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Actinorhizal plants: How they fix nitrogen

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Abstract
Nitrogen (N) is one of the most crucial elements for plant development and productivity. Growing plants cannot utilise the approximately 78% of available atmospheric nitrogen because of its stable state. Biological nitrogen fixation (BNF), which has the potential to boost agricultural output and sustainability without compromising the environment or the health of the soil, is one of the potential biological alternatives for N-fertilizers. Plants may utilise ammonia, which is created when biological N fixation (BNF) converts atmospheric nitrogen into it. The use of N2-fixing actinobacteria as a bio-inoculant has shown to be one of the most efficient and ecologically friendly strategies to increase crop plant growth and output because nitrogen is a main limiting factor for plant growth. Actinobacteria that fix atmospheric nitrogen use a nitrogenase enzyme complex to do this (Kim and Rees, 1994).

Keywords: Actinobacteria, biological Nitrogen fixation (BNF), Actinorhizal nodules

Introduction

Actinorhizal plants are a group of angiosperms characterized by their ability to form a symbiosis with the nitrogen fixing actinobacteria *Frankia*. Actinorhizal plants are dicotyledons. This association leads to the formation of nitrogen-fixing root nodules. Actinorhizal nodules have generally an indeterminate growth, new cells are therefore continually produced at the apex and successively become infected. Mature cells of the nodule are filled with bacterial filaments that actively fix nitrogen. Not much information is available concerning the mechanisms leading to nodulation. No equivalent of the rhizobial Nod factors have been found, but several genes known to participate in the formation and functioning of Legume nodules (coding for haemoglobin and other nodulins) are also found in actinorhizal plants where they are supposed to play similar roles.

Total of 200 species of plants belonging to 23 genera of 8 different families of 3 different orders are able to form symbiosis with actinobacteria. Three orders are Fabales, Cucurbitales and Rosales. Fabales consist Casuarinaceae, Betulaceae and Myricaceae. Cucurbitales consist Dasticaceae and Coriariaceae. Rosales consist Rosaceae, Elaeagnaceae and Rhamnaceae.

Actinobacteria are Gram positive, aerobic, and spore-forming, and their DNA contains a significant amount of guanine and cytosine (more than 55% by mole) (Krogius-Kurikka *et al*. 2009) [3]. Numerous nitrogen-fixing actinobacteria, which provide fixed nitrogen to the surrounding plants, have been isolated from the rhizosphere of numerous crops, including Agromyces, Arthrobacter, Corynebacterium, Frankia, Micromonospora, Mycobacterium, Propionibacterium and Streptomyces (Peoples and Craswell 1992; Sellstedt and Richau 2013; Verma *et al*. 2014, 2015) [4, 5].

In both symbiotic and free-living situations, the actinobacteria Frankia spp. aid in the fixation of N in nonlegumes. According to Gtari *et al*. (2012) [1], non-Frankial actinobacteria have significantly risen, which has prompted research into the causes and appearance of diazotrophy in actinobacteria. Mycobacterium flavum, Corynebacterium autotrophicum, and a fluorescent Arthrobacter species have all been reported to have usable nitrogenase activity in the past ten years. Arthrobacter humicola IARI-IIWP-42, a nitrogen-fixing rhizospheric actinobacterium able to fix atmospheric nitrogen, connected to wheat growing in India's central zone, was identified and characterised by Verma *et al*. in 2014 [5]. It has also showed other PGP characteristics in addition to nitrogen fixation, such as solubilization of P (61.9 ± 0.2 µgmg-1 per day) and Zn (2.4 ± 0.1 µgmg-1 per day) and formation of IAA (27.8 ± 1.2 µgmg-1 protein per day).

As in legumes, nodulation is favored by nitrogen deprivation and is inhibited by high nitrogen concentrations. Depending on the plant species, two mechanisms of infection have been described:

- The first is observed in casuarinas or alders and called as root hair infection. In this case the infection begins with an intracellular infection of a root hair and is followed by the formation of a primitive symbiotic organ lacking any particular organization, a prenodule.
- The second mechanism of infection is intercellular entry and is reported in *Discaria* species. In this case bacteria penetrate the root extracellularly, growing between epidermal cells then between cortical cells. Later on *Frankia* becomes intracellular but no prenodule is formed.

Actinorhizal nodules are modified lateral roots with a central stele that houses the vascular tissue. They are produced by cell divisions during the pericycle. Actinorhizal nodules that have reached maturity are essentially collections of coralloid structures with several branched lobes, each of which serves as a modified lateral root.

Nitrogen fixation in Nodules

Frankia can fix N2 both while free-living and in a symbiotic relationship, although there are changes in the subsequent nitrogen metabolism. Although Frankia can assimilate its fixed nitrogen when free-living, this activity is probably carried out by host cells in root nodules. N2 reduction in actinorhizal plants occurs in symbiotic vesicles that separate from the symbiotic Frankia's hyphal tips. Despite the absence of vesicles in Casuarina and Allocasuarina, dinitrogenase activity was discovered to be restricted to hyphae, with Casuarina's intracellular non-septate hyphae being thought of as the symbiotic vesicle's counterpart.

Conclusion

By all these we can conclude as most of the times chemical fertilizers or Rhizobial biofertilizers are used as Nitrogen source in plant but actinobacteria is less popular but having more potential to meet Nitrogen requirement of plants. In future, upcoming days more research work has to be conducted related to actinobacterial nitrogen fixing ability and commercialization of them has to be done.

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