International Journal of Plant & Soil Science

Volume 36, Issue 10, Page 571-576, 2024; Article no.IJPSS.125743
ISSN: 2320-7035

Contribution of PGPRs to Plant Growth: A Review

Harouna Maidoukia Abdoul Razack [a*], Ibrahim Jamilou [b] and Ibrahim Doka Dahiratou [b]

[a] *Département des Didactiques de Disciplines, Faculté des Sciences d'Education, Université Djibo Hamani de Tahoua, Niger.*
[b] *Université Abdou Moumiouni de Niamey, Ecole Normale Superieure, Niger.*

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/ijpss/2024/v36i105107

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/125743

Review Article

Received: 25/08/2024
Accepted: 27/10/2024
Published: 04/11/2024

ABSTRACT

PGPR play an important role in maintaining soil equilibrium. It is a living medium composed mainly of heterotrophic micro-organisms, and is a major reservoir of rhizobacteria. It contains a complex and varied microflora that plays essential roles for the soil ecosystem and higher soil organisms. The methodology used in this study was based on in-depth literature reviews and documentary research. The results obtained showed that basically, PGPRs are defined by three intrinsic characteristics, so they are divided into extracellular (ePGPR) and intracellular (iPGRP). Thanks to their metabolic plasticity, these soil microorganisms are involved in the degradation and immobilization of pollutants brought in by agriculture or industry. In the rhizosphere, in terms of biomass and taxonomic diversity, PGPR are by far the most abundant soil microorganisms. The aim of the study is to analyze the results of research showing the significant influence of PGPR on plant growth, thus contributing to a better understanding of crop nutrition.

**Corresponding author: E-mail: maidoukia5@gmail.com;*

***Cite as:** Razack, Harouna Maidoukia Abdoul, Ibrahim Jamilou, and Ibrahim Doka Dahiratou. 2024. "Contribution of PGPRs to Plant Growth: A Review". International Journal of Plant & Soil Science 36 (10):571-76. https://doi.org/10.9734/ijpss/2024/v36i105107.*

Keywords: PGPRs; soil equilibrium; plant growth; soil microorganisms.

1. INTRODUCTION

Rhizobacteria (PGPR, acronym for Plant Growth Promoting Rhizobacteria) are bacteria in the rhizosphere that are beneficial to plant growth and health. There are two main groups of PGPR: phytostimulators and phytoprotectants [1]. The term PGPR was first introduced at the end of the 1970s, when it was demonstrated by Kloepper and Schroth that strains of Pseudomonas fluorescens improved potato crop yields by up to 500% through the production of siderophores, iron chelators that deprive indigenous pathogenic bacteria of iron [1]. PGPR are of major agronomic interest, as their use could make it possible to reduce the use of chemical fertilisers and pesticides [2]. These are bacteria that actively colonise plant roots while increasing their growth and yield [3]. PGPR can be used in two different ways: phytostimulation (sometimes called biofertilisation), when the PGPR directly stimulates plant growth, and phytoprotection (also called biocontrol), when it inhibits the development of phytopathogenic organisms [4]. Plant growth-promoting rhizobacteria (PGPR) are considered an alternative to the use of chemicals in agriculture [5]. These PGPR are often used as model rhizobacteria [6]. They make up a significant proportion (up to 10%) of the cultivable rhizosphere microflora [7].

The aim of this study is to analyse the results of research showing the significant influence of PGPR on plant growth, thereby contributing to a better understanding of the nutrition of cultivated plants.

2. PLANT GROWTH PROMOTING RHIZOBACTERIA (PGPR)

Rhizobacteria are microorganisms that directly stimulate plant growth plant growth directly by increasing the uptake of nutrients from the soil nutrients from the soil, inducing and producing plant growth regulators and plant growth regulators and activating induced resistance mechanisms in plants. They indirectly stimulate plant growth through their antagonistic effect on harmful microflora, by transforming toxic metabolites. toxic metabolites. The establishment of the PGPR-plant association is essential for the expression of beneficial effects.

Expression of beneficial effects. Rhizobacteria are bacteria with the ability to the ability to colonise roots intensively. Non symbiotic bacteria that meet this definition belong to different genera and species, the most extensively studied being: Agrobacterium *radiobacter, Azospirillum spp, Bacillus spp, Pseudomonas spp* [8]. According to [8], the PGPR/pant relationship improves nutrient uptake, the same authors also concluded that the application of bacterial inoculations considerably improves N, P, and K uptake. Certain PGPR strains of the genera *Pseudomonas, Bacillus, Paenibacillus, Rhodobacter* and *Azospirillum* have recently been described for their direct positive effect on plant growth and increased crop crop yield [9]. PGPRs can promote host plant growth through various mechanisms such as nitrogen nitrogen (N2) fixation and solubilisation of trace elements such as phosphate (P) [10]. Basically, RMPs are defined by three intrinsic characteristics [11].

(1) They must be able to colonise the root;
(2) They must survive and multiply in the microhabitats associated with the root surface, in competition with other microbiota;
(3) They must promote plant growth [12].

2.1 Diversity of RMPs in the Rhizosphere

In the rhizosphere, bacteria are by far the most abundant microorganisms in terms of both biomass and taxonomic diversity [13,14] estimated that one gram of natural forest soil contains nearly 1.5. 1010 bacteria. Generally speaking, it is now considered that one gram of soil contains several thousand species and that the abundance of these species can vary from 108 to 1011 cells per gram of soil [15]. PGPR can be classified into two types according to their degree of association with root cells. They are divided into extracellular (ePGPR) and intracellular (iPGRP) [16]. ePGPR reside in the rhizosphere (mainly the rhizoplane) or in the intracellular space of the root cortex. iPGPR, on the other hand, mainly reside inside nodules. The bacterial genera belonging to extracellular PGPR are Azotobacter, *Serratia, Azospirillum, Bacillus, Caulobacter, Chromobacterium*, *Agrobacterium, Erwinia, Flavobacterium, Arthrobacter, Micrococcus, Pseudomonas* and Burkholderia. In contrast, endophytic bacteria belonging to intracellular PGPR include *Allorhizobium, Bradyrhizobium, Mesorhizobium,* and *Rhizobium*, as well as *Frankia* species, which can fix atmospheric nitrogen in actinorhizal plants [17].

2.2 Taxonomic Diversity of Rhizobacteria

PGPR colonise the rhizosphere using root exudates as nutrient substrates, but unlike other rhizospheric bacteria they in turn have a beneficial effect on the plant via a multitude of mechanisms (Fugure1). The enormous taxonomic and genetic diversity of rhizobacteria means that they are heavily involved in numerous environmental functions in the soil. Certain PGPR are involved in plant health and growth, the most extensively studied being rhizobial and mycorrhizal symbioses. The soil microbial component also plays an active role in the biogeochemical cycles of sulphur, phosphorus, iron and nitrogen. As far as the latter is concerned, their involvement in atmospheric nitrogen fixation, ammonification, nitrification and denitrification processes is well established [18]. PGPR are among the main players controlling the decomposition of organic matter. Due to their metabolic plasticity, these soil microorganisms are also involved in the degradation and immobilisation of pollutants (pesticides) brought in from agricultural or industrial sources. At soil level, the distribution of microorganisms is heterogeneous and is conditioned by the organisation of the soil (texture, structure, composition, etc.) according to [19]. The distribution of microorganisms in the soil is also highly dependent on nutrient resources and their spatiotemporal distribution. Consequently, the presence of a particular trophic niche will strongly structure the distribution of microorganisms in the soil [19,20]. have classified RMP into four sub-groups according to their modes of action:

- Bio-fertilisers (increase in the availability of nutrients to the plant);
- Phyto-stimulators (increase in plant growth, ability to produce phytohormones);
- Rhizoremediators (degradation of organic pollutants);
- Bio-pesticides (disease control, production of fungicidal and antibiotic metabolites).

Cultivable micro-organisms, with a diversity of genera and species, belong mainly to the following three phyla: Proteobacteria, Firmicutes and Actinobacteria [18]. At present, many bacterial genera include PGPR, revealing very diverse taxa [5].

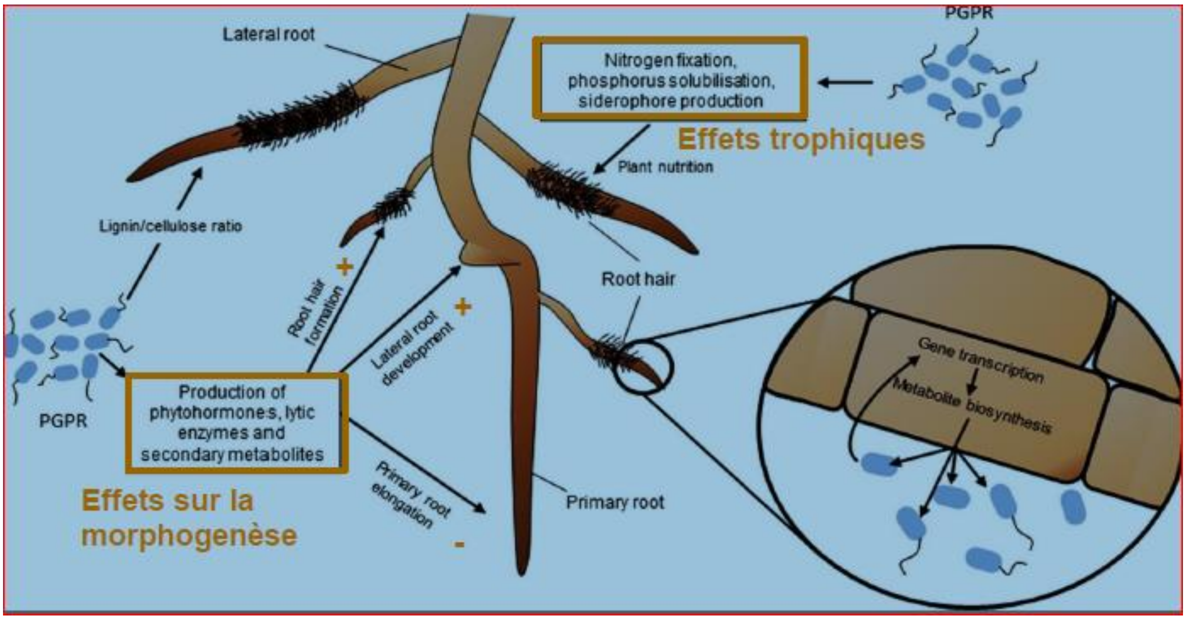

Fig. 1. Effects of rhizobacteria on root system architecture and root function [21]

3. MECHANISMS OF ACTION OF PGPR

The beneficial effects of PGPR on plant growth result from different mechanisms exerted by rhizobacteria whose modes of action are direct or indirect, although the difference between the two is not always obvious.

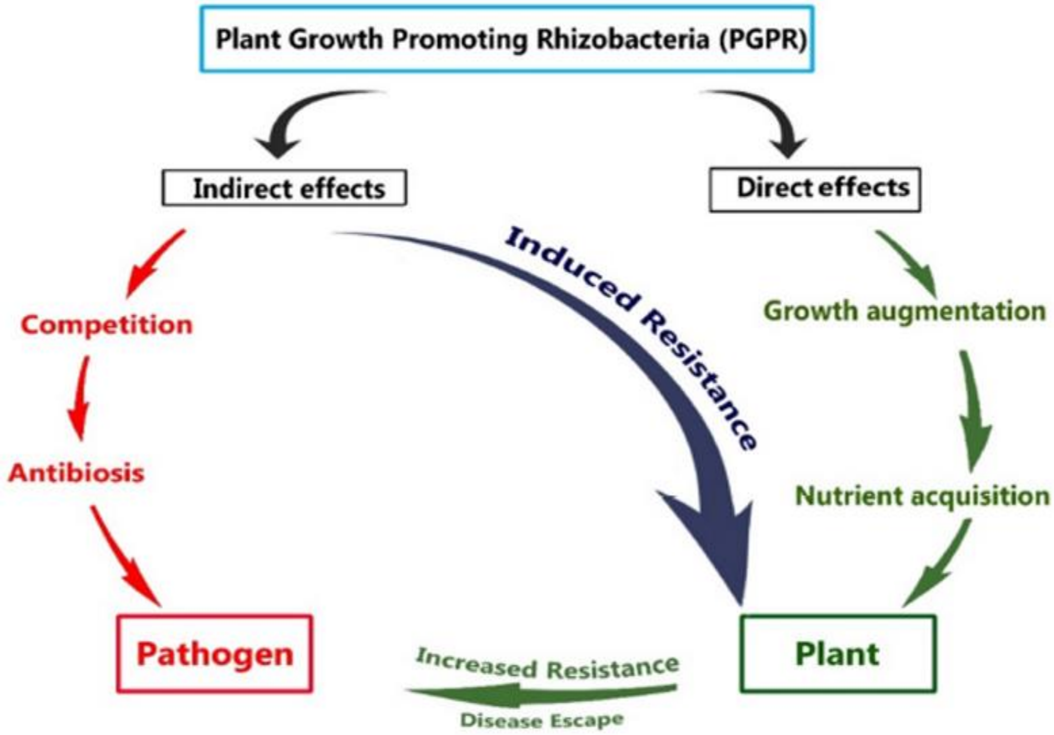

Fig. 2. Overview of the two direct and indirect modes of RMP [23]

Indirect mechanisms are generally those that occur outside the plant, whereas direct mechanisms are those that occur inside the plant and directly affect its metabolism. These mechanisms (Fig. 2) may be active simultaneously or sequentially at different stages of plant growth:

1. Solubilisation of phosphates, nitrogen fixation and mineral nutrients, making these foods available to the plant;
2. The production of phytohormones such as 3-indoleacetic acid (IAA);
3. The repression of pathogenic soil microorganisms (through the production of hydrogen cyanide, siderophores, antibiotics, and/or competition for nutrients [22]. In addition, PGPR can contribute to improving plant resistance to biotic and abiotic stresses (salinity, dryness and heavy metal toxicity) on the basis of their activities. [20] have classified PGPR as biofertilisers (increasing the availability of nutrients to plants), phytostimulators (improving plant growth, usually through the production of phytohormones), rhizoremediators (degrading organic pollutants) and biopesticides (controlling disease, mainly through the production of antibiotic and antifungal metabolites).

4. CONCLUSION

This review has revealed the role played by PGPR in the plant rhizosphere. The rhizosphere is home to various microorganisms that interfere with the plant. PGPR promote the growth of host plants through mechanisms such as nitrogen fixation and the solubilisation of trace elements such as phosphate. The beneficial effects of PGPR on plant growth result from different mechanisms exerted by rhizobacteria whose modes of action are direct or indirect, although the difference between the two is not always obvious. Certain PGPR are involved in plant health and growth, the most widely studied of which are rhizobial and mycorrhizal symbioses. The soil microbial component also plays an active role in the biogeochemical cycles of sulphur, phosphorus, iron and nitrogen. As far as nitrogen is concerned, the strong involvement in the fixation of atmospheric nitrogen, ammonification, nitrification and denitrification processes no longer needs to be demonstrated.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

I, the undersigned Dr HAROUNA MAIDOUKIA Abdoul Razack, hereby declare that NO generative AI technology such as Large Language Models (ChatGPT, COPILOT, etc) and text-image generators were used during the writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. García-Arenal F, McDonald B. An analysis of the durability of resistance of plants to viruses. Phytopathology. 2003;93:941-952. Garcia JL, Roger PA. Introduction à la microbiologie du sol. Polycopié de cours (Université de Provence, Université de la Méditerranée, École Supérieure d'Ingénieurs de Luminy). 2001;191. García Lucas JA, Schloter M, Durkaya T, Hartmann A, Gutiérrez-Maero FJ. Colonisation des racines de poivrons par une souche de Pseudomonas fluorescens favorisant la croissance des plantes. Biol Fertil Soils. 2003;37(6):381-385.
2. Morrissey O, Nelson D. The role of the World Bank in the transfer of policy knowledge on trade liberalisation. Document présenté à la conférence sur Political Economy of Policy Reform, Tulane University; 9-10 novembre 2002. Available:www.tulane.edu/~dnelson/PEReform.htm
3. Wu H, Hayes MJ, Wilhite DA, et al. The effect of the length of record on the standardized precipitation index calculation. Int J Climatol. 2005;25:505-20. Available:https://doi.org/10.1002/joc.1142
4. Lucy M, Reed E, Glick BR. Application of free living plant-promoting rhizobacteria. Antonie van Leeuwenhoek. 2004;86:1-25.
5. Kloepper JW. Plant-growth-promoting rhizobacteria as biological control agents. In: Metting FB Jr, editor. Soil Microbial Ecology. New York: Marcel Dekker. 1993;255-73.
6. Sorensen PW. Laboratory assessment of the role of a larval pheromone and natural stream odor in spawning stream localization by migratory sea lamprey (*Petromyzon marinus*). Can J Fish Aquat Sci. 2001;58(12):2374-85.
7. Kragelund BB, Knudsen J, Aplin RT, Poulsen FM, Dobson CM. Probing the nature of noncovalent interactions by mass spectrometry: A study of protein-CoA ligand binding and assembly. J Am Chem Soc. 1996;118(36):8646-53.
8. Hallmann J, Quadt-Hallmann A, Rodriguez-Kibana R, Kloepper JW. Interactions between Meloidogyne incognita and endophytic bacteria in cotton and cucumber. Soil Biol Biochem. 1997;29:1-6.
9. Wu YM, Kanamori H. Rapid assessment of damage potential of earthquakes in Taiwan from the beginning of P waves. Bulletin of the Seismological Society of America. 2005;95(3):1181-1185.
10. Orhan M, Scott D. Why women enter into entrepreneurship: an explanatory model. Women Manag Rev. 2001;16(5):232-47.
11. Barea JM, Werner D, Azcón-Aguilar C, Azcón R. Interactions of arbuscular mycorrhiza and nitrogen-fixing symbiosis in sustainable agriculture. In: Werner D, Newton WE, editors. Agriculture, forestry, ecology and the environment. Dordrecht: Kluwer Academic Publishers; 2005.
12. Niranjana SR, Hariprasad P. Understanding the mechanism involved in PGPR-mediated growth promotion and suppression of biotic and abiotic stress in plants. In: Future Challenges in Crop Protection Against Fungal Pathogens. Fungal Biology. Springer. 2014;59-108.
13. Schmidt FL, Hunter JE. Bias in standardized educational and employment tests as justification for racial preferences in affirmative action programs. In: Leicht KT, editor. The future of affirmative action. Stanford, CT: JAI. 2002;285-302.
14. Torsvik V, Sorheim R, Goksoyr J. Total bacterial diversity in soil and sediment communities—a review. J Ind Microbiol. 1996;17:170-8.
15. Roesch L, Fulthorpe R, Riva A, et al. Pyrosequencing enumerates and contrasts soil microbial diversity. ISME J. 2007;1:283-90. Available:https://doi.org/10.1038/ismej.2007.53
16. Gray NS, Brown AS, MacCulloch MJ, Smith J, Snowden RJ. An implicit test of the associations between children and sex in pedophiles. J Abnorm Psychol. 2005; 114(2):304-8. Available:https://doi.org/10.1037/0021-843X.114.2.304
17. Gouda AI, Toko II, Salami SD, Richert M, Scippo ML, Kestemont P, Schiffers B. Pratiques phytosanitaires et niveau d'exposition aux pesticides des producteurs de coton du nord du Bénin. Cah Agric. 2018;27(6):65002.

18. Hugenholtz P, Huber T. Chimeric 16S rDNA sequences of diverse origin are accumulating in the public databases. Int J Syst Evol Microbiol. 2002;53(1):289-93.
19. Ranjard L, Richaume A. Quantitative and qualitative microscale distribution of bacteria in soil. Res Microbiol. 2001; 152(8):707-16.
20. Somers DE. La formation d'un complexe SCFZTL est nécessaire pour une bonne régulation du rythme circadien. The Plant Journal. 2004;40(2): 291-301.
21. Belotti F, Daidone S, Ilardi G, Atella V. Stochastic frontier analysis using Stata. Stata J. 2013;13(4):719-58.
22. Understanding the mechanism involved in PGPR-mediated growth promotion and suppression of biotic and abiotic stress in plants. In: Future Challenges in Crop Protection Against Fungal Pathogens. Fungal Biology. Springer. 2014;59-108.
23. Basu R, Ferreira J. Mobilité durable dans la région métropolitaine de Boston dominée par l'automobile: Challenges and opportunities post-COVID-19. Transport Policy. 2021;103:197-210.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/125743