

## The Potential use of Plant Growth Promoting Rhizobacteria (PGPR) for Medicinal Plant Cultivation in Meghalaya: A Review

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### Abstract

Beneficial PGPR have been identified in a range of plant species, including those with medicinal properties. These PGPR have been shown to enhance the growth and development of medicinal plants through the improvement of nutrient availability in rhizospheric root systems. Some medicinal plants have been found to harbour specific strains of PGPR that are associated with increased medicinal properties and enhanced bioactive compound production. So, the use of PGPR can minimise the application of chemical fertilizer for the production of rare species of medicinal plants. This review highlights the future research works which are needed in many areas of Meghalaya by the use of various beneficial strains of PGPR to reduce the use of pesticide for commercial application in the cultivation of medicinal plants. The PGPR has the ability to increase the soil fertility by decreasing the concentration of inorganic fertilizer and thereby they are regarded as the potential strains to be used as biofertilizer which in turn will also improve the cultural practices of Meghalaya to conserve a large number of rare and endangered medicinal plants.



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Rhizobacteria.

### Introduction

From the ancient times, people have been depended on natural remedies especially derived from plants for producing drugs to cure various diseases which were based on some traditional knowledge and practice.<sup>1</sup> Rhizospheric bacteria helps to promote the growth and resistance to host from various pathogens and abiotic stress conditions. They have


the ability to synthesize the secondary metabolites which are found to show positive biological effects.<sup>2</sup> At present, a significant number of phytotherapeutic compounds are isolated from the beneficial microorganisms which are associated with the host.<sup>3</sup>

These remedies, often referred to as medicinal plants or herbs, have been used for their healing

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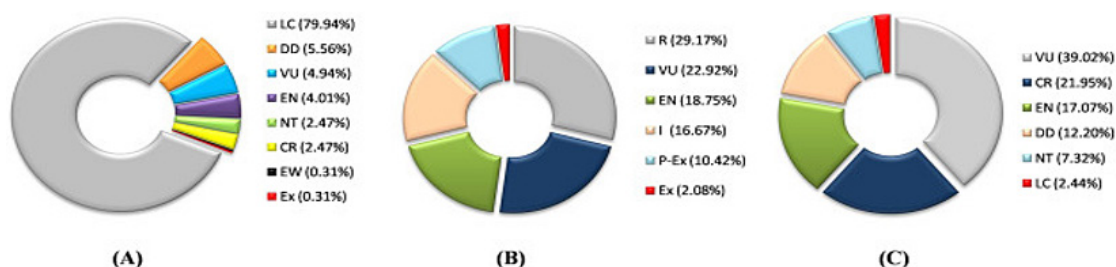
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properties for thousands of years. India, is known for its diverse culture, geography and climate where a very good number of medicinal plants were utilized by practitioners as herbal medicine from one generation to another generations.<sup>4-6</sup> In recent times, a great number of growth promoting rhizobacteria (PGPR) are being used for the formulations for commercial purposes which is considered as an affordable and safe microbiological method to reduce

the reliance on chemical inputs in the cultivation of medicinal plants.<sup>7,8</sup>

According to the Global Strategy for Plant Conservation 2011-2020 of the Convention on Biological Diversity, conservation and assessment of the flora of entire Earth is estimated. International Union for Conservation of Nature (IUCN) listed the threatened species of Meghalaya (Fig.1).<sup>9</sup>



**Fig. 1: Threatened plants in Meghalaya as per (A) IUCN (B) RDB (C) CAMP. (IUCN: International Union for Conservation of Nature; RDB: Red Data Book of Indian Plants, CAMP: Conservation Assessment and Management Plants.**

### Microorganisms and Medicinal Plants

The phytochemicals and antimicrobial properties of extracts obtained from different medicinal plants in combination with beneficial PGPR strains showed significant result to check various pathogenic attack of the host plants. The potential synergistic effects have been observed when most potent plant extracts are combined with suitable antibiotic treatment.<sup>10</sup> Numerous studies have investigated the impact of bio-stimulants, such as microorganism, rhizobacteria for *in-vitro* production of medicinal plants.<sup>11-13</sup>

Numerous studies indicated that humic substances have a great role in improving the absorption of soil elements and have indirect effects on the chemical and dynamic processes of microorganisms in the rhizosphere, which ultimately alters the interaction between the soil, plant and microbiota.<sup>12</sup> The combination of macro and microelements is closely related with the quality of humic substances and thereby facilitation the absorption of nutrients into the host plant.<sup>13,14</sup> Humic substances can be applied through various methods, including soil application, spraying and irrigation.<sup>15-17</sup>

The application of humic substances have been found to increase the biosynthesis and metabolism

of medicinal plants. As a result, there is an increase in the production of metabolites with biological and medicinal properties and humic substances have been found to enhance the production of metabolites with pharmacological properties.<sup>18,19</sup>

Studies have also demonstrated that using bactericides and fungicides can effectively lower the incidence of *P. notoginseng* root rot disease. However, the use of these agents can potentially lead to residual bactericides and fungicides which could pose a threat to the safety of herbal medicine.<sup>20,21</sup> The introduction and colonization of biocontrol microorganisms to combat root-rot disease has been widely reported as an alternative of environment friendly cultural practices. This method involves inoculating the plant with microorganisms that can suppress the growth and activity of root-rot pathogens, effectively reducing the incidence of *P. notoginseng* root-rot disease.<sup>22-24</sup> The diverse metabolic activities of microorganisms make them significant contributors to the biogeochemical cycles. These microorganisms have the ability to transform and cycle arsenic through various processes, highlighting their importance in the natural cycling of this element.<sup>25</sup>

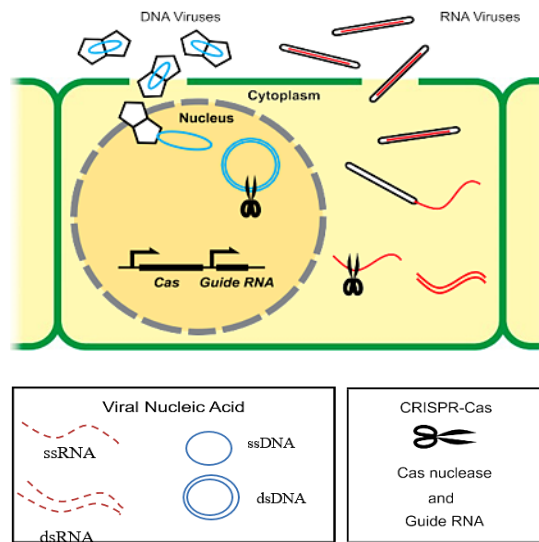
**Beneficial Role of Bacteria in Medicinal Plants Disease Resistance**

In crop breeding, CRISPR/Cas9 is used to accelerate the growth of medicinal plant varieties by increasing the length and Guanine-Cytosine content of sgRNA. The CRISPER/Cas9 system mainly focussed on plant genome modifications by introducing specific mutations in coding regions.<sup>26</sup>

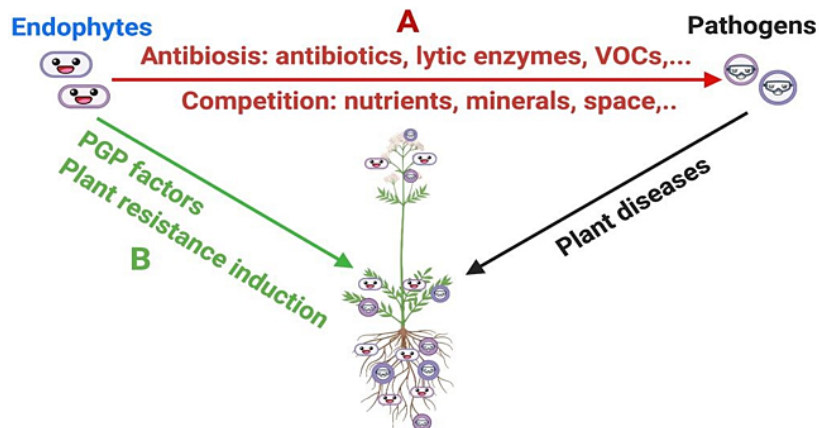
There are two processes i.e., perception of the pathogen attack, followed by responses to limited disease in gene-to-gene plant interaction.<sup>27</sup> CRISPR-

Cas is used as molecular scissors in the field of antiviral defence mechanism in the host plants which breaks the substrate of DNA or RNA molecules at targeted specific sequences. (Fig. 2).<sup>28</sup>

The endogenous phyto-melatonin accumulation was promoted by application of exogenous melatonin.<sup>29,30</sup> Medicinal plants are very important resources for the synthesis of bioactive molecules. The bacterial endophytes also produce antimicrobial against various plant pathogens for the induction of disease resistance in host plants (Fig.2).<sup>31</sup>



**Fig. 2: The use of CRISPR-Cas platforms for generating sequence-specific ribonuclease proteins for the production of viral resistance in host plants.<sup>28</sup>**



**Fig. 3: Role of bacterial endophytes in the host plant. (A): Antibiosis (B): Plant resistance induction.<sup>31</sup>**

### Stress Resistance

PGPR has been reported as a viable remedy for reducing abiotic stresses and heavy metal contamination in plants.<sup>32</sup> It is being reported that application of PGPR enhances the IAA content by increasing the abiotic stress tolerance in wheat.<sup>33</sup>

Study demonstrated that diverse group of endophytes which are growing in wild populations are able to reduce the salinity stress by inhibiting the growth of *Fusarium oxysporum* pathogenesis which is regarded as an excellent tool for the production of biofertilizers and biocontrol agents.<sup>34</sup> The antagonistic rhizobacteria is found to be useful for biocontrol strategies in improving cropping systems.<sup>35-37</sup> A good number of PGPR were found to be associated with the genera like *Azotobacter*, *Pseudomonas*, *Bacillus*, *Mycobacterium*, *Methylobacterium*, *Brevibacterium*, and *Serratia* which enhances the overall plant growth by producing secondary metabolites and protects the host plant against the attack of various plant pathogens.<sup>38</sup>

### Growth Yield

The abiotic stress factors can lead to significant growth and yield reductions in the medicinal plants. Certain types of rhizobacteria enhance the growth and development of host plants directly by the supply of various phytohormones through the siderophores and uptake of soluble phosphates.<sup>39</sup> Plants engage in communication and interaction with a diverse range of microorganism, releasing a range of substances such as organic acids, water soluble sugars, phenolic compounds and hormones and other metabolites into the rhizospheric region of the soil for the nourishment of beneficial microorganisms. The rhizosphere is characterized by a high concentration of nutrients, which attracts a rich diversity of microorganisms, leading to increased interactions between these microbes.<sup>40,41</sup>

Microorganisms present in the rhizosphere are known to impact plant growth through various mechanisms and recycling of soil macro and micronutrients. The various species of *Acidobacterium*, *Bacillus*, and *Cellulomonas* sp. are particularly efficient in the recycling of plant polysaccharides by breaking down these complex compounds into similar forms and thereby helps in the absorption by the roots of the host plant.<sup>42-44</sup>

Secondary metabolites possessing antimicrobial properties can be produced by microorganisms. One such example is the antimicrobial activities showed by *Burkholderia* sp. through the generation of pyrrolnitrin against the various plant pathogens like *Fusarium oxysporum*, *Phytophthora capsici*.<sup>45</sup> In the context of medicinal plants, PGPR are active biological agents in the development of their hosts pharmaceutical properties or even be the primary source of such properties through a range of mechanisms such as nitrogen fixation, phosphate solubilisation.<sup>46-48</sup>

### Commercialization of Medicinal Plants

The separation, quantification and identification of plant extracts pose a complex challenge for the generation of medicinal plant products for commercial practices. To overcome these challenges, various techniques as well as detectors have been formulated to enhance the efficiency and accuracy of extract separation. It aims to improve selectively, sensitively and speed during the separation process, facilitating the commercialization of medicinal plant products.<sup>49</sup> As such, medicinal plant is a critical resource in promoting the well-being of both human and environmental health.<sup>50,51</sup>

The use of herbal medicines with historical roots is deeply embedded in the indigenous knowledge systems. These systems are integral in determining the use of medicinal plants and are an essential part of the local community's way of life.<sup>52</sup> The majority of individuals in the developed countries believe on traditional medicine as their primary source in healthcare practices. This form of medicine has been passed down through generations and is deeply ingrained in the culture and beliefs of these societies.<sup>53,54</sup> Pharmaceutical products in industrialized nations also have an indirect reliance on medicinal plants. Many modern medicines are derived from natural plant compounds, with research continually exploring new plant-based treatments. As such, there is a strong connection between traditional medicine and modern pharmaceuticals.<sup>55</sup> With over 38,660 species of medicinal plants, Asia is a major hub of bioresource centres worldwide. The vast variety of medicinal plants in Asia makes it an essential resource for the healthcare industry.<sup>56,57</sup>

The commercialization of medicinal plants is crucial for generating income and sustaining livelihoods, as well as being linked to the socio-cultural fabric of communities.<sup>58</sup> The utilization of medicinal plants holds significant importance in urban areas, both from an economic and social perspective. It is an essential aspect of healthcare and can provide economic opportunities for those involved in the industry.<sup>59</sup> It has been suggested that individuals with greater economic means would predominantly buy medicinal plants, while those with fewer resources would gather plants from the wild or employ alternative cultivation methods.<sup>60,61</sup>

### Limitations and Future Prospect

For sustainable agricultural practices, PGPR is considered as the important candidate. The PGPR are regarded as the environmentally friendly for the better yield in the crop. These mechanisms includes hormonal regulations, nutritional balance, inducing disease resistance etc. The study the mechanism of the PGPR for plant growth, extensive future research work is very much necessary to understand the biochemical potential of useful PGPR strains in the field of medicinal plant production. Private-public partnership for increased knowledge and improved future training is also very much necessary in the region of Meghalaya for the sustainable development and maintenance of the rare medicinal by the use of PGPR fertilizer. This review also emphasizes on the future prospects of the beneficial use of PGPR biofertilizer for the cultivation of rare and endangered medicinal plants of Meghalaya.

### Conclusion

The utilization of different PGPR formulations for commercial purposes has gained significant popularity in recent times. It is considered as a cost-effective and secure microbiological technique to decrease the dependency on chemical inputs during the growth of medicinal plants. The rhizosphere is a well-known environment that harbors diverse microorganism for the overall growth in the host plants. These microorganisms are found to influence plant growth through multiple mechanisms, including facilitating the recycling of soil nutrients and enhancing the uptake of the essential elements by the plants. It is considered that the use of beneficial strains PGPR will be very much beneficial for the maintenance of sustainable ecosystem. Thus, future research work is very much needed to use the beneficial strains of PGPR and thereby to reduce the application of pesticide especially in the cultivation of medicinal plants in Meghalaya.

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### Conflict of Interest

The authors declare that there is no conflict of interest.

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