THE POTENTIAL FOR INSECT PATHOGENS AS CONTROL AGENTS OF PEST INSECTS OF POTATO

BY
LAWRENCE A. LACEY AND DAVID R. HORTON
INSECT PATHOLOGY LABORATORY, YAKIMA AGRICULTURAL RESEARCH LABORATORY, USDA-ARS, WAPATO, WA 98951, EMAIL: llacey@yarl.ars.usda.gov

Insect diseases are important natural regulatory factors in many insect populations. Many species of the pathogens that cause disease in insects are also employed as biological control agents of insect pests in row and glasshouse crops, orchards, ornamentals, range, turf and lawn, stored products, and forestry and for control of pest and vector insects of veterinary and medical importance. The comparison of entomopathogens with conventional chemical pesticides is usually solely from the perspective of their efficacy and cost. In addition to efficacy, the advantages of using microbial control agents are numerous. These include safety for humans and other nontarget organisms, reduction of pesticide residues in food, preservation of other natural enemies and increased biodiversity in managed ecosystems (Kaya and Lacey, 2000). As with predators and parasitoids, there are three basic approaches for using entomopathogens as microbial control agents (classical biological control, augmentation, and conservation). Most examples of microbial control involve inundative application of entomopathogens. This is especially true for the most widely used microbial control agent the bacterium, *Bacillus thuringiensis* (*Bt*). The discovery of new varieties with activity against larvae of moths, beetles and certain flies has markedly enhanced the utility of this agent.

The use of microbial control agents for protection of potato has been primarily directed toward control of the Colorado potato beetle. Both *Bt* and the fungus, *Beauveria bassiana*, have been proven effective as control agents of the beetle (Poprawski and Wraight, 2000). A potentiating effect has been reported against Colorado potato beetle when *Bt* is used in combination with insect natural enemies, including a predator of the beetle (Cloutier and Jean 1998). Most of the research conducted to date has been in the more humid Eastern United States.

Our research at the Yakima Agricultural Research Laboratory in 1997-1999 was focused on evaluation of *Bt* and *B. bassiana* when used individually and as mixtures and alternations under irrigated desert conditions. In 1997 five weekly applications of low and high rates of *Bt* (1.2 and 7 l/ha) produced fair to excellent control of the beetle, yielded 33 and 40 metric tons of tubers/ha and enabled good survival of predators and other nontarget insects. Plots treated on the same schedule with *B. bassiana* resulted in poor control of beetle larvae prior to row closure. After row closure fair to good control was achieved. Yield in the *B. bassiana*-treated plots was 33 metric tons/ha and effect on diversity of nontarget insects was comparable to the *Bt*-treated plots. The lowest number of overwintering adult Colorado potato beetle was found in the plots treated with *Bt* and *B. bassiana* (0.68-0.84 adults/ 0.03m^3 of soil) and the highest was found in control and temik-treated plots (3.84 and 1.84 adults/0.03 m^3 of soil). Four weekly applications of a mixture of half label rates of *Bt* and the fungus or two applications of *Bt* prior to row closure and two of *B. bassiana* after row closure in field trials in 1998 resulted in good control of larvae and produced comparable yields to the high rate of *Bt*. In 1999 only two applications of a mixture of half label rates of *Bt* and *B. bassiana* resulted in good control of larvae and yields

comparable to the 1997 trials. An advantage of using *B. bassiana* in conjunction with *Bt* is the residual effect of the fungus on the sub-soil overwintering populations of the beetle.

Our current efforts are focused on development of insect pathogens for control of the green peach aphid (GPA) and wireworms. The only pathogen group that has been developed for control of aphids are fungi. Under certain conditions, natural outbreaks of fungi have resulted in spectacular crashes in aphid populations (Latgé and Papierok, 1988, Steinkraus, 2000). This points out the need to conserve these natural enemies whenever possible There is some evidence that fungicides can interfere with the activity of naturally occurring fungal pathogens of aphids (Lagnaoui and Radcliffe, 1998). The use of commercially available fungi for aphid control outside of greenhouses has been somewhat limited. Our research will focus on evaluating their potential for control of GPA in potato. Lab bioassays have revealed good potential of one commercially available species (*Verticillium lecanii*, produced by Koppert under the name "Vertalec"). Enhancement of the insecticidal activity of fungi with the neurotoxic chloronicotinyl insecticide imidacloprid has been reported by other researchers for control of root weevils (Quintela and McCoy, 1997, 1998). Preliminary evidence in our lab indicates that sublethal doses of this insecticide can also increase the insecticidal activity of *B. bassiana* for control of GPA. Another concern regarding the use of applied fungi in potato crops is the effect of fungicides on the insect pathogen. Research that addresses the effect of the type of fungicide and the timing of applications on activity of insect pathogenic fungi is warranted.

Wireworms will provide a challenging goal for development of microbial control agents. For the soil habitat of wireworm larvae, fungi offer the most potential for development. Zacharuk (1981), demonstrated the infectivity of the common fungus, *Metarhizium anisopliae*, but larger applied studies have not been conducted. Because of the barrier created by the soil habitat and the wireworms diffuse distribution, an attract and infect strategy offers the most economical approach. This strategy will require research on several fronts including knowledge of the insect's biology, chemical ecology and efficacy of fungal pathogens. In addition to attraction of larvae to a source of pathogen, the attraction of adults to traps where they can be inoculated with fungus also offers promise. Adults of several beetle species are susceptible to fungi that also kill their larvae. The dissemination of fungi by adult beetles into larval habitats would help to increase the incidence of fungal infection in larvae and reduce the expense of application to expansive areas.

Microbial control agents can be effective and have the potential to serve as alternatives to broad spectrum chemical insecticides in the potato agroecosystem. However, their increased utilization will require: 1) increased pathogen virulence and speed of kill; 2) improved pathogen performance under challenging environmental conditions (cool weather, dry conditions, etc.); 3) greater efficiency in their production; 4) improvements in formulation that enable ease of application, increased environmental persistence and longer shelf life; 5) better understanding of how they will fit into integrated systems and their interaction with the environment and other integrated pest management (IPM) components; 6) greater appreciation of their environmental advantages, and, ultimately 7) acceptance by growers and the general public.

References Cited

Cloutier, C. and C. Jean. 1998. Synergism between natural enemies and biopesticides: a test

case using the stinkbug *Perillus bioculatus* (Hemiptera: Pentatomidae) and *Bacillus thuringiensis tenebrionis* against Colorado potato beetle (Coleoptera: Chrysomelidae). *J. Econ. Entomol.* **91**: 1096-1108.

Kaya, H. K. and L. A. Lacey. 2000. Introduction to microbial control. *In* "Field Manual of Techniques in Invertebrate Pathology: Application and evaluation of pathogens for control of insects and other invertebrate pests" (L.A. Lacey and H. K. Kaya, Eds.), pp. 1-4. Kluwer Academic Publishers, Dordrecht.

Lacey, L. A., D. R. Horton, R. L. Chauvin and J. M. Stocker. 1999. Comparative efficacy of *Beauveria bassiana*, *Bacillus thuringiensis*, and aldicarb for control of Colorado potato beetle in an irrigated desert agroecosystem and their effects on biodiversity. *Entomol. Exp. Applic.* **93**: 189-200.

Lagnaoui and E. B. Radcliffe. 1998. Potato fungicides interfere with entomopathogenic fungi impacting population dynamics of green peach aphid. *Amer. J. Potato Res.* **75**: 19-25.

Latgé, J. P. and Papierok, B. 1988. Aphid pathogens. *In* "Aphids Their Biology, Natural Enemies and Control, Vol. B." (A. K. Minks and P. Harrewijn, eds.), pp.323-335. Elsevier Science Publishers B. V., Amsterdam.

Poprawski, T. and S. P. Wraight. 2000. Application and evaluation of entomopathogens in vegetable row crops: potato. *In* "Field Manual of Techniques in Invertebrate Pathology: Application and evaluation of pathogens for control of insects and other invertebrate pests" (L.A. Lacey and H. K. Kaya, Eds.) pp. 371-388. Kluwer Academic Publishers, Dordrecht.
Quintela, E. D. and C. W. McCoy. 1997. Pathogenicity enhancement of *Metarhizium anisopliae* and *Beauveria bassiana* to first instars of *Diaprepes abbreviatus* (Coleoptera: Curculionidae) with sublethal doses of imidacloprid. *Environ. Entomol.* **26**: 1173-1182.

Quintela, E. D., and C. W. McCoy. 1998. Synergistic effect of imidacloprid and two entomopathogenic fungi on the behavior and survival of larvae of *Diaprepes abbreviatus* (Coleoptera: Curculionidae) in soil. *J. Econ. Entomol.* **91**: 110-122.

Steinkraus, D. C. 2000, Documentation of naturally-occurring pathogens and their impact in agroecosystems. *In* "Field Manual of Techniques in Invertebrate Pathology: Application and evaluation of pathogens for control of insects and other invertebrate pests" (L.A. Lacey and H. K. Kaya, Eds.) pp. 303-320. Kluwer Academic Publishers, Dordrecht.

Zacharuk, R. Y. 1981. Fungal diseases of terrestrial insects. *In* "Pathogenesis of Invertebrate Microbial Diseases" (E. W. Davidson, Ed.), pp. 367-402. Allanheld, Osmun, Totowa, New Jersey.