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ISSN: 1948-5948
Journal of Microbial & Biochemical Technology

Perspective

Effect of Microbial Inoculants on Microbial Communities in Soil

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DESCRIPTION

The application of bio stimulants is considered as particularly appealing because it would significantly minimise the need of chemical fertilizers and pesticides, and an increasing variety of inoculants are presently being sold for diverse crops. Microorganisms, particularly Plant Growth-Promoting Microorganisms (PGPMs) play a vital role in agricultural systems. Changes in microbial composition may be undesirable if important native species are lost, potentially affecting future crops. The benefits of plant growth can be attributed primarily to three mechanisms: PGPMs that act as biofertilizers help plants absorb nutrients by supplying fixed nitrogen or other nutrients. Phytostimulators can directly increase plant growth by releasing plant hormones. Plants are protected against phytopathogenic organisms by biological control agents. A change in the bacterial community structure generated by inoculation, on the other hand, could be buffered by ecosystem resilience, which is determined by the level of diversity and interactions of the plant-soil-biota. The loss of some bacterial species, however, may not affect the system's functioning due to bacterial redundancy, because different bacterial species may carry out the same duties.

The soil microbial community is complex and dynamic, with composition varying between compartments and levels, posing a significant problem in soil ecology. The representativeness of the sampling is a critical issue in these types of investigations.

Major concerns continue to include the number of repetitions, sample size, whether sampling is randomised or at regular intervals, spatial scaling, and microsite variation. Most employed rhizosphere soil, however even in this case, defining it accurately is problematic. The side-distance effect on bulk soil, on the other hand, would be more reliable in addressing a more broad response. Time-course studies would also be required to assess the inoculation effect in relation to the ecosystem's buffering capability. The methodologies utilized to study soil microbial communities at the taxonomic and functional levels are time-consuming and limit the use of thorough samplings. The analysis is frequently limited to restricted samples in culture-dependent approaches, and a distorted image is formed.

Nevertheless, culture-independent approaches typically do not allow for unequivocal identification of taxonomic groups. Aside from the bias introduced by DNA extraction and PCR amplification, culture-independent approaches have other intrinsic drawbacks. Because of the large number of samples and replicates involved, high-throughput sequencing techniques, while more informative, are still not economically feasible for inoculation impact studies. In recent years, there has been a surge of interest in genes and transcripts that code for metabolic enzymes. Aside from problems about redundancy and variety, researchers are increasingly interested in the abundance of specific DNA and mRNA in various ecosystems.

Plant-based and soil microbial inoculants can interact directly with the native soil microbial community. These interactions may have a substantial impact on whether the inoculant survives and how it functions, particularly in guiding agro ecosystems to address climate change challenges. Competition with natural microbial species, for instance, can impair inoculant survival and consequently their function in the soil and/or the host plant. Furthermore, inoculants' short survival period and poor performance in diverse soil settings have severely limited their application and performance in the field. This aided the creation of microbial consortiums as inoculants. Evidence suggested that encouraging good interactions with the inoculant aided plant growth-promoting powers. Soil microbial populations are strongly intertwined to the Water and nutrient cycles due to their roles in soil organic matter mineralization, stability and sequestration, and GHG emission regulation, and may play an important role in crop yield maintenance. Inoculant-induced soil microbiome remodelling could thus influence the potential to steer agro ecosystem activities important to climate change adaptation and mitigation.

Microbial inoculation has the potential to drastically alter the number and content of taxonomic groups. However, the apparent effects are heavily influenced by the tools used to study the dynamics of soil microbial populations. Some works had no effect or had a brief effect, while others had a long-term influence. Impacts on plant development and protection may be due to induction or repression of local microbial populations

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Received: 02-Feb-2023, Manuscript No. JMBT-23-20295; **Editor assigned:** 06-Feb-2023, Pre QC No. JMBT-23-20295 (PQ); **Reviewed:** 20-Feb-2023, QC No. JMBT-23-20295; **Revised:** 27-Feb-2023, Manuscript No. JMBT-23-20295 (R); **Published:** 06-Mar-2023, DOI: 10.35248/1948-5948.23.15:547

Citation: Twain J (2023) Effect of Microbial Inoculants on Microbial Communities in Soil. J Microb Biochem Technol.15:547.

rather than a direct effect of the injected strain. Target and no target effects may potentially have synergistic/antagonistic interactions. These alterations could have an impact on beneficial soil activities like nitrogen fixation or N-cycling bacteria. The effect of these alterations on soil biology is still unknown and needs to be investigated further. The fundamental interest is how the influence on taxonomic groups relates to effects on the functional capacities of soil microbial communities. The dynamics of these impacts in respect to the host crop, the side-distance effect, the mid-term and long-term effects, crop rotation, and site variation are yet unknown and need to be researched further.

Unwanted growing conditions, such as biotic and abiotic stresses, are likely to contribute to inconsistent results and further complicate the problem, but they should be expected as part of agriculture's normal functioning. More light will be shed on the intricacy of the metabolic potentials of soil microbial communities and their importance to the soil ecosystem as DNA-sequencing tools evolve and become more accessible to various working groups.