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Review on the Role of Soil Microorganisms on Soil Physico-Chemical Properties and Plant Growth

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Abstract
The review summarizes the literature on the role of soil microorganisms on soil physico-chemical properties and plant growth. Most of investigators confirmed that Soil 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 help 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: Crop Production, Organic Matter, Soil Fertility, Soil Healthy, Soil Microbes
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1. INTRODUCTION

Agricultural land is necessary component for food production, shelter and fiber for mankind (Arshad A *et al*., 2020). In economic development of many developing countries agriculture plays a dynamic role and also provides self-employment (Gindling TH, and Newhouse D, 2012). 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 protests (Muller DB *et al.*, 2016). The microbial biosphere is the largest pool of biodiversity on earth (Bhatacharyya PN, 2012). In other words, microorganisms can be considered as soil machinery to recycle to the nutrients (Mus F *et al*., 2016). 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 (Kelly J, RL Tate 1998).

Soil holds millions of microbes which takes part in the improvement of soil fertility and increases plant growth (Christos *et al*., 2014). 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 (Lombard N *et al*., 2011). Improvement in soil quality, plant nutrition and maintenance of plant health is a fundamental role of soil microorganisms in agriculture.

Soil microorganisms represent the largest and most diverse biotic group in soil and their activities have the importance role in transformation on plant nutrients to available form and also have metabolisms related to soil fertility improvement. Soils bacteria have an important role in the nutrient cycling and influence decomposition and nutrient mineralization in the terrestrial ecosystems (Kathiresan, 2002). Distribution of microorganisms in forest soils is mostly determined by vegetation and soil physical and chemical properties. Microbial communities degrade most of the organic material that settled on the forest soils. The organic matter decomposition rate depends of physical factors, substrate quality and the type of microbial community. The degradation of certain compounds by specific microorganisms, lead to a succession of microbial community until all the substrate is completely decomposed.

Application of beneficial microbes may be a potential alternative to harmful chemical fertilizers and pesticides. Microbes stand an important role in improving crop productivity and soil management. Plant-associated soil microbes play a crucial role in plant growth and development such as nutrient cycling and crop productivity (Yan *et al*., 2015). Soil microbial dynamics determine the potentiality of soil crop productivity. While the interaction of plant and microbes is major factor for controlling ecosystem functioning, these plant–microbes interactions vary greatly and depend upon availability of nutrient and. Plant growth promoting microbes mostly used for plant growth promotion through various means such as plant growth regulation and nitrogen fixation (Ahmad *et al*., 2008). 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 (Garbeva P, 2004). Furthermore, it is noticed that many bacterial species have been used for the mineralization of organic contaminants in soil.

1.1 The objective of this paper

Hence, in this review paper, we have reviewed the literatures to explain the role of soil microorganisms on soil physic-chemical properties and plant growth.

2. LITERATURE REVIEW

2.1 The Role of Microorganisms in the Soil

Soil microorganisms are involved in many biogeochemical processes. They are a very important functional group of soil organisms. They are responsible for mineralization of organic matter, element circulation, synthesis of proteins, and nucleic acids, as well as transformation of phosphorus forms. Rhizosphere microorganisms increase plant health and can protect against pathogens (CHEN, X. *et al*., 2004).

Agricultural biodiversity concerns with indigenous bacteria, plants, fungi, animals, and their equivalents introduced into the agricultural space by man related to the structure of soil and its use (Conant, R. T., 2007). It is estimated that from 1 g of soil, about 4000–6000 different bacterial genomes can be isolated (Lugtenberg B, 2015). Classic microbial analyses of microorganisms allow isolating 0.1–10% of the population of bacteria present in the environment. The other species are not reared, which means that they cannot be reared under laboratory conditions. In research on the presence of microorganisms in soil, it is important not only to evaluate their quantitative, and qualitative assessment, but above all to perform their functions, their role in the ecosystem, and their impact on other organisms. The biological activity of the soil depends on the correct number and species composition of microorganisms and their enzymatic activity. Microorganisms mediate 80–90% of all processes occurring in the soil (Schulz S *et al.,* 2013). They create favorable conditions for germination of seeds and growth of the root system of cultivated plants, which is very important for a high yield (Brussaard, L., 1993). plants emit a large number of various chemical compounds into the soil, which shape the composition of microorganisms in the environment. Microorganisms use these root secretions as a source of food. The rhizosphere is a habitat mainly for bacteria and mycorrhizal fungi. Some microorganisms may produce antibiotics that block harmful microorganisms. In addition, soil microorganisms can also improve the condition of plants by releasing growth regulators (e.g., ethylene, auxin, and cytokine) and making available some nutrients (e.g., phosphorus). Polymer-producing microorganisms can improve the soil structure. Among the significant soil microorganisms, it is worth mentioning the bacteria of the genus *Pseudomonas* sp., bacteria that inhabit the root zone of plants (Gindling TH, Newhouse D., 2012).

Microbes in soils play a central role in in diverse ways, including cycling of nutrients that are essential for life, conversion of organic materials that are formed by primary producers back to CO2 during respiration. The microbes are, sometimes, assisted by such higher animals as herbivores and carnivores by digesting crude organic material with the aid of intestinal tracts microbes (decomposition). Microbes are also important in mineralization of organic compounds which occurs after being completely degraded completely into such inorganic products as CO2, NH3 and H2O. Fungi are the major agents of organic matter decomposition in the soil ecosystems. Both the fungi and bacteria, however, degrade complex organic molecules impossible for higher organisms to break down. A vast array of bacteria, notably those in Actinobacteria and Proteobacteria, break such soluble organic molecules as amino acids, organic acids and sugars as reported by Eilers *et al.* (2010). Also, some of such bacteria as Bacteroidetes, assist in degrading more resistant C compounds like lignin, chitin and cellulose. Bacteria targeting such recalcitrant C compounds may need relatively high available N rates in order to support extracellular and transport enzymes production (Treseder *et al*., 2011). Low N environments adapting bacteria, in contrast, are more capable of metabolizing such organic N compounds as amino acids.

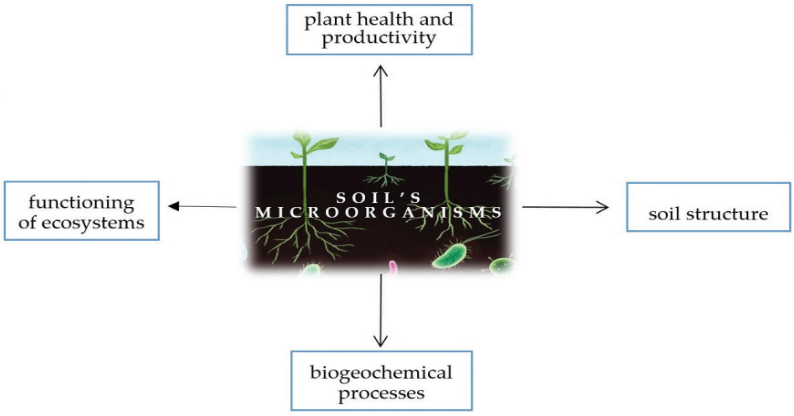

Figure 1 Functions of soil microorganisms.

2.2 The role of microorganism on the soil physico-chemical property

Soil microorganisms play an essential role in decomposing organic matter, cycling nutrients and fertilizing the soil. Without the cycling of elements, the continuation of life on Earth would be impossible, since essential nutrients would rapidly be taken up by organisms and locked in a form that cannot be used by others. The reactions involved in elemental cycling are often chemical in nature, but biochemical reactions, those facilitated by organisms, also play an important part in the cycling of elements. Soil microbes are of prime importance in this process.

Soil microbes are also important for the development of healthy soil structure. Soil microbes produce lots of gummy substances (polysaccharides and mucilage, for example) that help to cement soil aggregates. This cement makes aggregates less likely to crumble when exposed to water. Fungal filaments also stabilize soil structure because these threadlike structures branch out throughout the soil, literally surrounding particles and aggregates like a hairnet. The fungi can be thought of as the "threads" of the soil fabric. It must be stressed that microbes generally exert little influence on changing the actual physical structure of the soil; that is performed by larger organisms. Soil microorganisms are both components and producers of soil organic carbon, a substance that locks carbon into the soil for long periods. Abundant soil organic carbon improves soil fertility and water-retaining capacity. There is a growing body of research that supports the hypothesis that soil microorganisms, and fungi in particular, can be harnessed to draw carbon out of the atmosphere and sequester it in the soil. Soil microorganisms may provide a significant means of reducing atmospheric greenhouse gasses and help to limit the impact of greenhouse gas-induced climate change (Christopher Johns, 2017).

2.2.1The role of microorganism on soil physical property

Another aspect of soil health is the soil's physical condition-degree of compaction, amount of water storage, and drainage. When aeration, water availability, and soil strength are beyond optimum ranges, plant growth suffers. A soil's physical condition is influenced partially by organic matter because polysaccharides and polyuronides produced during decomposition help promote aggregation of soil particles. Secretions of mycorrhizal fungi are also important in promoting soil aggregation (Wright and Starr, 1998).

Microorganisms possess the ability to give an integrated measure of soil health, an aspect that cannot be obtained with physical/ chemical measures and/or analyses of diversity of higher organisms. Microbes aid soil structure by physically surrounding particles and 'gluing' them together through the secretion of organic compounds, mainly sugars. Microorganisms also affect the physical properties of the soil. Production of extra-cellular polysaccharides and other cellular debris by microorganisms help in maintaining soil structure as well as soil health. Thereby, they also affect water holding capacity, infiltration rate, crusting, erodibility, and susceptibility to compaction (Elliott *et al.,* 1996). Changes in microbial populations or activity can precede detectable changes in the soil's physical and chemical properties, thereby providing an early sign of soil improvement or an early warning of soil degradation (Pankhurst *et al.,* 1995).

Kalhapure et al. (2013) observed lower values of bulk density and higher values of infiltration rate were in the treatments where green manuring and compost are applied as organic fertilizers. Application of 25% RDF+ biofertilizers (*Azotobacter*+ PSB) + green manuring with sun hemp+ compost resulted in lowest bulk density (1.30g/cm3) and highest infiltration rate (3.74cm/hr) after harvesting the maize crop (Table 2). This treatment also recorded maximum values of decrease in bulk density and increase in infiltration rate, respectively over the initial values of these parameters. The main reason of decreasing bulk density was aggregation of soil particle due to increasing organic matter as well as stability of aggregates which leads to increase the total pore space in soil. Islam *et al.* (2012) has been also concluded that addition of organic matter through organic fertilizers decreases the bulk density of soil.

2.2.1.1The role of microorganism on soil structure
Soil structure strongly affects the distribution and functioning of microbes and microbial communities, the micro biota also play important roles in soil structural dynamics (Brussaard & Kooistra, 1993). Microbes create soil structure by a number of direct and indirect processes, including:
(i) Moving and aligning primary particles along cell or hyphal surfaces;
(ii) Adhering particles together by the action of adhesives involved in colony cohesion, and other exudates, such as extra-cellular polysaccharides (eps);
(iii) Enmeshment and binding of aggregates by fungal hyphae and actinomycete filaments, and associated mycelia;
(iv) Coating pore walls with hydrophobic compounds, particularly by fungi which produce such polymers to insulate their mycelia, which have a relatively large surface area: volume ratio.

These basic processes also operate to stabilize soil structure, noting that they all require the provision of energy to be manifest, and are linked to soil, vegetation and management type (Miller & Jastrow, 2000; Bronick & Lal, 2005). This explains why there is a relationship between SOM and what is perceived as 'good' soil structure. Soil structure is also destroyed by the action of microbes, since much of the organic material which serves to bind soil particles together is also potentially energy-containing substrate which microbes will decompose if they can gain access to it. This is the reason why frequent soil disturbance, such as where repeated tillage is applied to soils, typically leads to a degradation of soil structure and a loss of soil C (Conant *et al.,* 2007).

2.2.1.2 The role of microorganism on soil aggregation
Living microorganisms can adhere to soil minerals by forming direct electrostatic bonds (Huang *et al*., 2005). The microbial cell walls involved in these bonds are frequently stable against biotic decomposition (Chenu and Stotzky, 2002), and many of them persist after the death of the bacterium (Amelung *et al*., 2008). These findings were supported by observations of high proportions of amino sugars, which are of microbial origin and which were also found to be enriched within micro aggregates and fine-sized soil fractions (Zhang *et al*., 1999; Rodionov et al., 2001). Accordingly, Miltner *et al*. (2012) identified residues of microbial cell wall envelopes associated with micro aggregates. In this regard, bacteria attached to clay particles or small micro aggregates may actually serve both as a 'composite building unit' and as a nucleus for initial aggregation.

2.2.1.3 The role of microorganism on soil compaction
Soil compaction may cause problems by changing porosity in the soil. This has effects on biological activity, especially on enzymatic activity of the soil and may have negatively influenced on the plants and roots growth. Compaction can influence on the plant-available nutrients because the number and activity of microorganisms may be changed (Lee *et al.*, 1996). Li *et al.* (2003) indicated a reduction of biomass and microbial activity in compacted soils. The community of total bacteria was sensitive to the increase in soil density. Buck *et al.* (2000) and Dick *et al.* (1988) also detected reduction in dynamic processes, such as enzymes activities, especially dehydrogenases and phosphatases activities in compacted soils.

2.3 The role of microorganism on soil chemical property
Includes the levels of available nutrients, the pH, the salt content, etc. are important determinants of soil health. Plant growth can be adversely affected by either low nutrient levels, high levels of a toxic element (such as Al), or high salt concentrations. The biological, chemical, and physical aspects of soils all interact with, and affect, one another. For example, a very compact soil has few large pores and thus is less hospitable to organisms such as springtails, mites, and earthworms. In addition, lower levels of oxygen in compact soils may influence the forms of nutrients present and their availability (e.g. significant quantities of NO3 may be lost under anaerobic conditions).

According to Zak *et al*. (1994) who stated that bacteria and fungi are the major types of microorganisms found in soil and play an essential role in nutrient transformations and litter decomposition rates. Soil types influence the structure of microbial communities, especially bacterial population among soils of different textures (Garbeva *et al*., 2004 and Fang *et al*., 2005). 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 (Nihorimbere V *et al*., 2011).

Primary source of nitrogen for plants is atmospheric nitrogen gas (N2). Microorganisms are absolutely required to transform N2 into plant food. Electrical conductivity levels can serve as an indirect indicator of the amount of water and water-soluble nutrients available for plant uptake such as nitrate-N. Areas of saline soils need to be identified and managed differently from areas of non-saline soils. Soil microorganism activity declines as EC increases. This impacts important soil processes such as respiration, residue decomposition, nitrification, and denitrification.

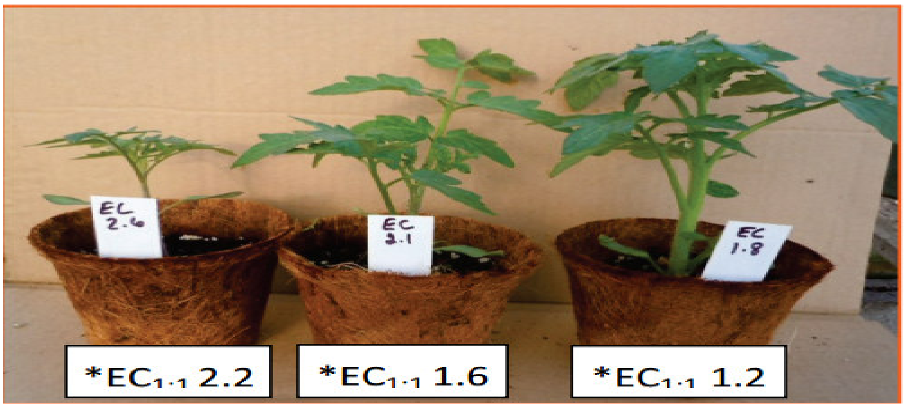

Figure 2 EC1:1 values using compost and tap water for tomatoes (Gage, 2012).

CONCLUSION

Soil microbes are the most important candidature for enhancing soil fertility and health. The plant growth promoting microbes and arbuscular mycorrhizae (AM) are used for enhancing plant growth and yields of agricultural crops under normal and stress conditions. It improves plant growth on various physiological parameters of plant in response to external stimuli by a number of different mechanisms.

In nutrients cycling within the soil microorganisms play a vital role 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 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.

Generally we organized this review from different scholar finding and we recommended that Soil microorganism play crucial role in improving the soil fertility and crop production so, it is better to create suitable environment for microbes to do their activities.

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