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Rhizobium-Legume Symbiosis and Actinorhizal Symbiosis

Swetha S. Meti
Assistant Professor, Department of Agricultural Microbiology, University of Agriculture Sciences, Raichur, Karnataka

SUMMARY

Rhizobium and Frankia are known to fix atomospheric nitrogen. Rhizobium fixes atmospheric nitrogen in legume crops like Green gram, Cowpea etc where as Frankia fixes atmospheric nitrogen in tree species like Casurina, Alnus sp etc to fix nitrogen in legume crops it involves Rhizobium and legume recognition and attachment, penetration and entry in the host cytoplasm, bacteroid formation and development of mature nodule. Where as Frankia penetrates in to the root cortex intercellularly or intracellularly to form nodules. To have a efficient root nodules and fix atmospheric nitrogen compatible species of Rhizobium and Frankia is required with their respective host plants.

INTRODUCTION

Rhizobium is a gram negative bacterium which help in fixing nitrogen through symbiotic associations with legume plants like chickpea, cowpea, greengram, .*Rhizobium* is a rod shape bacterium, they are aerobic, do not form spores and are characterized based on the species they nodulate this grouping is called cross inoculation group. Nodules are smaller in size (2-5mm) nodule colour is due to leghaemoglobin, *Rhizobium* grows in YEMA medium. Frankia is an nitrogen fixing actinobacterium it is filamentous, branching gram positive actinomycete it forms an symbiotic association with actinorhizal plants. It is a microaerophilic microorganism having high GC% content and grows slowely . It forms multilocular sporangia and hyphae. sporangia is either located terminally or intercalary. Vesicles are the sites of nitrogen fixation. It fixes atmospheric Nitrogen in non legume trees and shrubs like ex: *Alnus rubra, Casurina* etc. nodules are bigger in size (5-6cm) and nodule colour is due to anthocyanin. Frankia grow in propionate media.

Steps involved in *Rhizobium* legume symbiosis

Roots of legume plants secretes number of organic chemicals which are attracted by rhizobia and they move towards roots and starts growing. It is due to the flavonoids secreted by the plants which help in recognition of *Rhizobium* and plant roots. When *Rhizobium* attaches to the root, the root hair curling takes place due to the nod factors secreted by the *Rhizobium* species. Due to the root hair curling bacteria will enter in to the root hair and will induce the plants to form a cellulosic tube which is called as infection thread which is present inside the root hair. *Rhizobium* will enter in to the cytoplasm of the host cell through the infection thread where it gets distributed. Nod factors developed will stimulate the cell division of root cells which leads to the development of root nodule.When bacteria are present in the cytoplasm of the plant root cells which are released from the infection thread bacteria will change its shape in to irregular, swollen and branched. These bacterial structures are called bacteroids. These bacteroids are surrounded by plant derived membrane called peribacteriod membrane which results in the formation of structures called symbiosome, which are the sites of nitrogen fixation. These symbiosomes secretes harrmones which makes the polyploid cells to divide rapidly forming core of the nodule and the diploid cells will differentiate to cover the nodule which forms vascular connections with the root. Leghaemoglobin is secreted, as a result nodules appear pink in colour and help in nitrogen fixation. Haeme content which is a protein is synthesized by *Rhizobium* and globin is synthesized by legume. Leghaemoglobin is an oxygen buffer which keeps oxygen level low. Since nitrogenase enzyme is sensitive to oxygen.

Frankia induced nodulation

Depending on the plant host Frankia can penetrate the root cortex cells either intracellularly or intercellularly. In some of the plants like Casurina, Alnus, Myrica here root hair deformation and penetration occurs. When the root hair curling occurs there is an exchange of signals between Frankia and host cell. After the entry of Frankia filaments in to the curled root hairs infection continues in the root cortex intracellularly. plant derived encapsulation is rich in polygalacturonans along with plasmalemma and cytoplasm near the infected root hairs cell division occurs after infection forming a small protuberance called prenodule which consists of infected

and uninfected cells by Frankia. Prenodule is the primitive symbiotic organ. Mitotic activity takes place in the pericycle cells near to the prenodule resulting in the formation of nodule primordium. After getting infected with frankia the meristems undergo branching resulting in the formation of nodular structure called rhizothamnion which is an modified lateral root. An intercellular penetration is found in some of the plant families like *Rhamnaceae, Rosaceae, Elegnaceae.* During this type of infection root hairs will not be curled nor invaded by the action of actinobacteria. Frankia will enter the root through intercellular spaces found between adjacent epidermal cells and will penetrate midlle lamella and move further apoplastically through cortical cells with electron dense matrix secreted in to the intercellular spaces. Size and composition of the intercellular apoplast will be determined by the host plant for acccomdating frankia. from the pericycle nodule primordium will develop then there will be intracellular penetration by frankia and infection thread will be formed in the cortical cells of nodule primordium. prenodule stage is not observed in this infection process.

Advantages of symbiotic nitrogen fixation

1) Rhizobial inoculants as compared to chemical fertilizers is very low cost. When efficient indigenous rhizobia is inoculated with specific legume group there is an efficient root nodule formation and there will be nitrogen fixation. Hence no need of use of chemical fertilizers.

2) Nitrogen fixation through biological nitrogen fixation is assimilated and transported to host plants trough xylem vessels which supports vegetative and reproductive growth. Hence the

Nitrogen fixation helps in improving soil fertility by remaining in the soil and also helps in recycling of Nitrogen after organic matter decomposition.

3) High efficiency of nitrogen fixation and NO_3^- leaching and denitrification loss are very low hence symbiotic nitrogen fixation is environmentally friendly.

Advantages of Actinorhizal plants

They are tolerant to abiotic stresses, tolerant to salinity .it has beneficial effect on reforestation which helps in Nitrogen fixation in the Nitrogen lost soils and also in mine soils, they can be used for reclaimation of degraded lands.

CONCLUSION

Due to use of chemical fertilizers there is degradation of soil fertility which results in decreased crop yield. Appropriate selection of Frankia strain with compatible actinorhizal plants or tree species and specific legume plants with specific *Rhizobium* strains are very important for symbiosis, nodule formation and nitrogen fixation process and improves soil fertility. In case of Actinorhizal Symbiosis reclaimation of degraded lands is possible.

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