Nitrogen Fixation in Moong Bean (Vigna radiata)

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ABSTRACT

Moong (Vigna radiata), commonly known as mung bean, is a leguminous crop recognized for its role in sustainable agriculture through nitrogen fixation. This review explores the mechanisms of nitrogen fixation in moong, its agronomic benefits, and its significance in enhancing soil fertility and crop productivity. Because of its high grain protein level, the mung bean has a lot of potential in tropical climates. The majority of its nitrogen independence from fertilizers is also derived from its capacity to benefit from biological nitrogen fixation (BNF) through connection with native rhizobia populating nodule microbiome. Plant-growth-promoting rhizobacteria can be found in soil microbial communities, which are impacted by biogeographical variables and soil characteristics. The main function of legume root-nodule bacteria in symbiotic N2fixation is indicated by the strong interaction between genotypes for rootdry matter and %Ndfa and soil texture. This study showed that soil characteristics and genotypes have an impact on N2fixation in mungbean, highlighting the necessity of taking soil characteristics into account to optimize mungbean's N contribution to agricultural production systems.

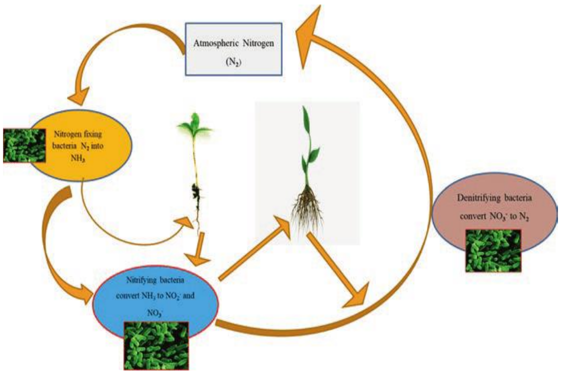
INTRODUCTION

Nitrogen is an essential nutrient for plant growth, yet it is often a limiting factor in agricultural productivity. Leguminous plants, including moong, have a unique ability to fix atmospheric nitrogen through symbiotic relationships with rhizobia bacteria. This process not only enhances soil fertility but also contributes to sustainable agricultural practices. Legumes can fix atmospheric nitrogen (N) and help meet agricultural N needs when they symbiose with rhizobia. In order to improve agricultural nitrogen efficiency and lower nitrogen losses to the environment, nitrogen fixation is crucial (Maseko *et al*. 2020). The process by which N2-fixing bacteria known as diazotrophs convert atmospheric N2 into plant-available ammonia (NH3) through the use of nitrogenase enzymes is known as "biological fixation of atmospheric N2 by legumes" (Unkovich *et al*. 2008). According to Foyer *et al*. (2016) and Peoples *et al*. (1995), legume crops are a good choice for supplying nitrogen (N) to companion and subsequent crops as well as for creating more environmentally friendly production systems. Other stated benefits of adding legumes into crop rotations are improved microbial and crop variety, soil fertility, and reduction of insect incidence (Diatta *et al*. 2016a; Franke *et al*. 2018; Giller 2001; Matusso *et al*. 2014; Singh *et al*. 2020; Vanlauwe *et al*. 2019). Furthermore, under smallholder agriculture, legume crops represent a significant and cost-effective source of protein, minerals, and vitamins for human diets and animal feed (Diatta *et al*. 2016b; Graham and Vance 2003; Tharanathan and Mahadevamma 2003).A popular short-duration legume crop in tropical dry and semi-arid regions is mungbean. It is cultivated on more than 7 million ha and has lately undergone production increases due to the introduction of varieties with short and synchronous maturity, higher yield, and greater disease resistance (Nair *et al*. 2019).

The majority of research on N2 fixation has concentrated on main crop legumes, including cowpea, groundnut, and soybean. On the other hand, estimates of mungbean's biological N2 fixation remain absent (Raji *et al*. 2019). According to a study done in Pakistan by Shah *et al*. (2003), 55–86 kg N ha−1 of fixed N may meet 54–82% of the N requirements for mungbean plants. Nevertheless, lower values between 19 and 47 kg N ha−1—representing between 32% and 49% of mungbean total N needs—were observed by Hayat *et al*. (2008). Rosales *et al*. (1995) recorded values ranging from 21 to 85 kg N ha−1, while George *et al*. (1995) found that N fixed by mungbean ranged from 61 to 90 kg N ha−1.

Nitrogen Fixation Mechanism

1. **Symbiotic Relationship**: Moong forms a symbiotic association with specific strains of rhizobia, primarily *Rhizobium* spp. Upon infection, these bacteria establish nodules on the roots, where they convert atmospheric nitrogen (N_2) into ammonia (NH_3) through the nitrogenase enzyme. Benefiting from a symbiotic connection with local rhizobia bacteria that reside in nodules on its roots is the mung bean (Vigna). An illustration of biological nitrogen fixation (BNF), a process that transforms atmospheric nitrogen (\(N {2}\)) into ammonia (\(NH_{3}\)) that plants may use, is this connection.



Fixing nitrogen symbiotically with biofertilizers source (Research gate)

Process

The bacteria live in nodules on the plant's roots, where they use solar energy to convert N_2 into NH_3. The plant absorbs the NH_3 and uses it for growth.

Mutualistic

Because of the mutualistic nature of the connection, the bacteria and the plant both gains. The bacteria give the plant fixed nitrogen, and the plant gives the bacteria a niche and fixed carbon. The bacteria also consume the carbon and carbs that the plant produces.

Significance

Sustainable food production depends on BNF. It's mostly restricted to legumes in agricultural systems, although researchers are interested in establishing similar symbioses in other plants.

2. **Nodule Formation**: The process begins with root exudates from moong that attract rhizobia. The bacteria penetrate the root hairs, leading to nodule development, where nitrogen fixation occurs. This nodule formation is influenced by plant hormones and environmental conditions.

Here are some additional details regarding nodules and nitrogen fixation:

Rhizobia

The genera Bradyrhizobium, Mesorhizobium, Sinorhizobium, and Rhizobium are among the bacteria that grow nodules on legumes.

Mutually beneficial relationships Rhizobia and legumes have a very specialized connection, with each species or strain interacting with a particular class of legumes.

Fixation of nitrogen via biological means Legumes are not the only organisms that fix nitrogen biologically; lichens, free-living soil bacteria, and blue-green algae are all examples.

Ecological Ramifications: Because biological nitrogen fixation depends only on sunlight for energy, it has few negative ecological effects.

Nitrogen Availability: The ammonia produced is then assimilated into amino acids, which are vital for plant metabolism and growth. Moong not only benefits from this process but also enriches the soil with nitrogen, making it available for subsequent crops.

Agronomic Benefits

1. **Soil Fertility Improvement**: By fixing nitrogen, moong significantly improves soil fertility, reducing the need for synthetic nitrogen fertilizers. This is particularly beneficial in low-input farming systems.

Nitrogen Concentration

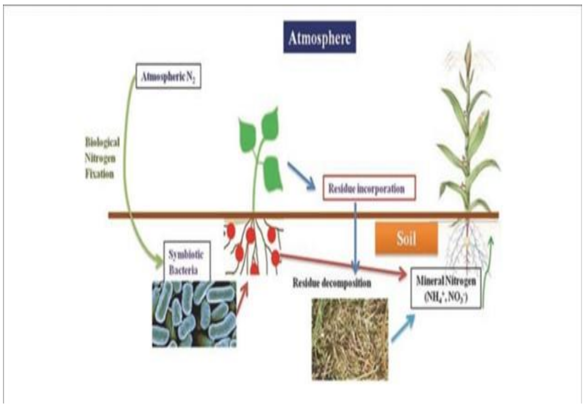
By transforming nitrogen gas from the atmosphere into nitrogen compounds that plants may use, nitrogen-fixing bacteria and plants in the soil raise the amount of nitrogen in the soil.

Plant material

The addition of organic matter to the soil by nitrogen-fixing plants enhances the soil's structure, ability to hold moisture, and ability to retain nutrients.

less requirement for artificial fertilizers

Because nitrogen fixation increases soil fertility organically, less synthetic fertilizer is needed. Nodule degradation Upon legume death, the nodules decompose and blend into the soil, enhancing its fertility.



NO_2 fixation in soil (source: Meena *et al*)

2. **Crop Rotation**: Moong is often used in crop rotation systems due to its ability to restore soil nutrients. Rotating moong with cereals can enhance the yield of subsequent crops through improved soil quality.

Winter wheat and mung beans

A well-defined crop rotation strategy that entails preparing the soil for mung beans in June or July, spreading the seeds, and applying fertilizer. After that, in September, the ground is ready for winter wheat, which is sown in October and harvested in June or July. This rotation technique optimizes agricultural productivity while assisting in the preservation of soil fertility and health.

Rice and mungbeans: After the rice harvest, mung beans can be sown in East Timor's south coast. Broadcasting or manually planting mung beans with a dibble stick are two options. Although broadcasting needs less work, it requires more seed and can be more challenging to weed.

Mungbeans and wheat-or cotton-wheat: Use mung bean types that mature in 70–110 days to include them in these rotations.

Leguminous plants: Crop rotation that includes leguminous crops can help to enhance soil health.

3. **Enhanced Crop Yield**: Fields cultivated with moong exhibit increased productivity in subsequent crops, a result of the residual nitrogen from the previous moong crop. This effect is critical for sustainable intensification of agriculture.

Environmental Impact

1. **Reduction of Chemical Inputs**: The nitrogen-fixing ability of moong reduces reliance on chemical fertilizers, leading to lower production costs and diminished environmental impact, including reduced soil and water contamination.

2. **Biodiversity Promotion**: Incorporating moong into cropping systems enhances biodiversity and promotes ecological balance. Diverse cropping systems are more resilient to pests and diseases.

Challenges and Future Directions

1. **Inoculation Techniques**: While many farmers recognize the benefits of nitrogen fixation, challenges exist in ensuring effective inoculation with appropriate rhizobia strains. Research into improved inoculation methods and the development of superior rhizobial strains is needed.

2. **Climate Resilience**: Investigating the impact of climate change on the nitrogen-fixing ability of moong is essential. Understanding how environmental stresses affect rhizobia and plant interactions can guide future breeding programs.

3. **Awareness and Training**: Educating farmers about the benefits of integrating moong into cropping systems is crucial. Extension services should focus on sustainable practices that highlight the role of legumes in soil health.

CONCLUSION

Moong (Vigna radiata) plays a vital role in nitrogen fixation, contributing significantly to soil fertility and sustainable agricultural practices. Its symbiotic relationship with rhizobia enhances nitrogen availability, benefiting both the crop itself and subsequent agricultural production. Continued research and innovation in cultivation practices, coupled with farmer education, will enhance the role of moong in promoting sustainable agriculture and food security.

REFERENCES

Ali S, Ullah I, Imran M, Ahmad S, Ali Khan A, Ali S, Habibullah M (2015) Phthalporus levels' effects on mungbean cultivars' yield and yield-related characteristics in the Peshawar Valley, volume 5

Dakora FD, Belane AK (2010) Using 15 N natural abundance, 30 field-grown genotypes of cowpea (Vigna unguiculata L. Walp.) in Ghana's upper west were found to have symbiotic N 2 fixation. Fertil Soils Biol 46:191–198. In this case, 10.1007/s00374-009-0415-6

eyan SM, Dakora FD, and Wolde-meskel E (2018) An evaluation of plant development and N 2 fixing in genotypes of soybeans grown in uninoculated soils gathered from several Ethiopian locales Symbiosis: 1–15. The doi: 10.1007/s13199-018-0540-9

Keeney DR, Bremner JM (1966) Identification and investigation of the isotope ratios of several types of nitrogen in soils: 3. Exchangeable nitrate, nitrite, and ammonium by extraction and distillation techniques Soil Science Society of America Proceedings 30:577–582 10.1136/sssaj1966.03615995003000050015x was published online.

Khan E, Sajad MA, and Ali H (2013a) Heavy metal phytoremediation: principles and applications. Chemistry 91:867-981

Hasan A, Ijaz S, Ali S, and Ansar M (2013b) Mungbean (Vigna radiata) yield at semi-arid Pathwar with minimal tillage and di-nitrogen fixation. J Anim Plant Sci Pakistan 23:198–202

M. Chadha (2001) In southern Africa, mungbean (Vigna radiata L.) is a preferred crop for enhancing soil and human health. In: using plants to fight desertification. Pages 263-271, Springer. Use this link to get the 10.1007/978-1-4615-1327-8_25.

Nkgapele RJ, Dakora FD, and Ayisi KK (2000) Six types of cowpea (Vigna unguiculata L. Walp.) cultivated in a nitrogen-rich field soil in South Africa exhibit nodule production and function. The URL is 10.1016/j.soilbio.2012.05.017.

Food and Agriculture Organization (FAO). (2017). *The Role of Legumes in Sustainable Agriculture and Food Systems*.

Giller, K. E., & Wilson, K. J. (1991). Nitrogen Fixation in Tropical Cropping Systems. *Field Crops Research*, 25(2-3), 241-266.

Hungria, M., & Vargas, M. A. T. (2000). Environmental Factors Affecting Nitrogen Fixation in Legumes. *Soil Biology and Biochemistry*, 32(4), 553-565.

Williams R., Chauhan Y. (2018) Physiological and agronomic methods for raising mungbean output in Northern Australia's climate-variable environments Agronomy 8:8