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The potential use of plant growth promoting Rhizobacteria (PGPR) for Tea Plant Cultivation in Assam: A Review

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ABSTRACT

Plant growth promoting bacteria (PGPR) have been found to be highly beneficial for plants as they help defend against fungal diseases commonly found in soil. They play an important role in plant growth, health and productivity. They increase seedling tolerance to drought, high temperatures, toxic heavy metals, high or low pH and even extreme soil acidity. The use of PGPR has proven to be an environmentally best way to increase the crop yield by facilitating plant growth through either a direct or indirect mechanism. Tea is grown all over the Assam and cultivated in major areas where chemical fertilizers are used. So, the use of PGPR can minimise the application of chemical fertilizer for the production of organic tea. This review highlights the future research works which are needed in many areas of Assam by the use of beneficial strains of PGPR to reduce the use of pesticide for commercial production of organic tea for healthy consumption by the people at large.

Key words: *PGPR, Soil acidity, Tea cultivation, Chemical fertilizer, Abiotic stress.*

Introduction

The plant growth promoting bacteria (PGPR) are very much favorable for plants. This bacteria helps to defend plants against many diseases that are mostly fungal diseases borne in soil. Presently very high amount of pesticides are used in plant. PGPR have been found to be highly beneficial for plants as they help defend against fungal diseases commonly found in soil. These bacteria colonize the rhizophere of plants and stimulate plant growth through various mechanisms as defined by Kloepper and Schroth (1978).

The overuse of chemical fertilizers and pesticides in crop production has become a significant problem that threatens the environment and human health (Kumar *et al.*, 2017). Studies have shown that the use of chemical fertilizers can increase yields by approximately 50%, but this comes at the expense of ignoring the biological potential of roots and the rhizosphere (Meena *et al*., 2017). PGPR can help increase plant nutritional status and reduce the need for pesticides (Pérez-Montaño *et al.*, 2013; Aloo *et al.*, 2019).

PGPR use two mechanisms to promote plant growth :direct and indirect .Direct mechanisms include the production of Phytohormones (Cassán *et al*., 2009) such as auxins (Khalid *et al*., 2004b); siderophores (Yu *et al*., 2019); phosphorous

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solubilisation (Krey *et al*., 2013), or nitrogen-fixing (Riggs *et al*., 2001). Indirect mechanisms are related to biocontrol, such as antagonistic activity against phytopathogenic microorganism (Bashan and Holguin, 1997; Ahmad *et al*., 2016; Khatoon *et al*., 2020). Additionally, the massive use of nitrogen and phosphorus fertilizers is harmful to soil microorganisms affects soil fertility, and pollutes the environment. Thus, the use of PGPR is an urgent need to maintain high productivity while minimizing environmental impact (Youssef *et al*., 2014; Slepetiene *et al*., 2020).

PGPR in Rice

Rice (*Oryza sativa*) is a crucial cereal crop in India that belongs to the family Grmineae. Asia is the largest producer of rice, with India, Bangladesh, china and Pakistan being the major contributors. In many states of India, rice is the primary source of carbohydrates, and irrigated lowland rice accounts for over 75% of rice production (Ram *et al*., 2003; Yuan *et al*., 2021).

However, the availability of irrigation water is threatened by global water shortage, which negatively effects crop growth and productivity (Cai *et al*., 2020). PGPR could play a vital role in alleviating the negative effects to drought stress on plant. Research has shown that the application of PGPR improves rice growth traits, including shoot length, tiller number, panicle number and shoot dry weight. Rice plants treated with PGPR showed a significant increase in these parameters compared to untreated plants (Ahuja *et al*., 2010; Shekoofa and Sinclair *et al*., 2018). Moreover, the combined application of PGPR and irrigation at 100% ETc recorded the best growth parameters, while the treatment $I_{80}\times^{-}$PGPR showed the lowest values of growth parameters. Therefore, the application of PGPR could be a promoting strategy to increase rice yield productivity and cope with the water shortage crisis. However, further research is needed to investigate the response of rice plants to combined PGPR with deficit irrigation regimes synchronized with salt-affected soils (Abd *et al*., 2022).

PGPR in Sugarcane

PGPR have been found to play a crucial role in enhancing salt stress tolerance in sugarcane plants. Sugarcane is a valuable cash crop grown worldwide but its sessile nature makes it vulnerable to salinity stress. High salt concentrations cause toxicity and symptoms that directly affect its physiological and metabolic processes, as well as its nutritional value, leading to reduced growth (Gomati *et al*., 2014; Khan *et al*., 2018). Although the mechanism of PGPR and Nitric oxide in facilitating salt stress tolerance in sugarcane plants is yet to be fully investigated, recent studies have explored the use of salt-tolerant PGPR from the sugarcane rhizophere to mitigate salt stress on sugarcane plants (Sharma *et al*., 2021).

Table 1. Effect of integrative deficit drip irrigation and plant growth promoting rhizobacteria on growth characteristics of rice plants grown under saline soil for (SI) 2017 and (SII) 2018 seasons (Abd *et al*., 2022).

Source of variation	Shoot length (cm)	Tillers no. plant"1	Panicles no plant"1	Shoot dry weight (g)
Season	NS	NS	NS	NS
(SI) 2017	53.44 ± 1.20a	1.92 ± 0.23a	1.79 ± 0.15a	3.45±0.33a
(SII) 2018	53.66 ± 0.99a	1.95 ± 0.23a	1.77 ± 0.21a	3.47 ± 0.43a
Irrigation	**	*	**	**
FI	55.62 ± 1.20a	2.04 ± 0.32a	1.88 ± 0.23a	3.84 ± 0.45a
DI	51.49 ± 0.89b	1.83 ± 0.54b	1.67 ± 0.30b	3.08 ± 0.32b
PGPR	**	*	**	**
“PGPR	51.16 ± 0.88b	1.80 ± 0.31b	1.63 ± 0.29b	3.01 ± 0.28b
+PGPR	51.16 ± 0.88b	2.07 ± 0.33a	1.93 ± 0.31a	3.91 ± 0.43a
I×PGPR	**	*	**	**
$I_{100}\times''$PGPR	53.04 ± 1.40b	1.88 ± 0.41b	1.7 1± 0.25b	3.38 ± 0.31b
$I_{80}\times^{-}$-PGPR	49.28 ± 1.21c	1.72 ± 0.21c	1.54 ± 0.43b	2.65 ± 0.41c
$I_{100}\times^{+}$PGPR	58.20 ± 0.42a	2.21 ± 0.33a	2.05 ± 0.21a	4.31 ± 0.59a
$I_{100}\times^{+}$PGPR	53.69±0.98b	1.94 ± 0.23b	1.81 ± 0.40b	3.51 ± 0.36b

***Respectively, differences at p≤0.05 and p≤0.01 probability level, ns indicates no significant difference. Means followed by the same letter in each column are not significantly different according to the LSD test (p<0.05).

In a study, sugarcane plants were grown in the presence or absence of PGPR *Paraburkholderia* sp. SOS3 under a hybrid chemical organic fertilisation regime. After one year of growth, the plants were harvested, leaving the root system intact (Paungfoo-Lonhienne *et al*., 2020). The remaining plants were grown second year without addition of PGPR; the results showed a significant improvement in cane and sugar yields for plants that were treated with PGPR mediated systematic abiotic stress tolerance in plants and encourages the use of microorganisms (Chanyarat *et al.*, 2021).

PGPR in vegetables

PGPR have emerged as a promising alternative to synthetic fertilizers and pesticides in vegetables are crucial for food and nutrient security, providing an inexpensive source of energy, nutrient, vitamins and minerals for good health (Schreinemachers *et al.*, 2018).

However, conventional agricultural practices that rely on synthetic chemicals have adverse effects on human, animals, and the environment .In this context, PGPR offer a potential solution to these problems (Choudhary *et al*., 2018; Aloo *et al*., 2019). A better understanding of the plant-growth promotion activity of PGPR is likely to enhance the production of safe, fresh and high quality vegetables while reducing chemical inputs in different agronomic setups (Méndez-Bravo *et al*., 2018). Overall, the use of PGPR as a vital component s of soil fertility, plant growth promotion and antagonistic effects against phytopathogens through a wide variety of mechanisms in the rhizosphere in crucial for sustainable vegetable production (Sharma *et al*., 2017; Parewa *et al*., 2018). The most potential and widely reported PGPR genera associated with Solanaceous vegetable crops induce *Pseudomonas, Bacillus, Azotobacter* etc. (Gupta *et al*., 2017). Direct mechanisms involve various processes such as phosphate, solubilisation, nitrogen fixation, production of siderophore, HCN, ammonia, vitamins and phytohormones. Indirect mechanisms include ACC deaminase activity production of antibiotics, hydrolytic enzymes (Mekonnen *et al.,* 2021).

PGPR in Tea

PGPR have been found to be beneficial in tea cultivation by enhancing the build-up of PGPR, the physical and biochemical responses of tea plants to environmental stress are improved, resulting in increased immune resistance (Choudhary *et al*., 2007; Kumar *et al.,* 2018).

Tea is an economically significant crop in the north-eastern part of India and primarily grown in the regions north-eastern zone (Bhattacharyya *et al*., 2020). Rhizoshere of tea plant composed of a metabolically functional PGPR; which have utilized as a biofertilizers (Chakraborty *et al*., 2015; Dutta *et al*., 2015). The application of PGPR has been found to promote plant growth promoting root development, root hair formation, and lateral root length (Yaºar *et al*., 2021). *Azospirillum* and *PSB* are two types of bacteria that help to maintain plant growth and work as a PGPR in tea plant nutrition (Tennakoon *et al*., 2021). However, repeated cultivation of tea in the same field have been found to damage some beneficial soil bacteriaincluding *Acidobacteriaceae, Burkholderiaceae, Rhodanobacteraceae,* and *Sphingomonadaceae Pseudomonas, Rhodanobacter, Bradyrhizobium, Mycobacterium,* and *Sphingomonas* (Li *et al*., 2016; Arafat *et al.,* 2017; Shen *et al*., 2021). So, the application of PGPR inoculum will play a very effective role for the commercial production as well as cultivation of tea plants which are mostly grown in Assam.

Conclusion

PGPR are one type of bacteria which helps to reduced fungal diseases in plant. In this case, the bacteria colonized the rhizophere of plant and helps plant to grow in different mechanism. Now a days, huge amount of pesticide use for tea crop production. But, PGPR can helps to provide nutritional value in crop and also to reduce the use of pesticides especially in the tea plant cultivation. It's a natural process, if we use PGPR in future for plant growth and development then it should be beneficial for plant and environment also. Thus, future research work is needed in many areas of Assam to use the beneficial strains of PGPR to reduce the use of pesticide for commercial production of organic tea for healthy consumption by the people of this region.

References

Abd, E.T.A., Abd, E.S.A. and El-Saadony, M.T. 2022. Plant Growth-Promoting Rhizobacteria Improve Growth, Morph-Physiological Responses, Water Productivity, and Yield of Rice Plants Under Full and Deficit Drip Irrigation. *Rice*. 15: 16.

Ahuja, I, de Vos RCH, Bones, A.M. and Hall, R.D. 2010. Plant molecular stress responses face climate change. *Trends Plant Sci.* 15: 664-674. https://doi.org/10. 1016/j.tplants.2010.08.002

Aloo, B.N., Makumba, B.A. and Mbega, E.R. 2019. The potential of Bacilli rhizobacteria for sustainable crop production and environmental sustainability. *Microbiol. Res*. 219: 26-39.

Arafat, Y., Wei, X., Jiang, Y., Chen, T., Saqib, H.S.A., Lin, S. and Lin, W. 2017. Spatial distribution patterns of root-associated bacterial communities mediated by root exudates in different aged ratooning tea monoculture systems. *Int. J. Mol. Sci.* 18: 1727.

Bashan, Y. and Holguin, G. 1997. *Azospirillum*-plant relationships: environmental and physiological advances (1990-1996). *Can. J. Microbiol*. 43: 103-121. doi: 10.1139/m97-015

Bhattacharyya, C., Banerjee, S. and Acharya, U. 2020. Evaluation of plant growth promotion properties and induction of antioxidativedefense mechanism by tea rhizobacteria of Darjeeling, India. *Sci. Rep.* 10: 15536.

Cassán, F., Perrig, D., Sgroy, V. and Masciarelli, O. 2009. inoculated singly or in combination, promote seed germination and early seedling growth in corn (*Zea mays* L.) and soybean (*Glycine max* L.). *Eur. J. Soil Biol*. 45: 28-35.

Chakraborty, A. P. C. and Chakraborty, U. 2015. *Bacillus megaterium* from tea rhizosphere promotes growth and induces systemic resistance in tea against *Sclerotiumrolfsii*. *Indian Phytopathol.* 68: 237-247.

Chanyarat, P.L., Nantida, W., Ian, P., Ratchaniwan, J. , Peeraya, K. and Klanarong, S. 2021. Plant growth promoting rhizobacteria enhance the ratoon productivity of sugarcane. *AJCS.* 15(12): 1442-1445.

Choudhary, M., Ghasal, P.C., Yadav, R.P., Meena, V.S., Mondal, T. and Bisht J. 2018. Towards plant-benefciaryrhizobacteria and agricultural sustainability. Role of rhizospheric microbes in soil: *Springer*. 1-46.

Choudhary, D. K., Prakash, A. and Johri, B. N. 2007. Induced systemic resistance (ISR) in plants: Mechanism of action. *Indian J. Microbiol*. 47: 289-297.

Dutta, J., Handique, P. J. and Takur, D. 2015. Assessment of culturable tea rhizobacteria isolated from tea estates of Assam, India for growth promotion in commercial tea cultivars. *Front. Microbiol.* 6: 1252.

Gomathi, R. and Thandapani, P. 2014. Influence of salinity stress on growth parameters and yield of sugarcane. *IOSR J. Pharm. Biol. Sci*. 93 : 28-32.

Gupta, S. and Kaushal, R. 2017. Plant growth promoting rhizobacteria: Bioresource for enhanced productivity of solanaceous vegetable crops. *Acta Sci. Agri*. 1(3) : 10-15.

Khalid, A., Arshad, M. and Zahir, Z.A. 2004a. Screening plant growthpromotingrhizobacteria for improving growth and yield of wheat. *J. Appl. Microbiol*. 96:473-480.

Khan, N., Zandi, P., Ali, S., Mehmood, A., Shahid, M.A. and Yang, J. 2018. Impact of salicylic acid and PGPR on the drought tolerance and phytoremediation potential of *Helianthus annus*. *Front. Microbiol*. 9: 2507.

Khatoon, Z., Huang, S., Rafique, M., Fakhar, A., Kamran, M.A. and Santoyo, G. 2020. Unlocking the potential of plant growth-promoting rhizobacteria on soil health and the sustainability of agricultural systems. *J. Environ. Manag*. 273 : 111-118.

Krey, T., Vassilev, N., Baum, C. and Eichler-Löbermann, B. 2013. Effects of long-term phosphorus application and plant-growth promoting rhizobacteria on maize phosphorus nutrition under field conditions. *Eur. J. Soil Biol*. 55: 124-130.

Kumar, A. and Verma, J. P. 2018. Does plant-Microbe interaction confer stress tolerance in plants: A review. *Microbiol. Res*. 207: 41-52.

Li, Y., Li, Z., Li, Z., Jiang, Y., Weng, B. and Lin, W. 2016. Variations of rhizosphere bacterial communities in tea (*Camellia sinensis* L.) continuous cropping soil by high-throughput pyrosequencing approach. *J. Appl. Microbiol.* 121: 787-799.

Li, Y.R. and Yang, L.T. 2015. Sugarcane agriculture and sugar industry in China. *Sugar Tech*. 17: 1-8.

Meena, K.K., Sorty, A.M., Bitla, U.M., Choudhary, K., Gupta, P. and Pareek, A. 2017. Abiotic stress responses and microbe-mediated mitigation in plants: the omics strategies. *Front. Plant Sci*. 8: 172.

Mekonnen, H. and Kibret, M. 2021. The roles of plant growth promoting rhizobacteria in sustainable vegetable production in Ethiopia. *Chem. Biol. Technol. Agric.* 8: 15.

Méndez-Bravo, A, Cortazar-Murillo, E.M., Guevara-Avendaño, E, Ceballos Luna, O., Rodríguez-Haas, B. and Kiel-Martínez, A.L. 2018. Plant growth-promoting rhizobacteria associated with avocado display antagonistic activity against *Phytophthorac innamomi* through volatile emissions. *PLoS One*. 13(3): 1-13.

Paungfoo-Lonhienne, C., Watanarojanaporn, N. and Jaemsaeng, R. 2020. Plant growth promoting rhizobacteria enhance the efficiency of the combination of organic and chemical fertilisers in sugarcane. *OJE*. 10 : 440-444.

Penna, C. and Luna, V. 2009. *Azospirillum brasilense* Az39 and *Bradyrhizobium japonicum* Kumar, A., Maurya, B. R., Raghuwanshi, R., Meena, V. S. and Tofazzal Islam, M. 2017. Co-inoculation with enterobacter and rhizobacteria on yield and nutrient uptake by wheat (*Triticum aestivum* L.) in the alluvial soil under Indo-Gangetic Plain of India. *J. Plant Growth Regul*. 36: 608-617.

Pérez-Montaño, F., Jiménez-Guerrero, I., Contreras

Sánchez-Matamoros, R., López-Baena, F.J., Ollero, F.J. and Rodríguez-Carvajal, M.A. 2013. Rice and bean AHL-mimic quorum-sensing signals specifically interfere with the capacity to form biofilms by plant-associated bacteria. *Res. Microbiol*. 164: 749-760.

Ram, P.C., Maclean, J.L. and Dawe, D.C. 2003. *Rice Almanac*, 3rd edn. *Ann. Bot.* 92(5): 739.

Riggs, P. J., Chelius, M. K., Iniguez, A.L., Kaeppler, S.M. and Triplett, E.W. 2001. Enhanced maize productivity by inoculation with diazotrophic bacteria. *Funct. Plant Biol*. 28: 829-836.

Schreinemachers, P., Simmons, E.B. and Wopereis, M.C. 2018. Tapping the economic and nutritional power of vegetables. *Glob Food Sec*. 16: 36-45.

Sharma, I.P., Chandra, S., Kumar, N. and Chandra, D. 2017. PGPR: Heart of soil and their role in soil fertility. *Agriculturally Important Microbes for Sustainable Agriculture: Springer*. 51-67.

Sharma, A., Singh, R.K., Singh, P., Vaishnav, A., Guo, D.-J., Verma, K.K., Li, D. P., Song, X. P., Malviya, M.K. and Khan, N. 2021. Insights into the Bacterial and Nitric Oxide-Induced Salt Tolerance in Sugarcane and their Growth Promoting Abilities. *Microorganisms.* 9 : 2203.

Shekoofa, A. and Sinclair, T. 2018. Aquaporin activity to improve crop drought tolerance. *Cells*. 7:123.

Shen, F.T. and Lin, S.H. 2021. Priming effects of cover cropping on bacterial community in a tea plantation. *Sustainability***.** 13: 4345.

Slepetiene, A., Volungevicius, J., Jurgutis, L., Liaudanskiene, I., Amaleviciute Volunge, K. and Slepetys, J. 2020. The potential of digestate as a biofertilizer in eroded soils of Lithuania. *Waste Manag*. 102: 441-451.

Tennakoon, P.L.K., Rajapaksha, R.M.C.P. and Hettiarachchi, L.S.K. 2021. Indigenous plant growth-promoting rhizobacterial consortia greatly reduces fertilizer need for tea nurseries: Characterization and evaluation. *Sri Lanka Journal of Food and Agriculture*. 7(1): 41-52.

Ya°ar, E., Ramazan, C., Meral, K. and Hakan, K. 2021. Evaluation of the Effects of Triple PGPR Isolates and Biological Fertilizer Formulations Formed with Different Carriers on Growth Parameters in Pazar-20 Tea Clone. *Manas Journal of Agriculture Veterinary and Life Sciences*. ISSN: 1694-7932.

Youssef, M.M. and Eissa, M.F. 2014. Biofertilizers and their role in management of plant parasitic nematodes. *E. J.Biotechnol. Pharm. Res*. 5: 1-6.

Yu, H., Ling, N., Wang, T., Zhu, C., Wang, Y. and Wang, S. 2019. Responses of soil biological traits and bacterial communities to nitrogen fertilization mediate maize yields across three soil types. *Soil Till. Res*. 185: 61-69.

Yuan, S., Linquist, B.A. and Wilson, L.T. 2021. Sustainable intensification for a larger global rice bowl. *Nat. Commun.* 12: 7163.