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Bioherbicides: A Need of Organic Agriculture

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Biological control of weeds is the use of living organisms to control of weeds. Use of bioherbicides is the inundative approach of biological control that is based on mass culturing of fungal and bacterial pathogens and applied to similar to herbicides. Bioherbicides can be developed from plant pathogens. Other natural products like corn gluten meal, byproducts of ethanol production, extracts from natural sources, essential oils from various plants, allelopathy, and deleterious rhizobactria can be exploited for its potential to be used as bioherbicides. Since chemical herbicides cannot be used in organic agriculture, bioherbicides in integration with other nonchemical methods provide an immense opportunity to control the weeds in organic agriculture. Simultaneously it will help in solving the issue of herbicide resistance decreasing cost of production and increasing yield. Since a few bioherbicides have been registered further research is needed to be carried out to develop more cost effective and efficient bioherbicides.

Biological control of weeds is the intentional use of biotic agents to reduce the vigor, reproductive capacity, density, or impact of weeds (Quimby and Birdsall, 1995). The approaches of biological control can be classified in two broad categories: (I) classical or inoculative, and (ii) inundative or mass exposure. The classical strategy is based on introduction of host-specific insects, pathogens, nematodes from the weed's origin into regions where the weeds has been introduced and gradually established. Thus, classical biological control is a long-term process that mainly requires several years to achieve significant control over the weeds. Inundative strategy on the other hand involves mass scale production of the agent to control the weeds in the year of its release. The bioherbicide approach is the inundative approach which involves application of pathogens in a manner similar to application of herbicides. Since most of the bioherbicides are prepared from the fungal pathogens they are also called as mycoherbicides Organic farmers need to take long-term approaches to control weeds without causing yield loss. Successful organic weed control needs to begin with an ecological understanding of weeds and their roles in agriculture (Schonbeck, 2011). Hand-weeding and cultural methods should be integrated to prevent yield losses due to weed and to control the weeds. Organic agriculture excludes the uses of synthetic herbicides. The use of bioherbicides to control weeds through the use of natural products, extracts, and biological agents such as fungi and bacteria to attack weeds is becoming an emerging tool.

Bioherbicides from Pathogens

Currently most of the microbial agents are under evaluation for their potential to be used as bioherbicides including obligate fungal parasites, soil borne pathogens, pathogenic and non pathogenic bacteria and nematodes. One of the first bioherbicides registered was Devine

which is the inoculants of *Phytopthora palmivora* used to control strangle vine on citrus in Florida. Later a number of pathogenic fungi and bacteria have been developed to control weeds.

The mycoherbicides like Collego and Biomal containing active ingredients of *Colletotrichum gloespoproide* has highly virulent fungal plant pathogens that can be mass cultured to produce large quantities of innoculum for controlling weeds. The rust fungus *Puccinia canaliculata* is a foliar pathogen of yellow nut sedge. The fungal pathogen *Chonrotereum purpureum* when applied to wounded branches or stumps of weedy tree species inhibited then resprouting and decayed woody tissues (Prasad, 1996). Pathogenic bacteria *Xanthomonas campestris pv poannua* and *Pseudomonas syringae pv tagetis* have been developed as bioherbicides to control annual bluegrass (*Poa annua*) and Asteraceae weeds, respectively (Johnson *et al.*,1996). The fungi *Fusarium tricinctum* and *Alternaria conjuncta* was found to control parasitic weed dodder and can be used as bioherbicides in organic agriculture.

Bioherbicides from Natural Extracts

Extracts from natural sources may also have potential as bioherbicides. Secondary metabolite extracts from the leaves of *Ailanthus altissima* had inhibitory effects on seed germination and plant growth of *Medicago sativa* (Tsao *et al*., 2002). The essential oils from eucalyptus (*Eucalyptus spp.*), Lawson cypress (*Chamaecyparis lawsoniana*), rosemary (*Rosmarinus officinalis*), and white cedar (*Thuja occidentalis*) significantly inhibited the weed species Amaranth (*Amaranthus retroflexus*), Purslane (*Portulaca oleracea*), and Knapweed (*Acroptilon repens*), and may be applied for biological control of weeds as pre-emergent weed seed germination inhibitor (Ramezani *et al*., 2008). A black walnut extract-based commercial product completely inhibited growth of Horseweed (*Conyza canadensis*) and Hairy fleabane (*Conyza bonariensis*) at a concentration of 33.3%, showing potential as a pre- and post-emergent bioherbicide (Shrestha *et al*., 2009).

Deleterious Rhizobacteria

These are the bacterial pathogens which are non-parasitic in nature and can able to colonize plant roots and suppress plant growth. The deleterious rhizobacteria *Psudomonas fluorescens* was first reported which can effectively suppress downy brome in cereal grain crops.

Weed Management in Organic Agriculture

Organic agriculture is a form of sustainable agriculture that excludes the use of chemicals. Bioherbicides may emerged as the most effective approach in managing weeds as a component in a biological weed management that is associated with the organic agriculture. Biological weed management advocates the use of diversity of biological agents such as bioherbicides and other biopesticides, and biological approaches including exploitation of allelopathy, competitive crop cultivars and other cultural practices to achieve weed control similar to herbicides. Though the effect of bioherbicides would not be evident for one to two years it can in long term have the potential in addressing the threats due to continuous use of herbicides in conventional cropping system. The synergistic effect can be obtained when bioherbicides used in combination with other components like mulching, deleterious rhizobacteria and other preventive and cultural methods as a component of integrated weed management.

Factors Affecting Bioherbicides' Efficacy

The efficacy of bioherbicides is the main limiting factors in its use due to various environmental factors like humidity, a long dew period as the organisms requires critical environmental factors for their growth and multiplication. Also, some bioherbicides have short shelf lives and cannot be stored for longer period. Since these are sprayed in a manner

similar to herbicides application method keeping in mind the spray droplet size, spray retention and distribution, volume of spray and kind of equipment also determines their efficacy. The type of formulation, spectrum of bioherbicides also contributes to its efficacy. In addition to bioherbicide efficacy, the high cost and the potential human health threats associated with it pose limitations for use of bioherbicides.

Conclusion

The need of the hour is better understanding of the mode of action of mycoherbicides involved in the host-pathogen interactions, which consequently leads to enhance virulence of a pathogen and/or suppression of the host plant's defence. Toxins and/or enzymes produced by fungal pathogens may play an important role in host-pathogen interactions and could represent important tools in future for improving, directly or indirectly, the efficacy of mycoherbicides. Although the use of mycoherbicides is the only safe, cost-effective, truly successful, and environmentally sustainable method of weed control, however, much remains to be done in the use of fungi for weed control, especially in the developing countries where the coordination among the private companies and the universities, institutes is leading. As a few bioherbicides are registered for use, there is a need to develop more cost-effective and efficient bioherbicides, as well as to optimize their use in production systems.

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