Editorial

Biological Control: The Second Century

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Since 1985, an interdisciplinary Working Group on Biological Control, under the auspices of ESCOP (Experiment Station Committee on Policy), has been promoting biocontrol as an interdisciplinary science. In January 1989, the Working Group published and distributed the National Biological Control Initiative. This document refers to the potential contributions of traditional and contemporary science related to the critical issues of environmental pollution, food safety, efficient food production, and how the environment and the food supply might be improved by increased investment in biological control research.

The science of biological control began 100 years ago. In 1889, the vedalia beetle was introduced to California from Australia to control the cottony cushion scale, which was then devastating the fledgling citrus industry in the Golden State. The beetle was remarkably successful, and the industry flourished. This success story formed the pattern for the subsequent century's "classical" approach to the biological control of insects. Classical biological control of insects focuses strongly on foreign exploration for detecting parasites, predators, and pathogens (natural enemies) of introduced pests. These pests were often introduced with new crops while the natural enemies were left behind. Thus, the necessity arose to return to the origins of the crops to find the natural enemies of the pests.

Biological control of plant pathogens evolved later. Initially, it was an outgrowth of research on soilborne pathogens and on the ecology of the rich microbial flora found in the rhizosphere. This work began during the second half of the 20th century and now forms the basis for a unique plant pathological province of biological control, based heavily on microbial and microbe-plant interactions. In this conceptual province, such terms as antagonism, competitive inhibition, and hyperparasitism are operative labels describing some of the interactions. Not all the useful organismic interactions involve microbes, however. Some small soil insects and other soil fauna have been shown to feed on and destroy plant pathogens.

A rapidly evolving area of biocontrol in plant pathology is the use of disease in the control of weeds. There have been some clear successes in this approach, and it appears more are on the horizon. In this area, fundamental plant pathological technology is applied to the search for plant pathogens with characteristics that make them good candidates for use as weed biocontrol agents. Subsequent work then is done on epidemiology, inoculum production, formulation, application, and the sustainment of epidemics that are necessary for success.

Forty years of effective chemical control, primarily with soil fumigants, made research on biocontrol of nematodes unnecessary—or so it appeared. Now, however, the withdrawal of the registrations of most of these fumigants has given considerable urgency to the search for alternative control agents. Research on predators, parasites, and pathogens useful in the biological control of nematodes is accelerating. The primary candidates to date have been fungi. Predacious, obligately parasitic, and opportunistic fungi are all potentially useful. Because they can be cultured and readily studied, the opportunistic fungi appear most promising.

Cross protection is another biological control method that has worked in specialized cases with both fungi and viruses. Strains of a pathogen that induce mild symptoms are used to inoculate plants and protect them from subsequent infection by strains that would induce severe symptoms, thus reducing losses. One of the exciting recent variations in viral cross protection is the genetic transformation of plants by inserting components of viral genomes to suppress infection by related viruses. This approach is being intensely explored.

Because biological control is based on organismic interactions, it involves ecological studies of factors that regulate or affect the interactions. This concept is the basis for research on biological control in plant pathology, nematology, and entomology, and it provides the principle upon which to build an interdisciplinary science. Advances in molecular biology have provided new tools to study the genetics of organismic interactions in biological control. Understanding of these interactions will lead to improvements in the selection and adaptation of biocontrol agents and thus will enhance pest and disease control.

To significantly increase the development and use of biological control of plant diseases will require new thinking and new, more sophisticated approaches to disease management. Biological control agents will be more specifically targeted and more narrow in their spectrum of activity than were most chemical pesticides; successful use will therefore require more careful management. Many of the biocontrol agents that will be available will fit, unfortunately, in a category akin to that of "orphan drugs"—those with limited commercial potential. Therefore, research and development of biocontrols will depend heavily on funding from governments and nonprofit organizations.

Recent advances in biological control research show promise of reducing the need for chemical pesticides. This reduction will be timely, because regulations promulgated in response to public opinion are leading inexorably to diminished use of these pesticides. Chemical pesticides were very attractive because of their broad spectrum of activity, relatively low cost of application, and reliability. Unfortunately, the actual long-term costs have proved to be higher than anticipated. I do not need to recount the horror stories of environmental pollution and food safety issues associated with 45 years of use of the synthetic organic pesticides, nor need I remind anyone of the process currently under way that is likely to result in removal from the market of some of the plant disease control chemicals used in the United States. The accuracy of the basis for some of the decisions in this process is much in question, but the momentum to remove certain pesticides is so great that there is little question it will happen in some cases.

Much greater advances than have been made heretofore will be required in research to significantly replace some of the lost chemicals with biological controls. Nevertheless, replacement is a very realistic hope. Research in biological control has accelerated during the past 8 years, although only because of redirection of current resources. Much more progress needs to be made to reach the potential of biological control. The first century of this branch of science was dominated by the biological control of insects. Now plant pathology and nematology have taken their places as major disciplines in biocontrol, and they will be strong contributors to its further scientific and practical growth.