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Editorial

Paradigm shift towards Microbial Consortium Technology

The term "biological control" or "Biocontrol" has been used in different fields of biology, most notably entomology and plant pathology. The organisms that suppress pests or pathogens are referred to as the biological control agents (BCAs) which are used now-a-days instead of Biopesticides. Among the agents some can also increase plant growth, so these should be considered as plant growth promoting agents. Since the current day emphasis is on sustainable agriculture therefore, possibility of seed/planting material treatment and biopriming of nurseries with biopesticides/ BCAs has been prioritized. The interaction between plant pathogens is not only affected by the density or microbial spectrum of the community, but also by the function or activity of the individual components in that community. Our lack of knowledge of how these interrelationships are driven, along with the fact that a vast number of soil microbial species are still unknown indicate that more research is needed. We really need to clearly understand how the natural soil populations, microbial diversity and community are influenced by different agroecosystems and environment. The trend towards a biological system management is to develop an integrated relationship between the biological system of the agroecosystem with the crop production system. The interrelationships between biological entities –plant, pathogen, pest and microbial community with a particular ecosystem play an important role in developing management strategies. Today research on biocontrol is a buzz word and vogue of every lab not knowing its fate. Large number of experiments are being designed for sake of publications. Reviews are available on this subject which allows us to understand how antagonists have established their role in the management of pests. Prioritization of biocontrol research and application is an utmost requirement of all plant protection managers for organic farming and integrated pest management systems. There is a requirement of excellent field research and the technological transfer which would be a great boon to the farmers for whom the technologies are developed.

Different microbial consortia can also be used for better control of plant diseases. A microbial consortium can be defined as group of two or more microbial agents living together symbiotically. Consortia can be endosymbiotic or ectosymbiotic. This microbial consortium concept was first introduced by Johannes Reinke in 1872. Later, it proceeded to the term symbiosis that was introduced into biology. In natural environments, several microorganisms live in communities and some of them have mutual beneficial interactions and provides beneficial effects to plants. When these microbes in a consortium are introduced to soil they interact with a host plant, and as a result the natural soil conditions are partially mimicked. Therefore, the current investigation trend has focused towards investigating the part of microbial consortia in promoting plant health against several pathogens as well as growth. There is a paradigm shift from the earlier investigations which involved single microbe uses. Recently, research has indicated that the plant growth promotion and triggering defense responses in host plants during pathogen ingress mechanisms through microbial consortia. This is revealed through enhancement of the defense signaling cascades by microbial consortia enhances transcriptional activation of several metabolic pathways. This situation does not occur when a microbial consortium is used. However, along with progression an understanding has been developed about microbial consortium-induced plant defense responses. Further creation of evidence on host's responses against pathogen attacking the presence of microbial consortia at purposeful level is ongoing. The outcomes of microbial consortia used till now to protect crop plants against numerous plant pathogens. The possible research findings are explained for disease reduction when a microbial consortium is used, comparison of use of single microbe and in small microbial consortium, possible limitations in achieving desired product from the introduced consortia, and the justification for development of an operative microbial consortia which can induce enhanced systemic resistance. Lastly, some potential biotechnological applications to withstand the effect of microbe-induced defense responses in host plants are also suggested.

Recently, number of consortial bioformulations have been evaluated against various crop diseases. Various microbes such as *Trichoderma, Glomus, Rhizobium, Bacillus, Pseudomonas* etc. are used to develop a consortium of microorganism. *Trichoderma* spp.-based consortium play crucial role in the growth of host. The mixed usage of *Glomus, Trichoderma* and fluorescent *Pseudomonas* has been reported to be effective against Fusarium wilt of tomato; basically combined usage is better as it is 50% more beneficial over single usage of *Glomus.Trichoderma koningii* had greater ability to suppress all pathogens of wheat when used with some *Pseudomonas fluorescens* strains instead of using *T. koningii* alone. The same scenario can be seen with some of the reported strains of *Bacillus* which enhance the peroxidases and superoxide dismutase activities by 25- 50% when used in combined in pepper and tomato against seed and soil borne pathogens. The ability of microorganism to form phytohormones, their antagonistic activity against pathogens, ability to fix atmospheric nitrogen and phosphorus solubilizing action in soil, all the criteria play a role in rational selection of these microorganism to be used in consortia. The selected microorganisms which are efficient enough to enhance nutrient content can induce systemic resistance reselected and included in consortia of microbes. Consortia based on *Trichoderma* and entomopathogenic fungi *Metarhizium* and *Beauveria* have also been reported for pest management. It is observed that use of several biocontrol agents having different mechanisms of disease control satisfy the norms of integrated pest management for disease suppression when applied simultaneously. The benefit of such concept is that if one or other mechanism is not effective, the other mechanism can compensate the absence of former. Although it is equally important to have efficacy of consortia of biocontrol agents for disease suppression, at the same time it is necessary to learn how the consortia influence plant metabolism and molecular mechanism of such interaction. This study is relatively unexplored and requires investigations on different aspects of the application. Efforts are needed to identify compatible strains of biocontrol agents which can positively influence the host physiological and transcriptional regulations for development of potent and cost effective commercial consortial bioformulation. Also, there is need to develop methodologies to assess probable impacts of the consortia on the crop health. The efficacy of microbial consortium depends on the synergistic effects of two or more biocontrol agents. Based on theoretical definitions of Bliss independence or Loewe additivity, the combination of biocontrol agents needs to be evaluated for the independence-synergistic-antagonistic interactions. There is evidence of synergistic effects among biocontrol agents, though, if properly analyzed antagonistic effects towards each other may be observed. Most of the research findings have indicated the antagonistic interactions of biocontrol agents and the synergistic interactions were rare events. Several research hypotheses are based on the biocontrol mechanisms for microbial consortium for the biological control of plant diseases. There is a major concern on the biosafety and environment which limit the prospects of microbial technology. The development of microbial biological formulations are based on microbial characterization and chemistry, bioefficacy testing at lab, green house and field data of the microbes against crop pests, growth promotion of the crop in different agroclimatic zones along with the toxicology tests, environmental safety testing, shelf life, packaging and labelling. Registration procedures for commercialization are available for single microbial formulation. It is a high time that we develop procedures for the registration of consortiums so that the bioformulations reach to the real stakeholders. The future of a microbial biopesticide is not only in developing new active microbes but also in transforming the technology to the fields. The patenting of such technologies is regulated by a series of national and international treaties but an authorization of commercialization of technology is purely based on government regulations and policies of that country. Role of industry needs to be emphasized and they should also come out with their viewpoints. We also need to develop a second generation besides the most promising and common tested biocontrol agents .

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