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Rhiz bia Symbi sis in Legumes and N n-Legumes Cr s

Bezabih Addisu*

Gambella University, College of Agriculture and Natural Resources, Department of Plant Science

Abstract

Legumes are very important food sources and therefore, the nitrogen ýxing ability of legume-rhizobia symbioses have great potential to improve crop yields. Biological nitrogen ýxation, an important source of N in terrestrial ecosystems, plays a critical role in terrestrial nutrient cycling and net primary productivity. Symbiotic Nitrogen Fixation is the most e ective and economic measures in agriculture to increase crop yield. Currently, symbiotic rhizobia refer to the soil bacteria in alpha and beta-proteobacteria that can induce root nodules on some legumes and a few of non-legumes. Symbiotic nitrogen ýxation is part of a mutualistic relationship in which plants provide a niche and ýxed carbon to bacteria in exchange for ýxed nitrogen. This process is restricted mainly to legumes in agricultural systems, and there is considerable interest in exploring whether similar symbioses can be developed in non-legumes. A biotechnological approach where cereal crops are engineered to ýx nitrogen has the potential to reduce fertilizer use in the developed world and greatly reduce the environmental impact. Nitrogen ýxation in non-leguminous crops and bacterial associations has been investigated elaborately for their agronomic signiýcance. Three approaches are currently considered as promising such as transfer of nitrogen
abiotic factors include water stress, temperature and soil acidity are inþuenced symbiotic nitrogen ýxation. When studying any living organism, it is important to know how each species grows and responds to certain conditions that can be found in their natural environment. Future Prospects in biological nitrogen ýxation has focus on e cient strain selection, inoculums production and quality. However, the nitrogen ýxation research is the quest for nitrogen ýxation in cereals.

Keywords: Nitrogen xation; Symbiosis; Nodulation; Non-legume; Legumes

Introduction

Nitrogen is one of the most abundant elements in the earth's atmosphere; however, more than 78.08% of the total nitrogen is in the form of nitrogen gas which is unavailable to living organisms, and plays a critical role for plant growth and production. Plants can use nitrogen in the form of ammonium or nitrate ions **[1]**. Biological nitrogen xation (BNF) is one of the pathways of nitrogen (N) inputs performed by free-living or symbiotic N xing organisms represents an important source of N in terrestrial ecosystems. e process of converting atmospheric nitrogen gas into these ions is known as nitrogen xation and it being carried out by nitrogen- xing microbes such as bacteria and algae **[1]**.

Rhizobia are diazotrophic bacteria that x nitrogen a er becoming established inside the root nodules of legumes (Fabaceae). To express

***Corresponding author:** Bezabih Addis, Gambella University, College of Agricultur_ ꜩC ξ ӿ ꞇ ᵀMis an open-access article distributed under the

organic substances from the rhizosphere of host plants **[5]**.

Nitrogen xing prokaryotes (diazotrophs) which are capable of producing the enzyme nitrogenase can x nitrogen. ese diazotrophs can be classi ed into three types: symbiotic (xes nitrogen only in specialized organelle, nodules, formed on speci c hosts of the Leguminoseae family, which forms symbiotic nodules on a variety of non-leguminous tree and shrub families), endophytic (exists inside the root of the plant of both legumes and non-legumes) and free-living (enhances BNF in the rhizosphere of both legumes and non-legumes).

Symbiotic nitrogen xation (SNF) has the highest e ciency of BNF, but it is limited to a few genera of the Leguminoseae. While, most of the crop plants are not capable of forming SNF, they are able to bene t from the nitrogen xed by free-living and associative diazotrophs which exist in the rhizosphere **[6]**. Several mega-grand challenge projects have been commissioned around the world focusing on transfer of the BNF traits from legumes into cereals **[7]**. Most of the attempts to engineer these BNF traits involve transfer of a minimal set of genes from legumes into cereals **[8]**.

Di erent authors recognized that competent rhizobial strains could be applied to legumes and non-legumes to increase their production. According to Abdul (2012), Rhizobium culture signi cantly a ected the growth and yield components of mung-bean. Similarly Mahmoodi reported that the use of appropriate strains of inoculants in nitrogen de cient soils may o er an excellent opportunity for improving legume growth and development.

Other studies have also indicated the contribution of biological nitrogen xation in the growth promotion of non-leguminous plants through associative interaction with diazotrophs. Rhizobial inoculants have been recognized as endophytes (those microorganisms that live within host plants for at least part of their life and do not cause apparent symptoms of diseases) in the roots of non-legumes. Moreover, Sessitsch reported that rhizobia are now considered rhizobacteria of non-leguminous plants.

Rhizobial symbiosis in legumes

Some microorganisms can x nitrogen symbiotically by partnering with a host plant. ere are several examples of symbiotic nitrogen xation such as the water fern Azolla's symbiosis with a cyanobacterium, the symbiosis between actinorhizal trees and shrubs, such as Alder (Alnus sp.), with the actinomycete Frankia. One of the well-known symbioses occurs between two partners, legume plants and rhizobia. e rhizobium -legume symbiotic interactions induces specialized organs known as nodules on the roots of their host, and obtains their nutrients from the host plant. Inside nodules rhizobia reduce atmospheric N_2

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Endophytes

Endophyte has been known for long that some nitrogen- xing endophytic bacteria form nodule-independent association with cereal crops. One of the potent approaches for increasing biological N_2 xation in cereals is to enhance associative or endophytic root colonization by desirable bacteria. e inoculation of non-legumes, especially cereals, with various non-rhizobial diazotrophic bacteria has been undertaken with the expectation that they would establish themselves intercellularly within the root system, xing nitrogen endophytically and providing combined nitrogen for enhanced crop production. Azorhizobium caulinodans is known to enter the root system of cereals, other non-legume crops and Arabidopsis, by intercellular invasion between epidermal cells and to internally colonize the plant intercellularly, including the xylem. A particularly interesting, naturally occurring, non-nodular xylem colonizing endophytic diazotrophic interaction with evidence for endophytic intracellular symbiotic nitrogen xation, without the need for nodulation is that of Gluconacetobacter diazotrophicus in sugarcane.

A rhizosphere-associated nitrogen xation can occur in di erent ways. ey may be endophytic, which reside in the internal tissue of the plant when a lack of Nod genes, which results in a Nod factor-independent infection process, and rhizospheric, which reside within the rhizosphere.

E ect of inoculation of rhizobia on non-legumes crops

Following section highlights the improvement of growth and yield parameters of di erent non-legumes upon inoculation with rhizobia. Several studies indicate that rhizobia may act as natural elicitor for improving the growth and yield of rice. Growth stimulation of rice followed by inoculation with rhizobium has been reported by many workers.

According to Gutierrez and Martinez, (2001) reported that increased in maize yield upon R. etli inoculation. Similarly, while testing nine di erent rhizobial strains for their growth promotion e ects with six di erent non-leguminous plants in laboratory and greenhouse experiments reported that the rhizobial strain PAR-401 was the best for Zea mays and increased shoot and root dry weight of plants.

Furthermore, Ho ich (2000) conducted a series of experiments under greenhouse and eld conditions to see the growth stimulating e ects of rhizobia. He reported that R. leguminosarum bv. trifolii strain R39 promoted the shoot growth of maize grown in greenhouse experiments whereas in eld experiments. A recent report demonstrated that an indigenous maize landrace, characterized by an extensive development of aerial roots that secrete large amounts of mucilage, can acquire 28–82% of its nitrogen from atmospheric dinitrogen. Although the Sierra Mixe maize landrace is unique in the large quantity of mucilage produced, other cereal crops secrete mucilage from underground and aerial roots and we hypothesize that this may represent a general mechanism for cereals to support associations with microbial diazotrophs. A key feature of the Sierra Mixe maize landrace mucilage is the abundance of sugars that potentially serve as a source of energy for the diazotrophs.

e aerial root mucilage was found to maintain oxygen levels below 5% at a depth of 8 mm, suggesting that the mucilage could sustain a micro aerobic environment compatible with nitrogenase activity . Azoarcus sp. Strain BH72, a mutualistic endophyte of rice, is of agro-biotechnological interest because it supplies biologically xed nitrogen toits host and colonizes plants in remark high numbers without eliciting disease symptoms. Used four (BHUE-2, 3, 4 and 5) isolates of rhizobia for rice plant growth response studies under laboratory and greenhouse conditions. All four isolates gave a positive response in enhancing the plant growth measured in terms of plant height and shoot dry weight.

Similarly, tested six rhizobial strains isolated from a wide range of legume hosts to determine their growth promoting activities in lowland rice in a potted soil supplemented with varied amounts of mineral N and reported that inoculation with R.leguminosarum bv.trifolii E11Rhizobium sp. IRBG74, and Bradyrhizobium sp.

Factors affecting symbiotic nitrogen fixation

Several environmental conditions are limiting factors to the growth and activity of the N_2-fixing plants. When studying any living organism, it is important to know how each species grows and responds to certain