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Role of Soil Microbes in Agriculture; A Review

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Abstract

Soil provides base for agriculture crop production and microbial activity is very important to improve soil health for healthy crop growth because microorganisms play an important role in building a complex link between plants and soil. Soil microbes are a dynamic component of soil and performed many beneficial functions in the soil system. Microbes helps in different biological transformation such as organic matter conversion and biological nitrogen fixation. Moreover, they enhanced the availability of nutrients to the plants. Typically, one gram of soil having more than 90 million bacteria help plants in nutrient uptake by conversion of unavailable nutrients into available form. Due to lack of knowledge regarding their importance, people think about the negative impact of microorganisms because in many cases microbes act as disease-causing agents. However, according to the agricultural point of view microbes are very well beneficial for plant growth. Now a day's biotic stress is a big challenge for agrarian because dramatic increase in the human population is causing land degradation and reduces the microbial population which ultimately negatively affect the plant growth. Therefore, the present review describes the role of soil microbes in agricultural crop production.

Keywords: Soil Microbes; Nutrients; Availability; Agricultural Crop Production

Introduction

Agricultural land is necessary component for food production, shelter and fiber for mankind [1]. In economic development of many developing countries agriculture plays a dynamic role and also provides self-employment [2]. According to many plant physiologists, the soil is the major source of plant nutrients, but soil quality is necessary for agricultural production and quality is improved by soil bacteria, fungi and protists [3]. The microbial biosphere is the largest pool of biodiversity on earth [4]. In other words, microorganisms can be considered as soil machinery to recycle to the nutrients [5]. The quality of soil and its maintenances can be improved by soil microbes within the soil system. The breakdown of organic matter like animal remains and plant remains will be well-ordered by soil microorganisms, the formation of soil structure, and the rate of biogeochemical cycling is also controlled by soil microbes in the soil [6].

Due to a rapid increase in the rate of the human population, the pressure on agriculture land also increases to fulfill the requirement of food, fuel and raw material. To fulfill the requirements famers, apply chemical fertilizers and pesticides but this degrades the soil health and causes decline in soil biodiversity [7]. The demand for production of agriculture is increasing by up to 70% in the coming 30 years. Similarly, now a day's people becoming aware that practices of sustainable agriculture are essential for fulfilling the future world's agricultural demands [8]. Soil is differing all over the world due to its chemical and physical composition [9]. Soil holds millions of microbes which takes part in the improvement of soil fertility and increases plant growth [10]. Soil physical and chemical properties depend on quantity and quality of soil organic matter, pH and conditions of redox potential. All of these significantly influence the structure and dynamics of the microscopic community as well as soil functions [11].

Improvement in soil quality, plant nutrition and maintenance of plant health is a fundamental role of soil microorganisms in agriculture [12]. Generally, people think that microbes are disease-causing agents. The decomposition of organic matter will be done through the help of these microorganisms in the soil [13]. Furthermore, it is noticed that many bacterial species have been used for the mineralization of organic contaminants in soil.

i.e. bioremediation of soil pollutants [14]. Therefore, the present review describes the role of soil microbes in agricultural crop production.

Microbial Diversity and Its Interaction With Plant-Soil System

Soil microorganisms like bacteria, algae, fungi, actinomycetes, protozoa and the infective agents such as viruses are the bodies within the massive resources of activities of microscopic diversity [15]. These soil microorganisms perform many valuable functions as well as some harmful impacts. In the soil profile, the impact of soil biota is multifarious and difficult since the same action may be harmful or positive depending on its position [16]. On the other hand, plants show a different range of interactions with these soil-dwelling microorganisms which extends the full variety of biological possibilities (competitive, exploitative, neutral, commensal and mutualistic). However, according to current situation, the alleviating pathogenic effects such as infection and herbivory are more studied [17].

As the interactions between plant and microscopic communities are predisposed by various agronomic managements and biological factors predominantly in the present situation of worldwide revolution, the influence of ecological stress aspects must be considered, as they affect proper management of the interactions between crop-microbiome [18]. The soil formation with a high level of soil fertility is a result of more than hundreds of years of soil "evolution" this statement is not surprising due to the complex interactions among microbes and plant-soil system. [19]. The interaction among microbes and plants within the soil system is shown in Figure 1.

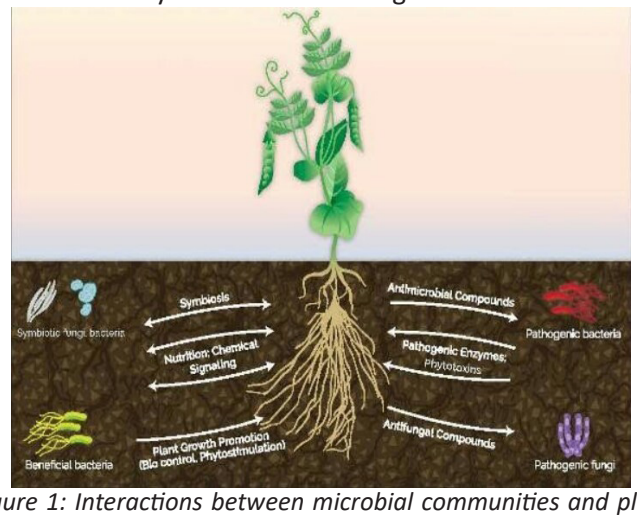

Figure 1: Interactions between microbial communities and plant (Source: Google).

Beneficial Aspects of Microbes

The soil fertility and its formation from mineral bedrock involves a multifarious interaction of chemical, physical and biological processes. The development rate of the soil is controlled by some factors such as topography, climate, time, bedrock type, plants and microbes [20] that's why the status of nutrients is determined by the quality and identification of microbes in soil [11]. Three types of machines are typically studied and put forward to describe that how microscopic activity can lead to the improvement in plant growth:

a. by manipulating the plant hormonal signaling [21];

b. by pathogenic microscopic strain outcompeting or repelling [22] and

c. by increasing soil-borne nutrients bioavailability [23].

Soil microbes create a link between soil and roots, nutrients recycling, organic matter decomposition and react rapidly to any variations that occur in the ecology of soil by performing as perfect indicators for definite functions in the surroundings of soils [24]. To increase plant yield, a range of non-symbiotic bacteria (Azotobacter, Azospirillum, Bacillus and Klebsiella sp.) and symbiotic bacteria (Rhizobium sp.) are now being used globally (Figure 2) [25]. The living constituents of soil organic matter is microbial biomass [26]. In the meantime, microbes are valuable in reducing the problems that are related to the application of chemical fertilizers and pesticides, they are extensively being applied in natural agricultural land and organic agriculture [27]. Microbial biomass affects nutrient storage, nutrient transformations, and cycling as the active component of organic matter [26].

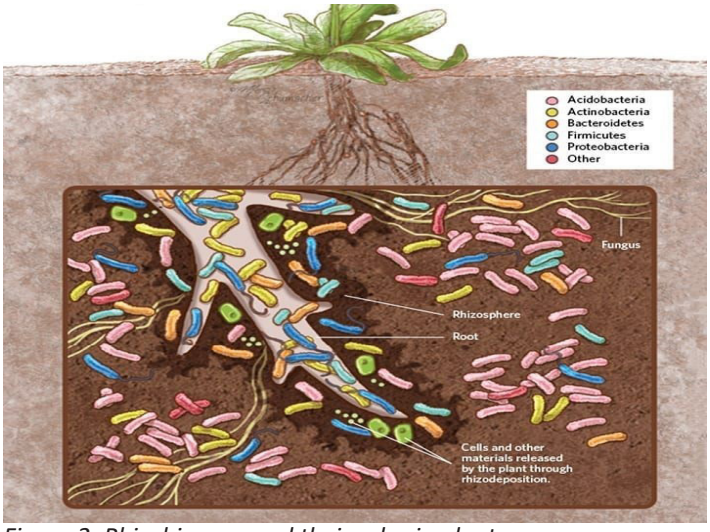

Figure 2: Rhizobium sp and their roles in plant.

The soil production and soil fertility may increase by both fungi and bacteria with organic matter [28]. According to an estimation, soil with the weight of one gram may

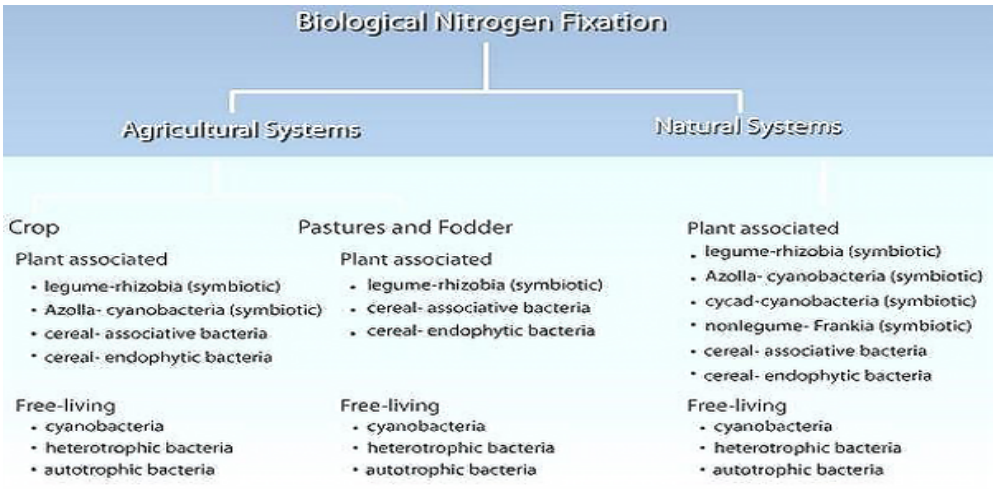

Figure 3: Types of microorganisms involved in BNF at a glance.

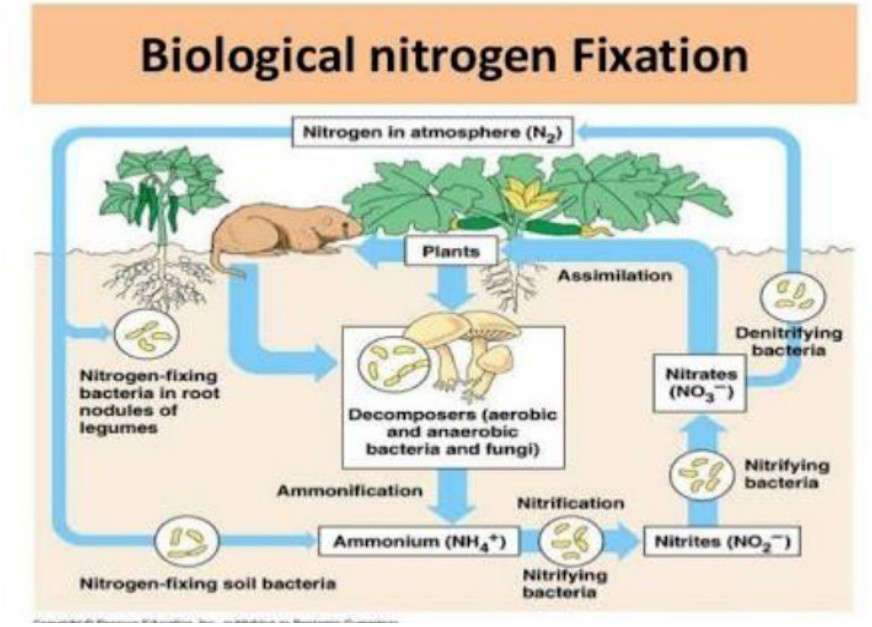

Figure 4: Biological nitrogen fixation cycle.

comprise 200 m hyphae of fungal and 6,000–50,000 species of bacteria [29] and the bulk of them are considered to be favorable for soils as well as plants. By controlling the source of obtainable nutrients to pathogens valuable microbes can overturn the growth of phytopathogens in a variability of ways such as contending for space and nutrients [30]. It also helps in plant growth promotion as well as phytopathogen suppression and causes mineral uptake from the soil, nutrient achievement and organic matter decomposition [31].

Nitrogen-Fixing Bacteria

Nitrogen plays an important role in the production of food and promotes plant growth, it is also essential for the synthesis of cellular enzymes, chlorophyll, proteins, RNA and DNA. Nitrogen is provided through the fixation of symbiotic interaction of atmospheric N2 by nitrogenase in rhizobial bacteroids for the nodulating legumes. In agriculture currently, 65% of the nitrogen is utilized through the process of biological nitrogen fixation and will remain to be vital in upcoming sustainable systems of crop production [31]. Favorable plant mutualistic symbionts comprise multifunctional arbuscular mycorrhizal (AM) fungi and the nitrogen-fixing bacteria. The diverse genera of bacteria collectively named "rhizobia" are capable to fix nitrogen in mutualistic symbiosis with plants legume [32]. It should be stated that nitrogenase genes are existing in miscellaneous microbial taxa concerning the taxonomy of nitrogen-fixing symbioses [33]. Significant biochemical reactions of biological nitrogen fixation occur mostly through the symbiotic relationship of legumes with nitrogen-fixing

microbes that alters elemental nitrogen into ammonia [34] and that non-leguminous plants have been recognized to host nitrogen-fixing microbial strains of bacteria [35] possibly indicating that other plant microorganism mixtures (not just legumes and Rhizobia) could be correspondingly optimized to indorse N2- fixation [36]. Other bacteria (actinomycetes) belonging to the genus Frankia form nitrogen-fixing nodules on the root of the so-called "actinorhizal" plant species having a great environmental significance [37-40]. The Group of microorganisms involved in biological Nitrogen Fixation is shown in Figure 3 and process of BNF is given in Figure 4.

Conclusion

In nutrients cycling within the soil microorganisms play a vital role and and all the beneficial microbes are located around the root zones of the plant. Microorganisms are the indicator of soil health as well as soil productivity. The presence of organic matter within the soil is itself nothing until or unless beneficial microorganism's act on it and convert it into available form (humus) by releasing the different types of enzymes. Manipulating the interaction between plant and microbes is leads to an increase in plant growth as well as soil health within the ecofriendly environment. Therefore, it is concluded that soil health and crop production can only be improved by soil microbes.

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