**Non-rhizobial endophytes in root nodules**

**Abstract**

Plants of leguminous family are associated specifically with *Rhizobium* sp. which plays a crucial role in agriculture, forestry and nutrient cycling by maintaining soil fertility through biological nitrogen fixation. The Rhizobia includes genus *Rhizobium*, *Mesorhizobium*, *Bradyrhizobium*, *Ensifer* and *Azorhizobium* collectively called rhizobial largely attributed to fix atmospheric nitrogen, a major contributor to the global nitrogen cycle. In addition to strains that can elicit nodules root nodules also accommodate various non-rhizobial bacteria having definite influence on the survival, nodulation and grain yield of the crop. In the absence of positive nodulation tests, they can be regarded as non-rhizobial endophytes (NRE). In past decade, several non rhizobial symbionts capable of forming nodules and fixing nitrogen in legume roots have been documented and grouped under α and β-subclass of Proteobacteria, which include *Methylbacterium nodulans*, *Blastobacter denitrificans*, *Devesia sp.*, *Ochromobacter lupini*, *Agrobacterium*, *Phyllobacterium trifolii*, *Herbaspirillum luzianum*, *Ralstonia taiwanensis*, *Burkholderia tuberum*, *Burkholderia phymatum*, *Burkholderia cepacia*. Few γ-proteobacteria (*Pantoea*, *Enterobacter* and *Pseudomonas*). Actinobacteria (*Arthrobacter*, *Microbacterium* and *Curtobacterium*) and Firmibacteria (*Bacillus*, *Paenibacillus* and *Staphylococcus*) also documented in root nodules. The occurrence of *Bacillus* species as endophyte has been also reported from different plants such as pigeon pea, wheat, kudzu and soybean nodules. These NRE bacteria have beneficial effects on the host plants, including plant growth promotion viz. nitrogen fixation and phosphate solubilization and thereby increase the availability of nutrients to synthesize important biomolecules like nucleic acids, amino acids, proteins etc. which is reflected as better plant growth. Besides these genera, several α- and β-Proteobacteria and several unclassified δ-Proteobacteria were documented in root nodules.

**Keywords:** Legume, Non-rhizobial endophytes, plant growth promotion, *Rhizobium*

**Introduction**

Leguminosae family of plants has more than 19000 species. Currently worldwide revealed that the legumes nodules both wild and cultivated inhabited by Rhizobia. The genus *Rhizobium*, *Mesorhizobium*, *Bradyrhizobium*, *Ensifer* and *Azorhizobium* collectively called rhizobial largely attributed to fix atmospheric nitrogen, a major contributor to the global nitrogen cycle. In addition to strains that can elicit nodules root nodules also accommodate various non-rhizobial bacteria having definite influence on the survival, nodulation and grain yield of the crop. In the absence of positive nodulation tests, they can be regarded as non-rhizobial endophytes (NRE). In past decade, several non rhizobial symbionts capable of forming nodules and fixing nitrogen in legume roots have been documented and grouped under α and β-subclass of Proteobacteria, which include *Methylbacterium nodulans*, *Blastobacter denitrificans*, *Devesia sp.*, *Ochromobacter lupini*, *Agrobacterium*, *Phyllobacterium trifolii*, *Herbaspirillum luzianum*, *Ralstonia taiwanensis*, *Burkholderia tuberum*, *Burkholderia phymatum*, *Burkholderia cepacia*. Few γ-proteobacteria (*Pantoea*, *Enterobacter* and *Pseudomonas*). Actinobacteria (*Arthrobacter*, *Microbacterium* and *Curtobacterium*) and Firmibacteria (*Bacillus*, *Paenibacillus* and *Staphylococcus*) also documented in root nodules. The occurrence of *Bacillus* species as endophyte has been also reported from different plants such as pigeon pea, wheat, kudzu and soybean nodules. These NRE bacteria have beneficial effects on the host plants, including plant growth promotion viz. nitrogen fixation and phosphate solubilization and thereby increase the availability of nutrients to synthesize important biomolecules like nucleic acids, amino acids, proteins etc. which is reflected as better plant growth. Besides these genera, several α- and β-Proteobacteria and several unclassified δ-Proteobacteria were documented in root nodules.

**Conclusion**

Rhizobia are widespread soil bacteria able to induce the formation of root nodules and to fix nitrogen in both cultivated and wild leguminous crops. These rhizobia are of economic importance in low input sustainable agriculture, agroforestry and land reclamation. Currently there are five genera of rhizobia in α-Proteobacteria recognized as *Azorhizobium*, *Bradyrhizobium*, *Rhizobium*, *Mesorhizobium* and *Ensifer*. Besides these genera, several α- and β-Proteobacteria and several unclassified δ-Proteobacteria were recently isolated from nodules of diversified legume plants. These are non nodulating but demonstrate plant growth promotion by different attributes like nitrogen fixation, phosphate solubilization, growth hormone production, siderophores production and control of pathogens by antagonism.

**Acknowledgment**

None.

**Conflict of interest**

None.

**References**


