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Frontline

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TreeAzin® – a natural systemic insecticide for use against the emerald ash borer in Canada

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Introduction

The emerald ash borer (EAB) is an invasive alien insect pest that can attack and kill most Canadian ash species. Since 2002, when it was first discovered in the Detroit/Windsor area, this highly destructive wood-borer has killed millions of ash trees within the infested zone, which currently spans a large area in southeastern Canada and the eastern United States. It is continuing to spread throughout Ontario and into localized areas of Quebec. EAB has already resulted in multi-million dollar impacts in many municipalities. Economic impacts are particularly acute in urban environments where ash trees were planted for aesthetic and shading purposes in boulevards, green spaces and parks. In the city of Toronto for example, the EAB management program cost an estimated $1 million in 2011 alone, primarily for removal of infested trees. Homeowners are also faced with covering costs as high as $1500 for removal and replacement of large individual ash trees that may be growing on their properties. The full economic impacts of EAB are much higher when the cost of depreciated property values, intervention, monitoring and research are included. As EAB continues to spread unchecked throughout the natural range of ash trees in North America there will be proportionally increasing economic losses as well as potentially significant ecological impacts.

From an ecological perspective, widespread EAB infestations pose several risks. Ash trees are often a major component of the tree canopy in riparian zones surrounding sensitive aquatic systems; they provide shade, intercept nutrients and pollutants, reduce soil erosion, contribute essential organic inputs into the system via leaf fall and provide habitat for a variety of wildlife species. Loss of ash from riparian zones can interrupt any or all of these ecological services. In the isolated woodlot remnants of a once heavily forested landscape in southern Ontario and Quebec, EAB-induced canopy openings could result in altered structure and function of the forest. These changes could include reduced suitability as habitat for certain forest-dependent species of birds and amphibians, including some that are already designated as at risk. In addition, early indications from research in southern Ontario are that such openings may provide footholds for invasive plants to become established. Currently, a Natural Resources Canada, Canadian Forest Service (CFS) research team is investigating the ecological implications of EAB infestations relating to these issues.

Scientists have been working to develop tools and techniques that can be used to mitigate the current and predicted economic and ecological losses due to EAB. TreeAzin® is a successful result of these efforts. Working in direct collaboration with BioForest Technologies Inc. (and with support and facilitation by the Ontario Ministry of Natural Resources), CFS researchers have developed TreeAzin as a natural, botanical, systemic insecticide that can be used to protect high value ash trees.

Great Lakes Forestry Centre (GLFC) Research

Following years of intensive research and several years of restricted use under emergency registration permits, TreeAzin received full national registration in October 2012. National registration is anticipated to greatly facilitate use of this natural botanical product in integrated pest management programs focused on slowing the spread of EAB and mitigating attendant economic, ecological and aesthetic impacts faced by urban foresters and public landowners alike.

A brief history of TreeAzin research and development

The development of TreeAzin as a systemic insecticide for use against the EAB originated with the work of a research team led by CFS scientists Blair Helson and Dean Thompson in 2003. These efforts were based on established knowledge that organic compounds known as azadirachtins exist in seeds of the neem tree and that these compounds have utility in protecting crops from the ravages of insect pests in India, where the tree is indigenous. Working in direct partnership with a small local company, BioForest Technologies, the collaborative team developed a suitable formulation of these compounds, as well as a prototype of a method to inject it directly into the tree as is required to have an effect on larval life stages. Systemic injection was recognized as being the application method of choice for use against

POLICY PERSPECTIVE

Two federal government departments have a mandate for dealing with invasive species. First is the Canadian Food Inspection Agency (CFIA), under the authority of the Minister of Agriculture and Agri-foods and the second is the CFS, under the direction of the Minister of Natural Resources. When an invasive pest is found in Canada, its control falls under the jurisdiction of the CFIA. The main legislation that directs this is the Plant Protection Act. This act is key to invasive species management because its purpose is to protect plant life and the agricultural and forestry sectors of the Canadian economy by preventing the importation, exportation and spread of pests and by controlling or eradicating pests in Canada.

To minimize the impact of the emerald ash borer on Canada's forests, a regulatory measure, called the Emerald Ash Borer Infested Places Order (April 13, 2012), was created under the Plant Protection Act. This prohibits the movement of ash materials and firewood from specific areas of Ontario and Quebec. Under the same Act, the Introduced Forest Pest Compensation Regulation has been created. This allows for the government to pay compensation to a person that has been given notice to dispose of a tree that is host to emerald ash borer. The government is legislated to pay the land owner between $40 and $300 per tree, depending on the land zoning.

The CFS supports the CFIA's work by providing the expert science and policy knowledge found through their research programs. Once an invasive species is within Canada's boundaries, CFS has a mandate to conduct research relating to the protection of the forest resources of Canada, under the Forestry Act. Also, under the Department of Natural Resources Act, one of the general duties of the federal Minister of Natural Resources is to assist in the development and promotion of Canadian scientific and technological capabilities. These two acts are the key pieces of legislation that underpin CFS efforts in the research and development of TreeAzin.

This research project is an excellent example of CFS science being conducted to develop information, tools and techniques in support of the Government of Canada's goals and priorities. This science directly supports other federal government agencies inclusive of the CFIA and the Pest Management Regulatory Agency and provides fundamental science knowledge to provincial government ministries to help them develop more effective tools for the management of established invasive species, such as the emerald ash borer, in their jurisdictions. And, perhaps most importantly, the research has led to municipalities and the general Canadian public now having strategies to mitigate the significant impacts of this pest as it continues to spread across the natural range of ash in Canada.

invasive wood boring insect pests such as EAB and particularly in urban environments, where treatment of individual high value trees and application technologies conferring the highest degree of human and environmental safety were required.

Thompson and colleague Dave Kreutzweiser have also published extensively on the fate and potential impacts of azadirachtins in relation to typical use scenarios, including systemic applications. Following years of rigorous laboratory and field testing (photo 1) focused on environmental fate, behaviour, efficacy testing and determination of key mechanisms of insecticidal activity, involving both the CFS and BioForest Technologies Inc., a registration request was submitted to Health Canada's Pest Management Regulatory Agency. In 2008, TreeAzin was granted emergency registration for control of EAB in Ontario and Quebec and gained full national registration in October 2012.

Photo 1. Ecotoxicology lab testing

Operational Use

Working from the original prototype developed by Blair Helson, BioForest Technologies Inc. ultimately developed an advanced micro-injection system known as EcoJect® that greatly facilitates application of TreeAzin or other systemic pesticides into individual trees. The portable system consists of a number of pressurized, reusable canisters that are filled with TreeAzin and attached to temporary micro nozzles that are inserted into the tree (photo 2). With this system, the formulation is pre-loaded into sealed canisters and can only be applied by trained and licensed operators using appropriate personal protective equipment. The formulation is injected directly into the tree and thus, barring a spill or accidental malfunction of the equipment during loading, the probability of any exposure of either professional operators, bystanders, pets or other non-target organisms is exceedingly low.

Although injection times vary with tree health, transpiration activity and growing environment, operational productivity records indicate time requirements of approximately 15-20 minutes per tree. The cost per tree varies depending on its size and accessibility but will be approximately $150-250 for a larger tree (30 cm diameter at breast height). Regular treatments every two years are likely to be required for a 6-10 year period while high EAB populations persist in a given area. Therefore, TreeAzin treatments are very likely to sustain healthy, fully functional trees over extended periods of time at a cost that is equivalent to or less than that for destructive removal and replacement

Photo 2. Application of TreeAzin

of an urban tree. In the longer term, it is hoped that either natural or augmented biocontrols will be developed and become available to suppress and maintain EAB populations at less damaging levels.

Operationally, trees are best treated via injections in early summer just prior to peak adult emergence. This allows the active compounds to be rapidly and efficiently translocated through the tree via conductive tissues where EAB larvae feed. A particular advantage to this timing is that canopy foliage will harbour active ingredients that are inhibitory to reproduction of the adult beetles, which feed on foliage as part of their sexual maturation process. TreeAzin does not cause direct mortality of either larval or adult life stages of EAB. However, it is very effective at inhibiting feeding and moulting of the larvae that are exposed to the compounds moving through the conductive tissues. It ultimately protects the tree from highly destructive larval feeding, which results in the distinctive galleries (photo 3) that cut off the flow of water and nutrients, causing symptomatic dieback starting in the upper canopy and ultimately resulting in tree death. Recent laboratory studies have shown that adult beetles feeding on systemically contaminated foliage produce very few viable eggs, thus reducing EAB populations within and in the immediate vicinity of treated trees. This is one explanation for the observation that treated trees are typically protected for two years following a single TreeAzin injection, even though the active ingredient compounds are non-persistent and become non-detectable in foliar samples within several weeks of treatment.

Photo 3. EAB feeding galleries

Environmental considerations

As natural botanical compounds, azadirachtins are innately non-persistent. In natural environments, these compounds are subject to rapid degradation by hydrolysis (reaction with water), photolysis (reaction with sunlight) and by microbial action. They have also been demonstrated to have very low toxicity to mammals and birds and other non-target wildlife species. In combination, these characteristics make azadirachtin-based formulations particularly well-suited for use in urban and environmentally sensitive areas, particularly when applied using advanced systemic injection techniques such as the EcoJect system. Non-target organisms that could be affected by such treatments are those that forage directly on treated trees. Studies by Kreutzweiser and Thompson demonstrate that, unlike the scenario for some other compounds proposed for control of EAB, leaves excised from TreeAzin-treated trees during natural autumn leaf fall do not pose a significant risk to either soil or aquatic decomposer organisms. Previous scientific studies demonstrated that azadirachtins have low to moderate persistence in water and soils and are relatively non-toxic to most beneficial insects and other non-target organisms including bees. Other studies have shown that, as with many insecticides, certain groups of zooplankton are known to be sensitive to expected concentration levels of azadirachtin that might result from broadcast application, highlighting the important environmental advantage of direct injection technologies. Most Canadian ash tree species are wind pollinated and treatments are applied well after ash trees flower in the very early spring, so potential exposure of these important beneficial insects is thereby reduced.

Ongoing research led by Thompson and colleague Amanda Tonon suggests that TreeAzin has parallel potential for use against other exotic, invasive wood boring insect pests including the Asian longhorned beetle (ALB). ALB has been found in Canada near Toronto and in several northeastern states, most recently in Ohio in 2011. While several of these historic infestations now appear to have been controlled and reduced to below detection thresholds for several years, occasional occurrences in other locations suggest a strong potential for this pest to re-appear in Canada. Moreover, given the variety of maple and other tree species susceptible to attack and the resultant greater potential for economic and ecological damage, this invasive wood boring species poses an extreme risk to deciduous forests of Canada. Therefore, with the support of the newly established Canada-Ontario Invasive Species Centre, co-located with the GLFC in Sault Ste. Marie, scientific data is now being generated that could support inclusion of ALB on the product label. If accepted, this would provide the option to use TreeAzin as part of an early and aggressive response to this continuously looming threat.

Conclusion

Although there is no doubt that EAB will continue to spread throughout the natural range of ash trees across the Canadian landscape, the development and recent national registration of TreeAzin now provides an efficacious, environmentally acceptable and non-destructive option for slowing the spread and managing this invasive alien pest. Its use will minimize the economic and ecological impacts in both urban and ecologically significant natural environments and provide homeowners an option for protecting their high value ash trees. Similarly, should ALB reappear in Canada, ongoing research efforts are expected to provide the scientific data required to support use of TreeAzin for protecting the many deciduous tree species susceptible to attack by ALB, which include maples that

are not only Canada's national symbol, but also the mainstay of the highly valued maple-syrup industry.

The research, development and delivery of TreeAzin as a natural botanical systemic insecticide for use against EAB and other invasive wood boring insect species in Canada is considered a classic example of successful cross-sectoral collaboration between federal and provincial governments and small-niche industry partners focused on meeting the critical needs of Canadians. The principal investigating scientists from GLFC wish to specifically recognize the significant contributions of others including:

Susana Grimalt, who worked with our team as a post-doctoral fellow from the Universitat Jaume I, Castellon, Spain; Derek Chartrand, Teresa Precepa, Melanie Coppens, John McFarlane, Barry Lyons, Gene Jones and Jean Turgeon and the late Peter de Groot all of GLFC; Taylor Scarr, Ontario Ministry of Natural Resources; Paul Bolan, Steven Meating and other partners and staff of BioForest Technologies Inc., and Al King of the Invasive Species Centre.

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