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Canadian Forest Service – Great Lakes Forestry Centre

The Use of Biotechnology for Forest Pest Management

INTRODUCTION

Biotechnology is the application of science and engineering to live organisms for the development of useful products and can include the manipulation of these organisms or their components. Natural Resources Canada, Canadian Forest Service (CFS) uses biotechnology techniques in the development of target-specific pest control products for various forest insects and diseases. CFS scientists use organisms such as bacteria and viruses that already exist in the natural environment in association with insect populations to develop biopesticides that affect only the target insect and have minimal environmental impact. The use of such biopesticides helps mitigate economic losses to the forest industry and contributes to the sustainability of Canada's forests. CFS research also contributes to the assessment of these products to ensure they are safe for use in the forest environment.

GREAT LAKES FORESTRY CENTRE (GLFC) ROLE

Historical perspective

Since the early 1950s, when the Laboratory for Insect Pathology was established in Sault Ste. Marie, CFS scientists have used biotechnology in their research for new pest control methods. Early on, researchers investigated microorganisms such as bacteria, viruses and fungi that could be used to combat forest insects as an alternative to broad-spectrum synthetic insecticides. The successful product *Bacillus thuringiensis* var. *kurstaki* (Btk) was developed from a naturally occurring bacterium found in the soil for use against the spruce budworm, forest tent caterpillar and gypsy moth. Btk it is now the most successful commercial product for use against forest insects, and is used widely in aerial forest protection programs in Canada and throughout the world. Other successful products that were developed include the first Canadian registrations for viruses to control redheaded pine sawfly, Douglas-fir tussock moth, gypsy moth and balsam fir sawfly; all of these viruses are termed baculoviruses.

Genetically modified baculoviruses

Viruses act by infecting the insect and eventually causing it to stop feeding and die. However, this can take from 5-14 days, during which time a large amount of defoliation can occur while the insects continue to feed. Use of a genetically modified virus with a faster mode of action could result in less damage to the trees. Such viruses have no deleterious effects on non-target species. Through advanced techniques used to analyze DNA, specific genes can be isolated, characterized and inserted into baculoviruses to enhance their effectiveness. These recombinant viruses are tested on insects in the laboratory and their physiological effects are investigated. Extensive tests are also conducted to confirm their host specificity and study the survival, persistence and dispersal of the virus to ensure its use meets government regulations.

GLFC scientists have developed such a genetically modified spruce budworm baculovirus that reduces feeding in infected larvae. The virus contains a gene that disrupts the critical developmental phase of larval molting and renders infected insects inactive. Importantly, the gene inserted in the virus comes from the spruce budworm itself, and is therefore not foreign to the host-virus interaction. Scientists are also working on the creation of new variants of the spruce budworm baculovirus that will shut down the expression of genes in infected hosts, such as those involved in various metabolic pathways. This type of control strategy, while not at the operational stage, has potential to provide control that is both highly host-specific and environmentally benign.

Genomics

In recent years, biotechnology has made possible the sequencing and identification of the complete suite of genes from any organism, a discipline called genomics. Of the several thousand genes in insect DNA, many will encode insect-specific biological processes. If key genes controlling these processes can be identified, then an environmentally benign solution for managing an insect can be designed based on the manipulation of the genes. This type of work relies on bioinformatics, which is computer analysis of DNA. Laboratory experiments are also required to determine whether the identified genes have potential to be useful in biological control of an insect population.

GLFC scientists are studying the antennae of the emerald ash borer (EAB), a highly destructive invasive alien pest that is threatening North America's ash tree population. The antennae are of particular interest because insects use them to find host trees, which emit chemicals unique to a given tree species (for food), as well as to find mates, with males detecting pheromones given off by female insects. Their highly developed antennae, like those of other insects, are capable of responding to the lowest levels of odours ever reported for any organism.

GLFC scientists are interested in how EAB detects tree volatile semiochemicals (chemicals that evoke a behavioural or physiological response in another organism) at the molecular level. Chemical odour receptors in the antennae of EAB are capable of converting the odour stimulus (a chemical signal) into a nerve impulse, which stimulates a neuron located inside the antennae of the insect. Scientists are striving to identify the key molecules in the insect that carry host tree volatiles to the neurons and to determine their structure. These studies are part of a longer-term effort that could lead to a biocontrol strategy for EAB. For example, by knowing the shape of important molecules, a replacement (false) molecule could be synthesized to interrupt the odour signal the insect needs to locate a host tree, its food or its mating partner. Understanding EAB olfaction as it relates to tree volatiles will also be useful for attracting and trapping insects. Once the tree volatiles that signal an insect to find a host tree are known, they can then be purified or synthesized and used as lures in traps. Traps are an essential tool in the early detection of new infestations, and early detection is of critical importance in managing outbreaks of invasive insect pests such as EAB.

Future work

Scientists intend to map the entire genome of EAB. This information will be helpful in identifying genes that are essential to the insect's growth and development, so that these genes can be targeted for control methods. In addition, through detailed studies of genetic variation among EAB populations, enhanced models that predict the patterns of spread will be created. Scientists will also investigate how ash trees respond to larval feeding by finding chemical or molecular signatures that can be used to diagnose the early stages of infestation to increase the efficiency and reduce the cost of EAB control. Economic implications and acceptability to Canadian society of such tools will also be investigated.

CONCLUSION

Techniques in biotechnology are powerful tools that can help researchers develop more insect-specific pest control methods, including the development of effective traps, which are needed for early detection, containment and monitoring for both invasive alien and native pests. In the case of EAB, for example, research conducted at GLFC will help scientists decipher how the insect navigates in a universe of odours, locates a suitable host tree, and finds mating partners and food. This information is critical for developing a complete understanding of this invasive pest's biology, and for developing better monitoring and control options.

The potential environmental effects of biological pest control products are thoroughly studied by CFS before they are released into the environment, and the science contributes to the development of national regulations that ensure safe use of these products. These pest management strategies all contribute to minimizing forest losses from insect defoliation and help protect ecosystems from native and invasive alien pest species.

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