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Effects of Climate Change on Plant Microbial Interaction

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Abstract: Global climate change is very serious concerns to every living organism on the planet earth. It is estimate that there is drastic change in biosphere due to changing climatic conditions and subsequent to alteration in plant microbe interactions and agricultural practices for sustainable development. Some of the microflora residing in association with plants generally promote plant growth along with showing disease resistance against stress. Moreover, climate change also directly influences the crop production and the structural dynamics of the relationships among diseases and crops. There are variety of physiological functions of plants that is supported by microbes likes biogeochemical cycles, phosphate solubilization, siderophore production etc. can be affected due to climate change.

INTRODUCTION

Microbes are ubiquitous and cosmopolitan in nature, however, in soil the microorganisms play pivotal role in biogeochemical cycling, ecosystem functions and services (Conant *et al.*, 2011). Earlier researcher explored that temperature may potentially involve and influence the metabolic activity and development of various microorganisms (Bradford *et al.*, 2010). Additionally environmental factor, precipitation is an important for enhancing the microbial activity when dropping over the dried soils (Austin *et al.*, 2004; Li *et al.*, 2018). Although there is scanty information on the effects of water availability on microbial activity. The effects of different climatic conditions in the environment directly or indirectly are corelated with the functionality of microbes. According to the reports of Intergovernmental Panel on Climate Change (IPCC), the atmospheric CO_2 concentration is continuously increasing in the environment (IPCC Climate change, 2007). Due to continuous increasing temperature it is possible that moisture content of water is expected to decrease in some areas and consequently create drought situations in different areas of the world. The continuous changing environmental conditions is affecting by and large the plant and microbes interactions in the soil ecosystem adversely. Owing to the changing environmental condition, the physiological activities of the plant are also little bit changed. They possess inherent potential to choose different pathways in order to complete their life cycle for their better metabolic activity and survival. It is demonstrated that under warming condition, the plants are able to sprouting out and shows early stage of flowering in the growing season (Cleland *et al.*, 2007, Wolkovich *et al.*, 2012). It is assumed that change in climatic condition may alter the root phenology and plant-rhizosphere interactions (Iveresen *et al.*, 2015).

The plant growth-promoting microorganisms having potential to colonize inside and nearby areas of the rhizosphere. The soil directly attached with the root surface are impacted by root exudates released by microorganisms along with population density of the microorganisms (Lugtenberg and Kamilova, 2009). It is reported that some microorganisms survive and penetrates through the root and rhizosphere of the host plants and promote the metabolic activity as an endophyte. Plant growth promoting arbuscular fungi such

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as arbuscular mycorrhizae, ectomycorrhizae, endophytic fungi and plant growth-promoting rhizobacteria are the group of microorganisms that promotes and help in growth of crop plant for sustainable agriculture. These microbes are majorly exploited as a biocontrol agent against variety of phytopathogens, potential biofertilizers, phytostimulators in agriculture as well as for decontamination of contaminated environment (Lugtenberg and Kamilova,2009) These important mechanisms adopted by the microorganisms in soil microbiota is adversely affected by altered environmental conditions.

There are several greenhouse gases like CO_2 (Carbon dioxide), CH_4 (Methane), O_3 (ozone), N_2O (Nitrous oxide), Chlorofluorocarbon, etc. and heavy metals such as Cd, Pb, and Hg are the factors which interfere the interaction among the plant and microbes. This chapter mainly focussed on the impact of environmental pressure on the interaction of microbes with the plant.

Effect of Temperature on Plant-Microbe Interaction

Currently it is reported that temperature plays pivotal role in plant growth and phenological characteristics along with their distribution and presence of microbial population in specific community (Sharma *et al.*, 2022). The increase in average temperature of the planet earth may directly influences the morphology of the different crop plants It is estimated by earlier researches that global warming could have a direct impact on microbial respiration rates present in the roots and rhizosphere (Classen *et al.*, 2015).

The Intergovernmental Panel on Climate Change reported that atmospheric carbon dioxide concentration is increasing continuously and altering the environmental conditions (IPCC, 2007). The global warming may occurs due to increase influx of greenhouse gases and afterward temperatures enhancement, ozone levels also impact the structural composition of microbial communities and its functional dynamics, which directly or indirectly influence the further co-evolution of plants and their pathogens (Singh *et al.*, 2019). It is predicted that slight changes in soil moisture may shows shifting of fungal community from one dominant member to another while no change in bacterial communities were observed.

Stress and heavy metal pollution

The organic carbon content of soil is in such area where heavy metal pollution loads is present and may lower the efficacy of the microbial population in mineralization of organic compounds. This is an plausible indication of the heavy metal pollution on soil microbial communities (Kozdroj, E.Jdvan.,2001). Arbuscular mycorrhizal fungi (AMF) possess potential to respond with higher temperature and promote plant colonization for the majority of strains for growth and development.

It is demonstrated that fungi function as parasitic in the form of necrotrophic fungi that kill the host cell by secretion of toxin and biotrophic, which directly feed on living host cells. They are responsible for inducing variety of disease symptoms such as leaf spots and cankers in plants (Laluk and Mengiste., 2010; Doughari., 2015; Sobiczewski *et al.*, 2017). Other microbes, such as nematodes directly feed on the plant parts and primarily causing soil-borne diseases leading to nutrient deficiency, stunted growth & wilting (Lambert and Bekal., 2002; Osman *et al.*, 2020; Shukla *et al.*, 2022).

CONCLUSION & FUTURE PERSPECTIVE

Each organism from unicellular to multicellular residing on planet earth is directly or indirectly influenced by changing environmental conditions. Microbes having beneficial properties could be useful and can be exploited for the improvement of agricultural crop plants in sustainable manner. Moreover, the variety of microbes which is associated with plant using indigenous mechanisms they survive against biotic and abiotic stresses. It is investigated that some of the indigenous microbial communities plays a role model for maintaining the plant health. Hence, it is vital to exploit and promote beneficial microbial communities. It is warranted that concerted efforts in research are needed to explored the effects of climate change on microbial communities through an experimental studies.

References

Austin AT, Yahdjian L, Stark JM, Belnap J, Porporato A, Norton U, Ravetta DA, Schaeffer SM. Water pulses and biogeochemical cycles in arid and semiarid ecosystems. Oecologia. 2004 Oct;141(2):22135.doi: 10.1007/s00442-004-1519-1. Epub 2004 Feb 24.

Bradford, M. A., Watts, B. W., & Davies, C. A. (2010). Thermal ad-aptation of heterotrophic soil respiration in laboratory mi-crocosms.Global Change Biology, 16, 1576–1588. https://doi.org/10.1111/j.1365-2486.2009.02040.x

Conant, R.T., Ryan, M.G., Ågren, G.I., Birge, H.E., Davidson, E.A., Eliasson, P.E., Evans, S.E., Frey, S.D., Giardina, C.P., Hopkins, F.M., Hyvönen, R., Kirschbaum, M.U.F., Lavallee, J.M., Leifeld, J., Parton, W.J., Megan Steinweg, J., Wallenstein, M.D., Martin Wetterstedt, J.Å. and Bradford, M.A. (2011), Temperature and soil organic matter decomposition rates – synthesis of current knowledge and a way forward. Glob. Change Biol., 17: 3392-3404. https://doi.org/10.1111/j.1365-2486.2011.02496.x.

Classen, A. T., Sundqvist, M. K., Henning, J. A., Newman, G. S., Moore, J. A. M., Cregger, M. A., *et al.* (2015). Direct and indirect effects of climate change on soil microbial and soil microbial-plant interactions: what lies ahead? Ecosphere 6:130. doi: 10.1890/ES15-00217.1.

Cleland, E. E., I. Chuine, A. Menzel, H. A. Mooney,and M. D. Schwartz. 2007. Shifting plant phenology in response to global change. Trends in Ecology and Evolution 22: 357– 365.

Doughari, J. (2015). An overview of plant immunity. J. Plant Pathol. Microbiol. 6:104172. doi: 10.4172/2157-7471.1000322.

IPCC (2007) Climate change 2007: the physical science basis. Cambridge University Press, Cambridge

J Kozdroj, E Jdvan. Structural diversity of microbial communities in arable soils of a heavily industrialized area determined by PCR-DGGE fingerprinting and FAME profiling. Applied Soil Ecology, 2001, 17(1):31-42.

Laluk, K., and Mengiste, T. (2010). Necrotroph attacks on plants: wanton destruction or covert extortion? Am. Soc. Plant Biol. 8:e0136. doi: 10.1199/tab.0136

Lambert, K., and Bekal, S. (2002). Introduction to plant-parasitic nematodes. Plant Health Instruct. 10, 1094–1218. doi: 10.1094/PHI-I-2002-1218-01

Osman, H. A., Ameen, H. H., Mohamed, M., and Elkelany, U. S. (2020). Efficacy of integrated microorganisms in controlling root-knot nematode Meloidogyne javanica infecting peanut plants under field conditions. Bull. Natl. Res. Centre 44, 1–10. doi: 10.1186/s42269-020-00366-0.

Sharma, B, Bansh Narayan Singh, Padmanabh Dwivedi and Mahendra Vikram Singh Rajawat. 2022. Interference of climate change on plant-microbe interaction: present and future prospects. Front. Agron. 3:725804. doi: 10.3389/fagro.2021.725804.

Sobiczewski, P., Iakimova, E., Mikiciński, A., Wêgrzynowicz-Lesiak, E., and Dyki, B. (2017). Necrotrophic behaviour of Erwinia amylovora in apple and tobacco leaf tissue. Plant Pathol. 66, 842–855. doi: 10.1111/ppa.12631

Singh VK, Shukla A K and Singh AK 2019. Impact of climate change on plant–microbe interactions under agroecosystems. Climate Change and Agricultural Ecosystems (Eds., Chaudhary KK, Kumar A and Singh AK) Woodhead Publishing ,153-179. doi.org/10.1016/B978-0-12-816483-9.00007-4

Shukla, A K, V K Singh, and S Maurya (2022). Climate Change: A Key Factor for Regulating Microbial Interaction with Plants. A. Vaishnav *et al.* (eds.), Plant Stress Mitigators, https://doi.org/10.1007/978-981-16-7759-5_2.

Wolkovich EM, Cook BI, Allen JM, Crimmins TM, Betancourt JL, Travers SE, Pau S, Regetz J, Davies TJ, Kraft NJ, Ault TR, Bolmgren K, Mazer SJ, McCabe GJ, McGill BJ, Parmesan C, Salamin N, Schwartz MD, Cleland EE. Warming experiments underpredict plant phenological responses to climate change. Nature. 2012 May 2;485(7399):494-7. doi: 10.1038/nature11014.