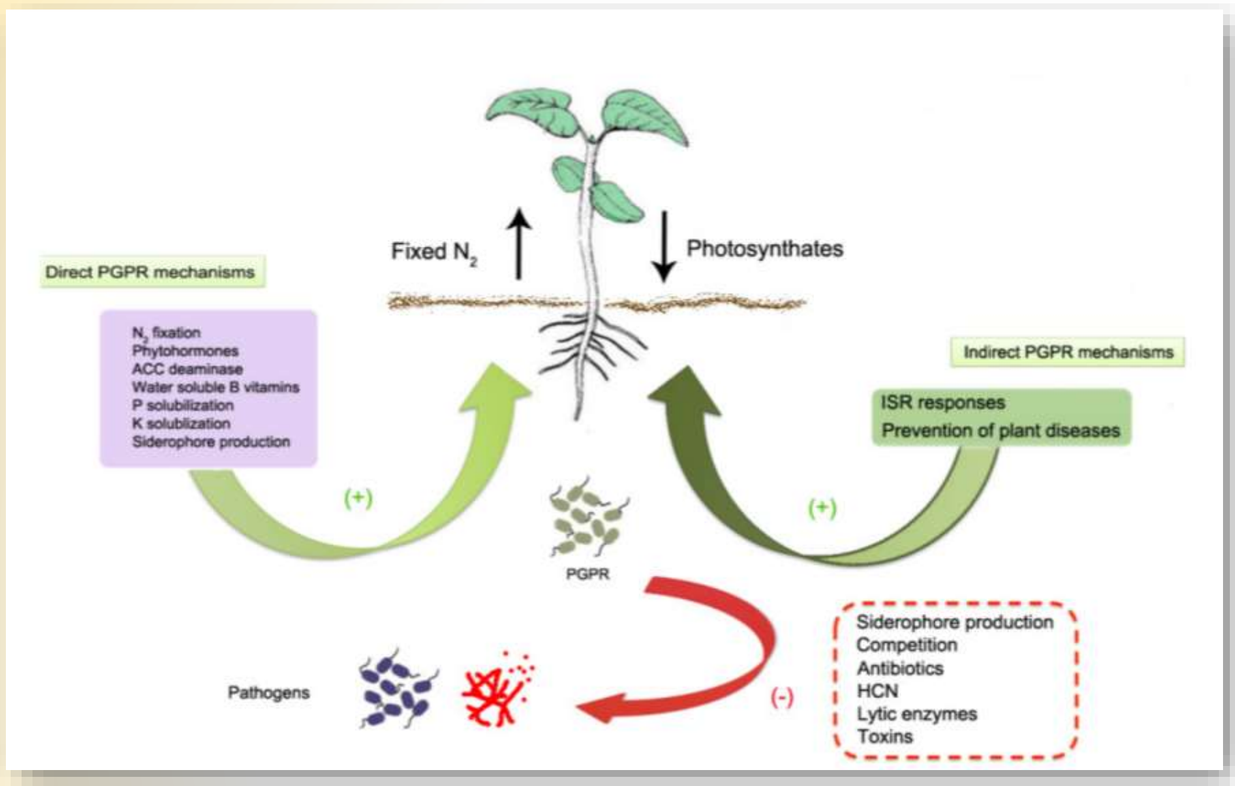

Fig 1. Mechanisms of Plant Growth-Promoting Rhizobacteria

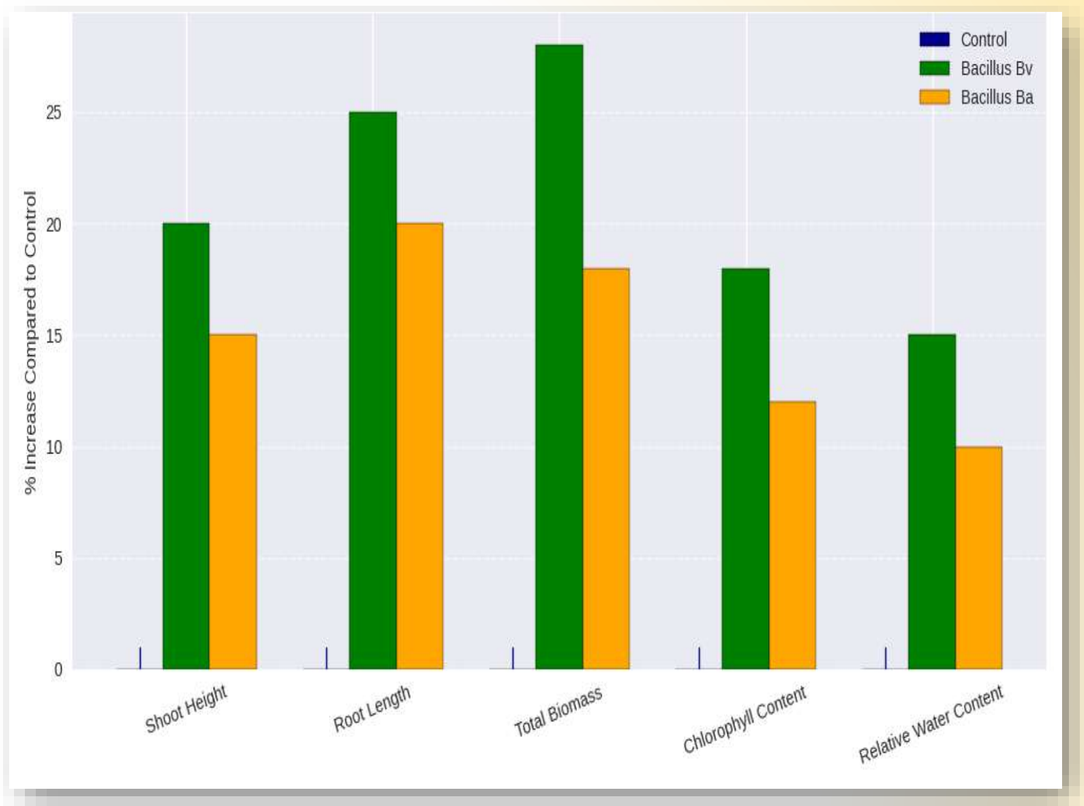

Fig. 2. Comparison of the effects of probiotic treatments on tomato growth under drought.

RESULTS AND DISCUSSION

Beneficial microbes, often referred to as plant growth-promoting microorganisms (PGPMs), can increase plant resistance to abiotic stresses such as drought by facilitating water uptake, modulating hormone levels, and improving soil structure. These microorganisms establish symbiotic relationships with plants, contributing to the host's ability to adapt and thrive in adverse environmental conditions (Koza, et al. 2022; Harman et al.,2021; Więcław, et al., 2022; Silvaet al., 2022; Seymour et al.. 2024). In our study, both bacterial treatments showed a positive effect with significant increases in the following parameters: shoot height (15–25%), root length (20–30%), and total biomass (18–28%). Chlorophyll content increased by 12–18%, compared to the control. Under drought stress, inoculated plants showed higher relative water content (10–15% increase) and maintained 25% higher biomass compared to the control group. The quantification test confirmed effective root colonization with a density of 10^6-10^7 CFU g^{-1} root.

Table 1. Growth dynamics of tomato.

parameter	control	Bacillus Bv	Bacillus Ba	indicator
Shoot height ↑ (%)	0	20	15	≥15% improvment
Root length ↑ (%)	0	25	20	≥20% improvment
Biomass ↑ (%)	0	28	18	≥25% improvment
Chlorophyll ↑ (%)	0	18	12	≥10% improvment
Relative water ↑ (%)	0	15	10	≥10% improvment

CONCLUSION

The plant probiotic bacteria, applied as biofertilizers formulated with single strains or with a consortia of isolates combining different beneficial effects, could serve as a possible solution to feed the world while protecting ecosystems and improving food quality. probiotics in agriculture also offers many other benefits including: improved efficiency of nutrition. improved efficiency of the root system, greater absorption of water and nutrients, healthier fruit and vegetables, greater resistance to stress.
Development of effective and safe products based on PPB, which will bring benefits not just for producers, but for the whole human being as well as for the entire Planet. These results demonstrate that plant probiotic bacteria can substantially enhance growth and drought resilience, offering a sustainable alternative to chemical inputs in agriculture. Integrating these strains into crop management strategies could improve yield stability and environmental sustainability.

REFERENCES

Doni, F., & Uphoff, N. (2021). Benefits to plant health and productivity from enhancing plant microbial symbionts. *Frontiers in plant science*, *11*, 610065.

Mayak, S., Tirosh, T., & Glick, B. R. (2004). Plant growth-promoting bacteria confer resistance in tomato plants to salt stress. *Plant physiology and Biochemistry*, *42*(6), 565-572.

Seymour, Z. J., Mercedes, J. F., & Fang, J. Y. (2024). Effect of heat acclimation on thermo tolerance of in vitro strawberry plantlets. *Folia Hortic*, *36*, 135-147.