BUMBLE BEE LEAVING THE HIVE TO DELIVER MICROBIAL CONTROL AGENT INOCULUM © JOHN SUTTON

What's the **buzz?**

Many farmers worldwide rely on using pesticides and fungicides to protect their crops, which can be harmful and unsustainable. **Professor Peter G Kevan**, **Dr Les Shipp** and **Professor Vernon G Thomas** are exploring the potential of using pollinators as biovectors as a viable alternative

PK: Professor Peter G Kevan

LS: Dr Les Shipp

VT: Professor Vernon G Thomas

Can you elucidate the process of bee vectoring?

LS: Bee vectoring, in its simplest terms, is using managed pollinating bees to deliver beneficial microbial agents to flowering plants for the control of insect pests and suppression of plant diseases. These beneficial agents include fungi, bacteria and viruses that target arthropod pests (such as insects and mites) or plant pathogens. The bee picks up the microbial inoculum on its body and hairs, and then spreads the inoculum powder to flowers during the pollination process or whilst self-grooming on plant leaves.

How do you protect the safety of pollinators carrying the biocontrol material?

PK: We have to be sure that the active biocontrol agent does not stress or kill the pollinators, so we must get the dose and formulation right to accommodate that whilst still suppressing the pest or pathogen incidence.

LS: The safety of the pollinators must be part of the evaluation process when we are investigating the possibility of an agent being bee vectored. The dispenser is designed so that the bee picks up the inoculum when it leaves the hive, but re-enters through another entrance hole, thus ensuring it does not bring the inoculum into the hive. Furthermore, not every hive requires a dispenser, and the inoculum can be rotated amongst the hives when there is a possibility of an agent having a negative effect.

Is bee vectoring compatible with different types of agriculture, such as organic and conventional growing?

PK: Yes; the only problem is that, for conventional chemical-based agriculture, more care would have to be exercised with insecticides.

VT: It is compatible with both, but especially organic approaches. Biovectoring can be seen as a vital adjunct to any type of organic agriculture because it does not rely on synthetic control agents or involve energy-intensive spraying; the control agents are all naturally-occurring and ubiquitous materials.

What are the advantages and disadvantages of using vector biocontrol as an alternative to conventional insecticides and fungicides?

LS: Greenhouse cage and field trials have shown that bee vectoring is as effective as chemical spraying. However, as chemical pesticides work faster than microbial agents (due to the nature of the infection process in the target host), bee vectoring of microbial agents must be applied early. It is also not a curative control measure, and is vulnerable to a number of different variables: weather can have a major impact outdoors (ie. too hot or wet); the bees may not fly; the inoculum can become caked and not remain powdery. Bee vectoring is not a silver bullet and, as such, should be used as part of a more holistic pest management programme.

Could you elucidate your plans to expand pollinator biocontrol vector technology (PBVT) into coffee production?

VT: My main goal is to get biovectoring assessed and, hopefully, deployed widely in coffee production. Trials already indicate that it has the potential to control several fungal diseases of coffee plants, as well as the coffee berry borer. I have a wide interest in several areas but, as a largely retired professor, I will focus on the coffee situation because globally it represents a vast crop that is in need of a new approach.

In what ways does PBVT still need refining?

LS: Like any technology, there will always be constant refining to improve efficiency. We have demonstrated that two fungal biocontrol agents can be combined in the same inoculum for both pest control and disease suppression. There is no reason why other combinations of microbial agents cannot be used.

PK: We need to explore a range of biocontrol agents that could be used against other pests and diseases, and on other crops. We also need to refine the technology so that it can be better used with honey bees.

VT: There is potential to use biovectoring to control viral diseases in crops. Subject to funding, this will be a focus of subsequent research.

BEE POLLINATED GREENHOUSE TOMATO FLOWER

DATE FOR YOUR DIARY

33rd Annual Guelph Organic Conference & Expo

30 January-2 February 2014
Guelph, Ontario, Canada

Professor Peter G Kevan will be presenting a PBVT workshop

Visit **www.guelphorganicconf.ca** for more details

Using pollinators for crop protection

Bees are crucial to the pollination of crops around the world, but widespread pesticide use in recent decades has significantly harmed pollinators. Now a team of researchers in Canada is working on a novel solution to this issue

THE INCURSION OF pests and diseases can have dire consequences for agriculture. For instance, grey mould can blight fruit crops such as strawberries and raspberries; the fungus that causes mummy berry can obliterate blueberry crops if left unchecked; and greenhouse tomatoes and sweet peppers can be affected by tarnished plant bug (TPB), western flower thrips, whiteflies and green peach aphids. These pests and diseases have the potential to ruin crops, with significant financial implications for farmers.

To combat pests and diseases, farmers often rely on the labour-intensive and costly process of spraying pesticides and fungicides. Whilst these are effective in the short term, their ecological viability is often highly contentious, due to the potential negative impacts of chemical pesticides and fungicides on pollinators and natural enemies in the agro-ecosystem, and the possible long-term implications of chemical control methods on the health of consumers and farmworkers. Additionally, pests and diseases can develop resistance to pesticides and fungicides over time, meaning that chemical control methods can become redundant within a mere matter of years. Moreover, use of synthetic pesticides prevents growers from obtaining organic status.

However, a number of naturally occurring microbial agents have been identified that successfully suppress plant pests and diseases, and studies suggest that there are few incidences where pests and plant pathogens have developed a resistance to them. Applied to crops, these microbial agents have the potential to provide an ecologically sound method of biocontrol.

Studies in the 1990s showed that as well as pollen, bees incidentally carry fungal spores and bacterial cells, including bee and plant pathogens, from flower to flower. By actively treating bees with naturally occurring microbial agents which are antagonistic/pathogenic to common pests and diseases, scientists could provide a novel, effective and labour-efficient means of suppressing pests and diseases.

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LEADING RESEARCH

Paving the way in the field of pollinator biocontrol vector technology (PBVT) are Professors Peter G Kevan and John C Sutton of the University of Guelph, Canada. By embracing plant pathology and crop protection with Sutton, Kevan is able to unite his interests in pollination biology and community and applied ecology with his passion for apiculture. Kevan was joined in 2001 by Dr Les Shipp, an expert in the biological control of greenhouse pests and a Senior Research Scientist with Agriculture and Agri-Food Canada at the Greenhouse and Processing Crops Research Centre in Harrow, Ontario, Canada.

Kevan and Shipp's research into PBVT is supported by several programmes facilitated by the Natural Sciences and Engineering Research Council of Canada (NSERC), not least the Canadian Pollination Initiative (NSERC-CANPOLIN), which was launched in 2009 as a five-year, CAD $5 million programme designed to examine the problems of pollination decline and management in agricultural and natural ecosystems. In addition, this research is also linked with NSERC's Biocontrol Network of Canada, as well as NSERC-Engage – a programme that gives companies across Canada access to the wealth of expertise available at Canadian universities. The research is further supported by Agriculture and Agri-Food Canada (the Canadian Government's department for agriculture), the Canadian Agricultural Adaptation Program, the Agricultural Innovation Program, and the Improved Farming Systems and Practices

> If pollinator biocontrol vector technology were adapted for major crops such as coffee, it could greatly reduce farmers' reliance on pesticides and fungicides on a global scale

FROM LEFT TO RIGHT: *BEAUVERIA* INFECTED LYGUS PEST • BACULOVIRUS-INFECTED CABBAGE LOOPER LARVA • *BEAUVERIA* INFECTED WHITEFLY • *BEAUVERIA* INFESTED THRIPS © JEAN PIERRE KAPONGO

Initiative. Evidently, PBVT is already inspiring optimism in many.

GETTING BUZZY

It all began in the early 1990s, when Sutton and Kevan showed that honey bees could suppress grey mould on strawberries by vectoring the fungal antagonist *Clonostachys rosea* – this so-called 'B52' bomber approach proved to be equally as successful as commercial fungicides. Since then, Kevan and his colleagues have continued to investigate the potential of bees as vectors of various microbial agents for pest control and disease suppression, identifying a number of microbial agents which can be applied to crops via PBVT to control a certain pest or disease. In 2003, having discovered that bees could be used to deliver the entomopathogen *Beauveria bassiana* to control TPB and thrips on greenhouse-grown sweet peppers, the researchers determined the optimal concentration of bee vectored *Beauveria* to be used for both peppers and tomatoes infected with whiteflies, thrips, aphids and TPB.

More recent research, meanwhile, has expanded the potential of bees as agents of PBVT, for example by demonstrating that bumble bees can vector *Clonostachys rosea*, *Beauveria bassiana* and *Bacillus thuringiensis* in outdoor crops (strawberries, blueberries and sunflowers) for disease and pest management, and also can be treated with two microbial agents (*Beauveria bassiana* and *Clonostachys rosea*) in a single inoculum as a means of controlling both crop pests and disease simultaneously.

FURTHER AFIELD

With the increasing demand for produce with little or no trace of chemical pesticides or fungicides, PBVT could provide an organic and environmentally sound means of preventing crop destruction and increasing pollination success for home-grown Canadian produce. However, the potential applications of PBVT could be of much broader international significance. If PBVT were adapted for major crops such as coffee, it could greatly reduce farmers' reliance on pesticides and fungicides on a global scale.

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In order to promote and develop the potential of PBVT in agriculture around the world, Kevan, Shipp and colleagues have been working with Professor Vernon G Thomas, a specialist in wildlife ecology with expertise in the transfer of science into conservation policy and legislation. Thomas hopes to garner support for the concept from the International Coffee Organization, having already secured support from the International Union of Biological Sciences in 2012 to apply PBVT to coffee production and other types of agricultural production. According to Thomas, things are looking positive so far: "We recently held an invited workshop at the 50th Anniversary meeting of the International Coffee Organization in Belo Horizonte, Brazil, on the potential use of bee biovectoring in coffee production," he explains. "There, representatives of several nations' coffee growers expressed strong interest in this novel approach to disease control."

LOOKING TO THE FUTURE

As well as pursuing the application of PBVT in global crops such as coffee, the team will continue conducting research into the efficacy of bee vectored microbial agents by conducting further commercial trials. Greenhouse pepper and tomato trials using an AcMNPV baculovirus for cabbage looper control, for example, are planned for the near future in association with a number of different private organisations.

Meanwhile, another key focus for the researchers is the dissemination of information regarding PBVT, so that pest management specialists can learn how it can be adapted to their needs. As well as having several workshops across Ontario planned for the upcoming year, Kevan, as President of the International Commission for Plant Pollinator Relations, also plans to visit the EU: "I will speak to fellow scientists, growers and beekeepers about the technology," he explains. With the combined efforts of these dedicated scientists, along with the support of such a powerful body of partners, it seems likely that their efforts to take PBVT global will be successful.

INTELLIGENCE

BIOVECTORING USING MANAGED BEES

OBJECTIVES

The use of managed pollinators aims to have several concomitant positive effects, including greater and superior yields, improved shelf and storage life and reduced use of synthetic pesticides.

PARTNERS

AAFC Pest Management Centre • AAFC Growing Forward 2 • Laverlam International Corp • Bee Vectoring Technologies Inc. • Biobest Canada Ltd • Koppert Canada Ltd • Ontario Greenhouse Vegetable Growers • Adjuvants Plus • Novozymes Biologicals Inc. • National Academy of Agricultural Sciences, Korea • Institute of Apiculture, Chinese Academy of Agricultural Sciences • Ontario Pesticides Advisory Board • Government of Alberta and Ontario Beekeepers' Association • Ontario Fruit & Vegetable Growers Association • Prince Edward Island Berries • Nova Scotia Fruit Growers' Association • Atlantic Canada Organic Regional Network

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PROFESSOR PETER G KEVAN is a pioneer in the research, development and innovation of the system and equipment for the deployment of biological control agents delivered by managed pollinators for the protection of crop plants from plant diseases and insect pests.

DR LES SHIPP is a Senior Research Scientist with Agriculture and Agri-Food Canada. His area of research is greenhouse pest management with the emphasis on biological control.

PROFESSOR VERNON G THOMAS focuses on the transfer of science to policy and legislation, as in the creation of protected areas networks, invasive species regulation, and the reduction of lead exposure in wildlife.

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