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Impact of global climate change on beneficial plant-microbe association

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ABSTRACT

Soil is considered as the hot-spot region of beneficial plant-microbe association. A wide range of soil microbial categories like nitrogen-fixing bacteria, ecto and endo-mycorrhizal fungi and plant growth-promoting bacteria and fungi are seemed to be associated with this beneficial plant-microbe association. The soil microbes confer increased plant growth and productivity against the root pathogenic fungi, bacteria, viruses and nematodes by a wide variety of mechanisms like phosphate solubilization, siderophore production, biological nitrogen fixation, phytohormones production, exhibiting antifungal activity, production of volatile organic compounds (VOCs), induction of systemic resistance (ISR) etc. Beneficial soil microbes have also been engineered to interfere with the synthesis of stress-induced hormones such as ethylene that can retard the root growth in plants and to produce antibiotics and lytic enzymes that predominantly exhibited their activity against the soil-borne root pathogens. However, a change in the type, distribution and coverage of soil microbial populations may occur with the changing climate scenario. Agricultural land-use systems along with proper exploitation of beneficial microbial strains are, therefore, regarded as one of the most effective climate change resilience farming systems as it promotes the proper management of soil, water, biodiversity and local knowledge, thereby, acting as a good alternatives for adaptation to climate change. In the present review, an attempt has been made to critically review the possible intervention of climate change on beneficial soil microbes associated with the plants.

Keywords: Climate change resilience farming systems, pathogen, phosphate solubilization, plant-microbe association, soil microbes.

INTRODUCTION

Climate change is the significant statistical change in distribution of weather patterns over an extensive period of time, ranging from decades to millions of years [1]. Climate change is usually caused by factors like oceanic circulation, variations in solar radiation, plate tectonics, volcanic eruptions and man-made alterations. Extensive loss of sea ice, accelerated rise in sea level, more intense heat waves, longer periods of drought and an increase in the number, duration and intensity of tropical storms are due to this global climate change. Global surface temperatures are predicted to increase in between 1.8 and 3.6 $^{\circ}$C by the year 2100 due to this climate changing phenomenon.

Soil is as an excellent medium for the growth and development of plants as well as microbes [2]. The plant-microbe interaction in soil is either beneficial or harmful. The beneficial plant-microbe interactions are caused by symbiotic or non-symbiotic bacteria and a highly specialized group of fungi (mycorrhizal fungi). Beneficial plant-associated microbes are known to stimulate the plant growth and enhance their resistance to degenerative diseases and abiotic stresses. Bacterial genera such as *Azospirillum*, *Bacillus*, *Pseudomonas*, *Rhizobium*, *Serratia*, *Stenotrophomonas* and *Streptomyces* fall under this category. These are popularly known as plant growth promoting rhizobacteria (PGPR). Growth promoting substances are produced in large quantities by these soil microorganisms that influence indirectly on the overall morphology of the plants. Mycorrhizal fungi, on the other hand are known for its symbiotic associations with the roots of many different plants ranging from garden vegetables up to the trees of old growth forests. Approximately 6000 species of Glomeromycotina, Ascomycotina and Basidiomycotina have now been reported as mycorrhizal [3]. There also exits mycorrhizal helper bacteria (MHB) that usually get involved in this mycorrhizal establishment and functioning. Enhancement in nutrient acquisition pathway, production of plant growth regulators, alterations in physiological and biochemical properties of the host plant and defending the plant roots against soil-borne pathogens are the possible mechanisms usually involved during this beneficial association [4]. Understanding the interactions in between the soil microorganisms routinely associated in the rhizosphere (it is the volume of soil, directly under the influence of living plant roots, meant for significant stimulation of microbial diversity and function) is, therefore, essential for better explanations about the soil-plant interface.

Change in climate can alter the environmental conditions drastically as a result of which plant-microbe associations are affected [5]. The mycorrhizal hyphal growth is reduced due to elevated CO_2 concentrations. Elevated CO_2 concentration is likely to increase the C (carbon) allocation to the plant roots and thereby significantly hampers the normal physiological and growth promoting activities of plant root associated microbes [6]. Increase in temperature can significantly alter the structure of mycorrhizal hyphal network system that may be linked to faster C allocation. Drought stress, another consequence of global climate change, is known to reduce the formation of extra mycorrhizal mycelium in plant roots. Different PGPRs, ecto or endo mycorrhizal taxa, however, respond differently to droughts in terms of their patterns of abundance. Examples are from mediterranean shrubs such as *Pinus muricata* and *Pinus oaxacana* etc. where drought significantly decreased the microbial colonization process [7]. Drought is also known to bring the losses in the photosynthates accumulating in the plants during photosynthesis. In stress agriculture, the rhizobacterial inoculants can thus, be used either as biofertilizer, plant strengthener, phytostimulator or biopesticide, depending on their mode of action and effectively.

Generally the symbiotic interactions in between the legumes and rhizobia get enhanced due to global climate change. Plant associated bacteria exclusively depends on the root exudates or plant metabolites and therefore, are influenced by the change in plant physiological processes like respiration, transpiration and photosynthesis. Exploitation of beneficial plant-microbe interactions could promote promising and environmentally friendly strategies in sustainable agricultural practices. Technologies have, therefore, been developed to use these microbial inoculants for use in stress agricultural biotechnology, which are usually generated by factors like drought, water logging, heavy metals and pathogenicity. Efforts have also been concentrated to introduce the beneficial plant-microbes as a mitigative measure on climate resilient agriculture. However, more research is needed to assure the general patterns of climate change on different groups of plant-associated microorganisms that respond differently in changing climate scenario.

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