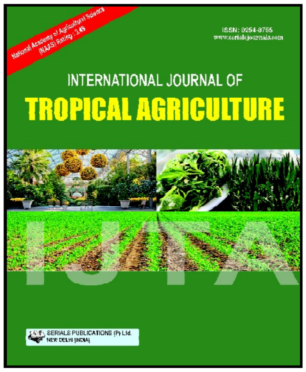

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Utilization of Potential Microorganisms for Sustainable Agriculture

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Abstract: Biodiversity is one of important bioresource on the planet Earth. Microbes are small size and having enormous impact on our lives, hence understanding of their role in the environment is great concern in order to maintain and exploit the microbial diversity on the earth. Microbes possess the largest genetics diversity on Earth; billions of species of bacteria are supposed to be exist on biosphere, however only 1-5% are characterized. They are ubiquitous and cosmopolitan in nature and can exist in most inhospitable habitats with extreme temperature, pH, water and salt stress. Selection of microbes their conservation and different test assays are the key steps in developing new technologies for the effective exploitation of microorganisms in various fields such as for sustainable agriculture, protection of environment, human and animal health. There are various microbial applications are widely used in solving major agricultural reforms i.e., crop productivity, plant health protection, and soil health maintenance and environmental issues like bioremediation of air soil and water from organic and inorganic pollutants. It is expected that microbes in combination with developments in electronics, software, digital imaging, and nanotechnology will play a significant role in solving global problems of the twenty-first century, including climate change. These advances are expected to enhance sustainability of agriculture and the environment. This article provides an overview of current trends in microbial exploitation in biotechnological application towards sustainable agriculture.

Key Words: Soil, Microbes, Sustainable agriculture, microbial application

INTRODUCTION

The microorganisms have been used since past 50 years in order to advance medical technology, human and animal health, food processing, genetic engineering, environmental protection, agricultural biotechnology, and more effective treatment of agricultural and municipal wastes provide a most impressive record of achievement. Many of these technological advances would not have been possible using physico-chemical methods.

Soil ecosystems are highly complex and dynamic in nature having an extremely varied biota comprising plants, animals and microbes. Soil is a highly heterogeneous matrix and is a habitat of an extremely diverse community of microorganisms including bacteria, fungi, archaea, protozoa, and algae. The soil micro-biota is the 'biological engine of the earth' essential for sustaining vital ecosystem processes and maintaining soil functions. Microbes play a fundamental role in a wide range of soil ecological processes, energy flows, degradation of toxic materials, and thus are a key player in climate change mitigation. Soil microorganisms are a key component of food webs, they regulate bio-geochemical nutrient cycling such as in the nitrogen cycle, and hence regulate the nutrient availability for the primary producers. Microorganisms possess inherent potential for modification of the soil physical structure so that to better withstand with disturbances and stress, allowing for more flexible responses to environmental changes than in low diverse communities. The microbial application for economic or industrial purposes has advanced considerably with fast-paced developments in industrial microbiology and biotechnology. Additionally the microbes were also exploited in various agricultural fields likes PGPR, endophytes and many other kinds. Microbial diversity has provided invaluable service to mankind since the ancient time. Almost all antibiotics have their origins in the metabolites of soil bacteria, especially within a family known as Actinomycetes. Microbes are also used to produce vaccine providing humans with immunity against several lethal diseases such as measles and smallpox. In addition, microorganisms are factories for industrial enzymes production which are used to enhance detergents, to clean up toxic wastes, to replace chemicals in paper and pulp processing, and for oil extraction. Furthermore, microorganisms and their enzyme systems are responsible for the degradation of organic matter. The wastewater treatment uses microbes to decompose organic matter in sewage. This article highlights the application of microbes in sustainable agriculture sectors.

BIOFERTILIZER AND BIOPESTICIDE

Microbes are the important tool as a biofertilizers and biopesticides (Bhardwaj et al., 2014). Microbial biofertilizers are the substances that contain microorganism in live state and applied either on the seed or plant surface and soil and consequently colonize the rhizosphere and help to promote plant growth by supplying primary nutrient to the host (Bhattacharyya and Jha, 2012). Microbial biopesticides are those microorganisms that protects and promote plant growth by controlling phytopathogenic agents through a wide variety of mechanisms like, HCN production, siderophores, production of hydrolytic enzymes and production of antibiotics acquired and induced systemic resistance (Chandler et al., 2008). Researchers are paying attention to exploit the native microorganisms to develop biofertilizer and biopesticide which assist in plant growth promotion as well pest and disease control. Rhizobia are known for their ability to colonize the root nodules, where the bacteria can fix nitrogen to ammonia and make it available to the plant. Addition of efficient *Rhizobium* strains in soil is in practice in various crops, because they can improve the soil fertility and help in plant growth by improving nutrient availability. However, scientific preparation and application of microbial formulation is important while developing the agriculture in a sustainable way.

AGRICULTURALLY IMPORTANT MICROBES (AIMS)

AIMs have diverse applications in various areas of agriculture sectors. AIMs are generally defined as a large group of frequently unknown microorganisms as described by Bhattacharyya et al. (2016). AIM interacts favorably in soils with plants to render the beneficial effects which are sometimes difficult to predict. There are beneficial effects that have been shown by microbial species of AIMs on certain plant species. Such microbes are *Bradyrhizobium* sp., *Azotobacter chroococcum, Azospirillum basilensis, Pseudomonas sp*, *Rhizobium* sp., etc. have been established to show their potential in plant growth promotion. The microorganisms also play a key role in crop protection through the process of biocontrol which help in disease resistance capacity of plants against phytopathogens, exhibiting antagonistic activities or acting as biotic elicitors against different biotic and environmental factors. Microorganisms are valuable in managing the various types of insect's pests, plant diseases, weeds, and other pests that usually damage the agricultural crops and forestry. Fungi is able to colonize in upper parts of the plants and provide benefits from drought as well heat tolerance, resistance to insects, and various plant diseases (Singh et al., 2011). Microbial biotechnology and its application in sustainable development of agriculture and environmental health are getting better attention.

MICROBES IN NUTRIENT MANAGEMENT

Nutrient management deals with utilization of soil and essential NPK inputs with diverse microbial communities that directly or indirectly helps in exploitation for nutrient use and enhances the efficiency for improving the quality of plant as well as soil health and environment (Miao et al., 2011). It is well known that plants usually absorb nutrients directly or indirectly from the soil through rhizosphere or using phyllosphere. Various types of chemical compounds (root exudates) are released through different parts of the plant root system that may create a special environment in the rhizosphere. The nature of these compounds is generally low/high-molecular weight and volatile organic compounds (VOCs) (Ortiz-Castro et al., 2009). Low-molecular weight compounds generally consist of sugars, amino acids, organic acids etc. and various secondary metabolites while, high-molecular weight compounds constitute, mucilage and proteins, whereas CO_2, certain secondary metabolites, alcohols are considered as volatile in nature. Some abiotic factors such as temperature, light and soil type can also directly or indirectly affect the nature and timing of root exudation. The plants grown under low phosphate condition or in the presence of toxic compounds the exudation of various organic acids such as citric acid, malic acid etc. is particularly increased. These compounds might act as signals for microbial colonization or it can be used as carbon sources for microbial nutrition.

Beneficial microbes are having potential to make associations with higher plant that ultimately helps in supplementing the important nutrients such as nitrogen, phosphorus and potassium. Arbuscular mycorrhizal fungi are a group of micro-biota for their symbiotic associations with the roots of higher plants. Their mode of nutrition might be obligate or saprophytic in nature and hence require a living host for their survival. The symbiotic associations with plant roots, mycorrhiza helps in the absorption of minerals such as P, water, and other important macro and micro elements that make them available for the growing plants. Various algal genera such as *Anabaena*, *Oscillatoria*, *Phormidium* etc. are well known for their ability to fix atmospheric nitrogen and helps the plant for growth. There are also certain blue-green algae that possess the ability for symbiotic associations with some other beneficial microorganisms such as fungi, mosses, liverworts, and aquatic ferns (*Azolla*) and thereby contribute significantly in the nutrient management process (Bhattacharyya et al., 2016).

MICROBES AS TOOL FOR BIOREMEDIATION

Bioremediation is the promising tool for the degradation of xenobiotic compounds using plants or microorganisms (algae, fungi, bacteria, actinomycetes etc.) via altering them into non toxic elements with little or no toxicity and consequently forming innocuous end products (Davis et al., 2003). In order to improve the process of bioremediation, various approaches have been employed which depends on the type of the contaminated environment. Among them bio-stimulation, involves encouraging the growth of indigenous microorganisms by addition of nutrients at the desired polluted site. As a consequence, the rate of biodegradation/could be enhanced. Other approach is well known as bio augmentation or bio addition where the addition of microbial species or accumulation of microbial populations to indigenous, alien or genetically modified organisms, in places where there is an failure of indigenous microorganisms to potentially mineralize to the pollutants. Microbes have been exploited with diverse approaches to overcome the toxic effects of metals and metalloids, utilizing accumulation, resistance or, more interestingly, by reducing their bio-availability or toxicity through bio-methylation and transformation (Gupta et al., 2016). It is predicted that the higher concentrations of waterborne heavy metals toxicity as an environmental problem in various aquatic ecosystems worldwide. Most of the heavy metals reach in ground water and others accumulate in seafood or in plants through bioaccumulation and create a major toxicity source for human beings. The rhizosphere is the most important site for amplified microbial activity that may enhance accumulation, degradation and bio-methylation of heavy metals like Se and other trace elements. Microbes in the rhizosphere are known to simplify the removal of toxic heavy metals or metalloids originated from wastewaters through process of biosorption, sulfide-precipitation, and biotransformation.

CONCLUSIONS

Microbial communities are potentially influenced by various natural and anthropogenic activities such as intensive agriculture, indiscriminate use of pesticides, pollution and urbanization. With the rapid increase of world population, there is a consequent increase in the rate of resource utilization and environmental perturbation. On the other hand, there is a urgent need to sustain and increase agricultural productivity and human health. Unexplored microbial diversity and available culturable microbes are the main bioresource to be exploited in order to solve the major challenges of twenty-first century. The genetic potential of various extreme habitats are considered to be useful for industrial technology. Future research and extension would go a long way toward applications of microbes for the improvement of environmental quality, agricultural productivity, human health and for novel uses such as global climate change etc. Efforts should be directed toward investigation of various unexplored habitats of microbial resources, exploitation of plant health and bioremediation research. The advancement in metagenomics, functional genomics led to the novel applications in sustainability of the environment and role of microbes in global climate change, crops, new drugs development, and transgenic development.

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