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Mini Review

Microbial Metabolites: Next-Generation Bioherbicides

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Abstract

Some rhizobacteria colonize the surface of weed plant roots and secrete phytotoxic metabolites, also known as allelochemicals, that selectively inhibits the growth of weed plants. These allelochemicals are also secreted by some crop plants such as wheat, sorghum, sunflower and many more. The herbicidal impact of microbial (bacteria and fungi) allelochemicals is higher than plant allelochemicals because they don't have to travel long distances from source to target which reduces their phytotoxicity due to biotic and abiotic soil factors. Therefore, microbial allelochemicals could be potentially exploited for their role as bioherbicides. Bacterial allelochemicals are more phytotoxic to weeds than fungal allelochemicals. The allelochemical metabolites from allelopathic bacteria could be commercialized to control weeds and contribute to integrated pest management systems without having toxic impacts on environment and human health.

Keywords: *Rhizobacteria; Allelochemicals; Allelopathic bacteria, Metabolites; Herbicide-Resistant; Climate Change; Crop Weeds; Pest management*

Background

Among the crop pests including weeds, microbial pathogens, insects and rodents; weeds are responsible for major losses in cereal crop production. Weed plants compete crop plants for resources and reduces growth yields and marketable quality of crops. Use of chemical herbicides is not only toxic to environment and human health but also disturbs biodiversity by killing nontarget species. Residual chemicals used to kill weeds, notably glyphosate, has been detected in several popular food products, including children's food and snacks [1]. Several chemically-derived herbicides are toxic, for instance carcinogenic, and their presence in food products is concerning. Hence, there is continuous need to develop more novel bioherbicides for suppressing weeds without harming environment and human health. Many rhizobacteria such as, *Pseudomonads, Streptomyces* and *Bacillus* have been successfully investigated for their potential as bioherbicides [2-5]. However, one of the limitations with microorganism-based bioherbicide is their poor persistence and efficacy in fields because of fluctuating environmental conditions (temperature and humidity) and presence of native competing microorganisms. Interactions between bioherbicides and other fertilizers, pesticides in soil also have variable impact on their efficacy.

Evidence

Several bacteria for example, *Pseudomonas* sp. *Lactobacillus* sp., *Streptomyces* sp. and fungal species like, *Colletotrichum*, *Phytophthora*, *Puccinia*) have been investigated for their bioherbicidal potential and commercialization [2]. However, only few products based on bacterial metabolites have been commercialized to date. One of the bacterial metabolites based bioherbicide product is MB-000EP, developed by Marrone Bio Innovations Inc., which contains fermentation compounds from a strain of bacterium *Streptomyces acidiscabies*. The active ingredient is thaxtomin A which is used to manage *Taraxacum officinale* in turfrolls [6] (https://patents.google.com/patent/US8476195). Such an approach has a great potential for further developments.

Advantages

The bioherbicides based on live microorganisms have inconsistent efficacy in fields and depends on environmental factors, such as temperature, humidity, and presence of native competing microorganisms. Application of extracts containing allelochemicals might be advantageous over raw biomass as biomass are released slowly and hence lacks effective concentrations required to suppress weeds. Until now, very few microbial metabolites-based products have been developed for weed suppression. With increasing risk of climate change, more new species of weed plants are likely to emerge as these adapt very quickly to fluctuating environment contrary to crop plants [7-10]. There is an urgent need to develop more novel bioherbicides based on metabolites that functions efficiently under extreme environmental conditions. Bioherbicides based on microbial-derived compounds that are not only effective in controlling multiple weed species in crop plants but also capable of arresting weed growth under variable environmental conditions are highly recommended. Development of novel bioherbicides will enhance the overall efficacy of the integrated pest management systems and managing weeds by rotation with other natural products. Multiple weed control strategies should be taken into consideration for maintaining sustainable agriculture.

Potential applications

The rapid proliferation of herbicide-resistant weeds is a major concern and is affecting the sustainability of crop production across the world. Therefore, producers, consumers, and governments are looking for greener and more sustainable solutions to control weeds. Since, allelopathic bacteria usually do not attack specific biochemical sites within the plant, they offer a promising solution to control weeds without causing direct selective pressure on the weed population, hence, preventing the development of resistance. In addition to this, microbial-derived compounds are environment-friendly and hence, will have less impact on the environment than conventional systems. Their maximum effect on weed control limits nontarget effects and sustains crop productivity. These characteristics make allelopathic bacteria and their allelochemicals an attractive approach for managing crop weeds in a biological and sustainable manner in different types of agricultural systems.

Conclusion

Advanced research in this domain is necessary to understand the promising effect of new-generation bioherbicides. The best knowledge of the factors influencing the activity of microbial metabolites in a synergistic mode will allow an effective utilization of microbial metabolites for weed management. New methods are needed to study mutual interactions of pathogens, crops and weeds, and to identify more new-generation of bioherbicides. Newer bioherbicides will reduce the use of synthetic herbicides and minimise the negative impact on the environment.

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