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Role of Biofertilizer in Agriculture

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Abstract

The worldwide increase in human population every year raises a major threat to the food security of the people as the land for agriculture is restricted and even drastic reduction with time. Therefore, it is essential that agricultural productivity should be enhanced significantly within the next few decades to meet the large demand of food by emerging population. Due to dependence on chemical fertilizers for more crop productions damages both ecosystem and human health with great severity. Biofertilizers are one of the greatest nature gifts of our agricultural science as partial replacement for chemical fertilizers. Biofertilizer contains microbes which encourage the adequate supply of nutrients to the host plants and ensure their proper development of growth and regulation in their physiology. Living microbes are used in the preparation of biofertilizers. Biofertilizers being essential components of sustainable farming play vital role in maintaining long term soil fertility and sustainability of crop production.

Introduction

Conventional agriculture plays an important role in meeting the food demands of a growing human population, which has also led to an increasing dependence on chemical fertilizers and pesticides (Singh *et al*., 2014). Chemical fertilizers are industrially manipulated substances which are composed of specific quantities of nitrogen, phosphorus and potassium, and their exploitation causes air and ground water pollution by eutrophication of water bodies. In this regard, recent efforts have been channelized more towards the production of 'nutrient rich high quality food' in sustainable comportment to ensure bio-safety. The innovative view of farm production attracts the growing demand of biological based organic fertilizers exclusive of alternative to agro-chemicals (Nedunchezhiyan *et al*., 2018). In agriculture, encourage alternate means of soil fertilization relies on organic inputs to improve nutrient supply and conserve the field management. The additional advantages of biofertilizers include longer shelf life causing no adverse effects to ecosystem. Organic farming is mostly dependent on the natural micro flora of the soil which constitutes all kinds of useful bacteria and fungi including the arbuscular mycorrhiza fungi (AMF) called plant growth promoting *rhizobacteria* (PGPR). Biofertilizers keep the soil environment rich in all kinds of micro- and macro-nutrients *via* nitrogen fixation, phosphate and potassium solubilization or mineralization, release of plant growth regulating substances, production of antibiotics and biodegradation of organic matter in the soil (Bhardwaj *et al.,* 2014).

Role of Beneficial Microbes in Sustainable Agriculture

The rhizosphere is the narrow zone of soil around plant roots, which can comprise up to 10^{11} microbial cells per gram of root. The collective genome of rhizospheric microbial community around plant roots is larger compared to that of plants and is called as microbiome, and interactions with plant determine the crop health in natural agro ecosystem by providing numerous services to crop plants like organic matter decomposition, nutrient acquisition, water absorption, nutrient recycling, weed control and bio-control. The agriculturally beneficial microbial populations which cover plant growth promoting *rhizobacteria*, N_2-fixing *cyanobacteria*, *mycorrhiza*, plant disease suppressive beneficial bacteria, stress tolerance endophytes and biodegrading microbes. Biofertilizers are a supplementary component to soil and crop management traditions like crop rotation, organic adjustments, tillage maintenance, recycling of crop residue, soil fertility renovation and the biocontrol of pathogens and insect pests, which can be helpful in maintaining the sustainability of various crop productions (Sahoo *et al*., 2013). *Azotobacter, Azospirillum, Rhizobium, Cyanobacteria, Phosphorus* and *Potassium* solubilizing microorganisms and *mycorrhizae* are some example of the PGPRs that were found to increase in the soil under no tillage or minimum tillage treatment. Efficient strains of *Azotobacter, Azospirillum, Phosphobacter* and *Rhizobacter* can provide nitrogen to *Helianthus annus* and to increase the plant height, number of leaves, stem diameter percentage of seed filling and seed dry weight. A synergistic interaction of PGPR and AMF was better suited to 70% fertilizer plus AMF and PGPR for P uptake (Bhardwaj *et al.,* 2014) (Figure 1).

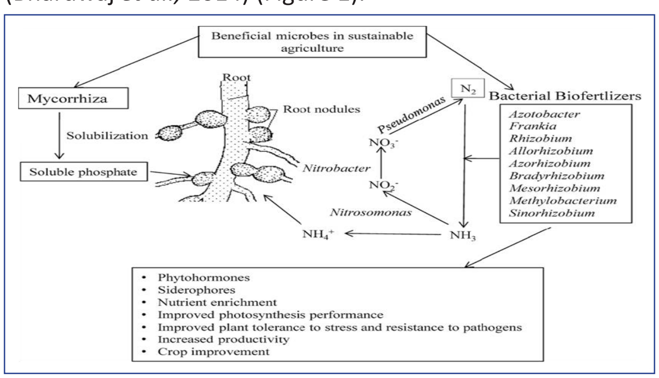

Figure 1: Potential use of soil microbes in sustainable crop production

Nutrients Improvement of Crops by Biofertilizer

Beneficial microbes can assimilate phosphorus for their own requirement, which in turn available as its soluble form in sufficient quantities in soil. *Pseudomonas, Bacillus, Micrococcus, Flavobacterium, Fusarium, Sclerotium, Aspergillus* and *Penicillium* have been reported to be active in the solubilization process. Similarly, two fungi *Aspergillus fumigates* and *A. Niger* were isolated from decaying cassava peels were found to convert cassava wastes by the semi-solid fermentation technique to phosphate biofertilizers. *Burkholderia vietnamiensis*, stress tolerant bacteria, produces gluconic and 2-ketogluconic acids, which involved in phosphate solubilisation. *Enterobacter* and *Burkholderia* were found to produce siderophores and indolic compounds (ICs) which can solubilize phosphate. Potassium solubilizing microorganisms (KSM) like genus *Aspergillus, Bacillus* and *Clostridium* are found to be efficient in potassium solubilization in the soil and mobilize in different crops. Mycorrhizal mutualistic symbiosis with plant roots satisfies the plant nutrients demand, which leads to enhance plant growth and development (Bhardwaj *et al.,* 2014).

Effect of Biofertilizers on Plant Tolerance against Environmental Stress

Abiotic and biotic stresses are the major obstacles which are affecting the productivity of the crops. Many methods of modern science that have been extensively applied for crop improvement under stress, and PGPRs play significant role as bio protectants. *Rhizobium trifolii* inoculated with *Trifolium alexandrinum* showed higher biomass and increased number of nodulation under salinity stress condition. *Pseudomonas aeruginosa* has been reported to withstand the biotic and abiotic stresses. *P. fluorescens* MSP-393 produces osmolytes and salt-stress induced proteins that overcome the negative effects of salt. *P. putida* Rs-198 improve the germination rate and several growth parameters like plant height, fresh weight and dry weight under condition of alkaline and high salt via increasing the rate of uptake of K^+, Mg^{2+} and Ca^{2+} and by decreasing the absorption of Na^+. Few strains of *Pseudomonas* conferred plant tolerance *via* 2,4-diacetylphloroglucinol (Schnider-Keel *et al.,* 2000) (Figure 2).

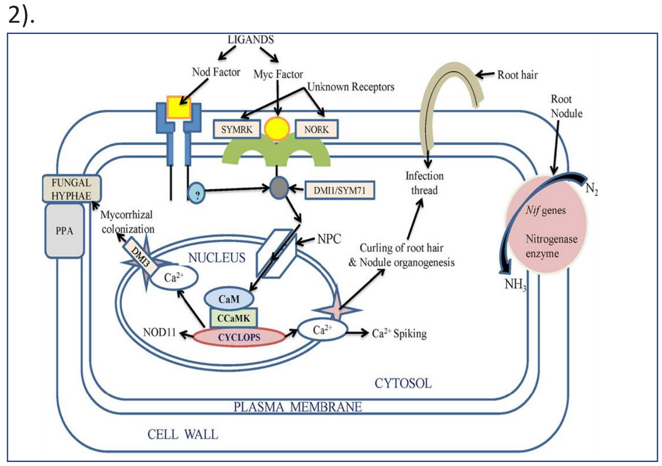

Figure 2: Hypothetical mechanism of action of biofertilizers in the root

Conclusion

Biofertilizers can help solve the problem of food production due to increase in global population at a time when agriculture is facing various environmental stresses. It is important to realize the useful aspects of biofertilizers and implement its application to modern agricultural practices. The new technology developed using the powerful tool of molecular biotechnology can enhance the biological pathways of production of phytohormone. If identified and transferred to the useful PGPRs, these technologies can help provide relief from environmental stresses. However, the lack of awareness regarding improved protocols of biofertilizer applications to the field is one of the few reasons why many useful PGPRs are still beyond the knowledge of ecologists and agriculturists. Nevertheless, the recent progresses in technologies related to microbial science, plant-pathogen interactions and genomics will help to optimize the required protocols. The success of the science related to biofertilizers depends on inventions of innovative strategies related to the functions of PGPRs and their proper application to the field of agriculture.

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