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Biological Control Strategies for Successful Stand Establishment: Introduction to the Colloquium

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More than 30 years ago, the Agricultural Research Council of the United Kingdom published an account on pesticides entitled "Report of the Research Committee on Toxic Chemicals" (Agricultural Research Council, 1964). That report introduced the phrase *integrated crop protection* (ICP) and defined ICP as "the co-ordination of all known cultural, biological, ecological and chemical methods in such a way as to obtain the maximum total benefit and especially to minimize harmful side effects that may result from exclusive use of chemical pesticides."

Today, chemical methods of pest control still dominate horticulture regardless of documented biological solutions in floriculture (Hoitink et al., 1991), ornamentals (Dreistadt, 1994; Raupp et al., 1993; Steiner and Elliott, 1987), tree crops (Hoy, 1985; Hunter, 1994), and vegetables (Finch, 1994; Flint, 1990; Hoffman and Frodsham, 1993). In the current commercial market, the emphasis on food and product safety, the tightening of restrictions by regulatory agencies, and the loss of many pesticides from the federal register make the role of biological control more significant.

The impact of biological control measures, specifically for stand establishment, has not been highlighted in the literature. Establishment is a critical phase for all crops, whether propagated, seeded, or transplanted. Seedborne and soilborne diseases alone can devastate emergence and decimate young seedlings, while insects and competition from weeds can further compromise stand development. The intent of this colloquium was to familiarize those working in horticulture with the many biological solutions, experimental and commercial, available in the area of stand establishment. Topics addressed include biological seed treatments, soil and soilless mix amendments, transplant growth promotion, insect control with nematodes, and weed control with plant pathogens. The contributors emphasized that the success of biological control lies in competitive, economical, and dependable implementation. An increased understanding of the empirical relationship among the control organism, its environment, and its place in commercial agriculture is necessary for successful implementation on a large scale. Research focusing on commercialization factors was recommended.

The future of biological control for better stand establishment was outlined by Hoy (1990) in a presentation to an audience of the New Zealand Entomological Society. She indicated that five changes must occur to enhance the role of biological control by the year 2000: 1) We must improve biological control success rates and expand their scope. 2) We must develop cost-effective, high-quality mass rearing methods for control agents and generate the guidelines necessary for their delivery. 3) We must acquire rapid, predictive, and cost-effective

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monitoring techniques to optimize the reliability of biological control. 4) We must improve the conservation and compatibility of biological control agents with other pest control methods. 5) We must effectively and rapidly train farmers to use all the available biological control tactics.

Those working to reestablish sustainable agriculture realize that biological control is not a panacea. However, it has not attained its rightful place in agriculture due, in part, to our unyielding dependence on chemical controls and our failure to develop the necessary strategies for its successful implementation. Expanding the use of biological control will require a multisystems approach, calling on pathologists, entomologists, horticulturists, ecologists, economists, commercial enterprises, and farmers. Integrating these numerous viewpoints and sources of research will help us progress in our theoretical and applied study of biological control.

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Biological Seed Treatments: Factors Involved in Efficacy

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INTRODUCTION

Biological pest control is an integral part of a sustainable agriculture. Biological seed treatments for control of seed and seedling diseases offer the grower an alternative to chemical fungicides. While biological seed treatments can be highly effective, it must be recognized that they differ from chemical seed treatments by their utilization of living microorganisms. Storage and application conditions are more critical than with chemical seed protectants, and differential reaction to hosts and environmental conditions may cause biological seed treatments to have a narrower spectrum of use than some chemicals. Conversely, some biocontrol agents applied as seed treatments are capable of colonizing the rhizosphere, potentially providing benefits to the plant beyond the seedling emergence stage.

Effective biological control agents have been developed for control of seed and seedling pathogens such as *Pythium* spp., *Rhizoctonia solani* Kuhn, and *Fusarium* spp. Several reviews that include discussions of biological seed treatments have been published (Bennett et al., 1992; Chet and Inbar, 1994; Harman, 1991; Nelson and Maloney, 1992; Taylor and Harman, 1990; Weller, 1988; Whipps and McQuilken, 1993), and Cook (1993) has summarized factors hindering the development of biological plant disease control strategies.

A wide variety of microorganisms are currently in various stages of development for use as seed treatments. The most intensively studied include bacteria of the genera *Pseudomonas*, *Enterobacter*,

Erwinia, and *Bacillus*; the fungi *Trichoderma* and *Gliocladium*; and the actinomycete *Streptomyces* (Becker and Schwinn, 1993). However, once an effective biocontrol agent has been identified for use as a seed treatment, there is no guarantee that consistent disease control will be obtained from its use. The efficacy of biological seed treatments can be affected by soil pH and iron concentration (Weller, 1988), moisture, temperature, and pathogen inoculum density (Mathre et al., 1994). Efficacy can also be influenced by certain characteristics of the biocontrol agent and of the seed treatment itself. These include the inoculum density of the biocontrol agent on the seed, adjunct treatments such as priming, formulations and additives that enhance the activity and survival of the biocontrol agent in the formulated product, crop and pathogen specificity of the biocontrol agent, and compatibility with other microbial inoculants or chemical fungicides. A discussion of these characteristics will be illustrated, where possible, with data from our research with biological control of *Pythium* seed rot of *sh2* sweet corn (*Zea mays* L.) by *Pseudomonas aureofaciens* AB254, a naturally occurring bacterial isolate from western Montana soil (Callan et al., 1990, 1991).

INOCULUM DENSITY OF THE BIOCONTROL AGENT

A minimum number of cells or propagules of a biocontrol agent are often required to provide an adequate level of seed protection (Fukui et al., 1994b; Osburn et al., 1989; Paulitz et al., 1992). Protection of 'Crisp 'N Sweet 710' (Crookham Co., Caldwell, Idaho) *sh2* sweet corn from *Pythium* seed rot increased with *P. aureofaciens* AB254 inoculum density in both the greenhouse and field at the Western Agricultural Research Center (WARC), Corvallis, Mont. In the field, log 7.1 colony-forming units (cfu) of AB254 provided 90% seedling emergence, equivalent to that from treatment with metalaxyl [N-(2,6-dimethylphenyl)-N-(methoxyacetyl) alanine methyl ester; Ciba-Geigy, Greensboro, N.C.), a fungicide that is selective for oomycetes, including *Pythium* spp. (Fig. 1). Under severe disease conditions in the greenhouse, log 7.5 cfu provided maximum seedling emergence. These experiments indicate that a minimum of log 7 to 7.5 cfu of *P.*

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