WHERE ARE THE BIOHERBICIDES? Steven G. Hallett, Assistant Professor, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN 47907.

Since the development and registration of Collego® and DeVine® in the early 1980s, there has been a consistent research effort into the development of bioherbicides. A generally accepted definition since the 1980s has been that a bioherbicide is a weed control product composed of propagules of a living organism applied in a manner analogous to a chemical herbicide. Importantly, the bioherbicide approach has promised effective weed management in intensive cropping systems, where the classical approach (utilizing exotic natural enemies) is largely unsuitable. The over-riding principle of the bioherbicide approach has been that the impact of an organism can be greatly increased when applied at high inoculum doses. The body of research that has been developed over the last two decades has effectively disproved the basic principle of the bioherbicide approach. Furthermore, the suggestion that bioherbicides developed in this way will become competitive with chemical herbicides in mainstream weed management systems should be abandoned.

While research has revealed weaknesses in the bioherbicide approach, it has also revealed significant potential in a number of areas. I argue that as research shifts into these new areas a new understanding of the breadth of the field will emerge and its potential to have genuine impacts upon weed management systems will become apparent. Four key areas for the development of weed biological control are:

1) *Careful selection of niche systems.* Plant pathogens with narrow host ranges can not be used effectively in cropping systems with complex weed communities without a clear understanding of how they may contribute to the overall weed management system. In some cases, it may be feasible to integrate bioherbicides into complex systems for the control of key weed escapes, particularly in minor/specialty crops where there is a lack of herbicide registrations. Better targets, however, are weeds such as the parasitic witchweeds (*Striga* spp.) and broomrapes (*Orobanche* spp.), since controlling these species will deliver significant yield benefits alone.

2) *Investigation of Broad Host Range Bioherbicides*. Plant pathogens such as *Sclerotinia* spp., with wide host ranges have significant potential and should be investigated in greater detail. Fears of non-target impacts should be replaced with epidemiological investigations that measure off-target impacts.

3) *Virulence enhancement.* Without virulence enhancement, bioherbicides will continue to be developed on a case-by-case basis and will always be restricted to niche systems. Different processes for inoculum production and formulation can increase efficacy in some cases, but the bioherbicide approach will only begin to approach its true potential when we begin to develop effective methods for producing genetically modified bioherbicides. Various avenues exist for the improvement of plant pathogens as bioherbicides.

4) *Conservation biological control.* The bioherbicide approach has been rooted in the direct augmentation of natural enemies. The indirect augmentation of natural enemies by the manipulation of natural ecosystems and agroecosystems can also have significant impacts upon weed populations and communities. Research in this area targeting weed management has been largely restricted to the manipulation of insect herbivores, but should be equally applicable to plant pathogens, and conservation approaches can be utilized to impact soilborne microbes that accelerate weed seedbank decline and inhibit weed seedling development.