ORGANIC SCIENCE CANADA

SCIENCE FOR PRODUCERS | ISSUE 3 | SPRING 2021

Wasps vs. spotted **wing drosophila**

New predator allies for berry producers in British Columbia

About Organic Science Canada Magazine

Organic Science Canada magazine is packed with the latest advancements in organic research and innovation from the national Organic Science Cluster (OSC) program. The magazine brings you trends, news and results from across Canada. The scientists who appear in these pages are working hard to improve the sustainability and profitability of organic and low-input agricultural systems.

Organic Science Canada magazine is published by the Organic Federation of Canada (OFC), in cooperation with the Organic Agriculture Center of Canada (OACC).

Created in 2007, the OFC is composed of ten organic associations representing nine provinces and one territory. Collectively, they promote the development of the Canadian organic industry across the country. The Federation is responsible for the maintenance and interpretation of the Canadian Organic Standards and the management of Organic Science Clusters 1, 2, and 3. OFC is based in Montreal.

The OACC was formed in 2001 with a mission to lead and facilitate organic research and education. The Centre plays a key role in national efforts to advance the science of organic agriculture. OACC also supports the training of the next generation of organic professionals. OACC's home base is in Truro, Nova Scotia, at Dalhousie University's Agricultural Campus.

OSC3 (2018-2023) is supported by the AgriScience Program under Agriculture and Agri-Food Canada's Canadian Agricultural Partnership, and by over 70 partners from the agricultural community. OSC3 has 27 research activities under five general themes: field crops, horticulture, pest management, livestock and environment.

FOR MORE INFORMATION:

- www.organicfederation.ca
- www.dal.ca/oacc
- @OrganicAgCanada

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Above: A lady beetle larva devours aphids. (Photo by Janet Wallace)

Cover photo: A male Leptopilina japonica parasitoid faces its species host, the female spotted-wing drosophila (Drosophila suzukii), on top of a blueberry. (Photo by Warren Wong)

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Organic Science Canada: Featuring organic horticulture

Dear Reader,

Despite the many challenges that arose throughout 2020, continuing the work in organic horticulture is vital to Canadian agriculture. As we witness the effects of COVID-19 unfold around the globe, it's inspiring to see how the industry has persevered. I believe we are poised to emerge stronger at the end of this! That same resilience is shown by all of the researchers, students, partners and participants who have worked tirelessly over many years to bring us sustainable solutions. Organic Science Canada magazine offers a glimpse into the efforts these dedicated people have made to helping farmers overcome many challenges and find new opportunities for growth and development.

As an organic greenhouse operation in Prince Edward Island, we have very specific needs and challenges that might not be shared with other horticultural producers or in other regions. This publication captured my interest by highlighting challenges faced by the organic horticulture sector across the country, and presenting the research being done to resolve these issues.

Over the years, I have been carefully following certain key research activities outlined in this issue. Results from this research have prompted me to implement changes to my operation. For example, the feature on Dr. Martine Dorais (pg. 27) accurately outlines the extensive research she has conducted in the organic greenhouse sector over the years. Every greenhouse producer can take away something from her work on managing the root environment and managing greenhouse effluent.

It is amazing to read how nature provides systems and tools to better manage our crops. Accomplishments in biological pest control over the last 10 years is captured by Janet Wallace (pg. 9). She aptly describes the complexity as "Biological pest control resembles a Shakespearean tragedy more than a simple food chain." Examples include planting flowers to attract parasitic wasps, and introducing parasitic wasps to help control spotted wing drosophila. There are great excerpts from research findings on how to manipulate habitat to attract biocontrol agents, use trap crops and release biocontrol agents and microbials.

The use of plant extracts is another area that seems to be limitless. A project by Dr. Simon Lachance, a researcher at the University of Guelph, explores using saponin extracts from waste tomato vines as a bio-pesticide (pg. 13). Taking a waste product and adding value – what a win-win scenario! Another researcher, Dr. Rene Van Acker, uses the essential oil of manuka (*Leptospermum scoparium*), a shrub native to Australia and New Zealand, as a herbicide (pg. 17). A lot of valuable information!

Besides managing the day-to-day agronomy on our farming operations, I believe it is also our responsibility as organic farmers to think bigger. One activity as part of Organic Science Cluster 3 works to understand the net greenhouse gas emissions (GHG) associated with organic field crop production. An interview with the activity leader, Dr. Peter Tyedmers, highlights how he will measure GHG emissions. (pg. 23). It is a complicated topic, however, the article may give you a better understanding of those complexities!

This issue is full of great information on current organic horticulture research to help you make better decisions to become more sustainable and prosperous in the future. As a member of the board of directors for the Organic Federation of Canada for a number of years, I certainly know that our collaboration with the Organic Agriculture Center of Canada is valuable as it has resulted in important information for Canadian farms as directed by Canadian farmers. The 2021 edition of Organic Science Canada is certainly a great testament to that.

Cheers to safe and sustainable farms for our future!

Sincerely,

Marc Schurman
Board member,
Organic Federation of Canada

Snippets

Research during COVID-19: Audrey-Kim Minville, M.Sc. student with Dr. Caroline Halde at Université Laval, washes roots for analysis. (Photo by Héloïse Henry)

ORGANIC RESEARCH DURING COVID-19

In this year of COVID-19, research in the Organic Science Cluster 3 was challenging. The 79 researchers who work on OSC3 projects persevered through the complete shutdown of labs and field research in the spring, to be faced with the risk management task of reopening during the summer, and in many cases, transitioning to teach their university courses entirely online in the fall.

While nearly every project experienced delays, we are proud to report that all 27 research projects are continuing. The research teams have shown tremendous resilience readjusting to the circumstances, sharing their results via webinars and virtual field tours, and keeping staff and students working.

On the OSC3 management side of things, there has been a volley of communications with researchers to readjust their plans and budgets, and we are thankful for their patience. We are also grateful for the efforts of our Agriculture and Agri-Food Canada colleagues, who govern the cluster program. OSC3 management has been in close communication with them throughout the year from our respective home-offices.

Finally, a big thank you to the producers across the country who have kept us fed throughout the pandemic. The growers and other food chain actors keep us going so we can provide them with new research outcomes to use in the future.

OACC CELEBRATES 20TH ANNIVERSARY

The Organic Agriculture Centre of Canada (OACC) was established in 2001 through the vision and determination of Dr. Ralph Martin at what was then the Nova Scotia Agricultural College in Truro, NS. Now a part of Dalhousie University, the OACC has worked toward the advancement of organic science and university level training in organic agriculture since its inception. The OACC supported the development of online degree-level courses at universities across Canada and still supports the delivery of the Certificate of Specialization in Organic Agriculture offered by Dalhousie University.

In its early years, the OACC focused on conducting research and supporting extension, working with hundreds of farmers and research collaborators across Canada and training many young professionals in organic agriculture. Since 2009, however, the OACC has been the voice and facilitator of organic science in Canada by representing the science of the organic sector in government meetings, and setting research priorities for the national Organic Science Cluster program which is co-managed with the Organic Federation of Canada. The Organic Science Cluster program has provided $30 million in AAFC and industry funding support to over 35 universities and AAFC research stations across Canada from 2009-2023. We at the OACC thank all of the collaborators, funding agencies and colleagues in the organic sector for working with and supporting the OACC over its two decades of service and look forward to continuing and new collaborations.

Snippets

Dr. Ralph Martin

OACC FOUNDER RECEIVES LEADERSHIP AWARD

Dr. Ralph Martin was awarded the second annual Leadership in Organic Science Award by the Canada Organic Trade Association in February 2020. The recently retired University of Guelph professor has made a huge contribution to organic agriculture education and research. His measured, comprehensive approach to problem solving has inspired his students and peers. Dr. Martin is a true systems thinker!

In 2001, Dr. Martin founded the Organic Agriculture Centre of Canada at the Nova Scotia Agriculture College (now Dalhousie University Faculty of Agriculture). He had a dramatic impact on teaching and established the web-based Certificate in Organic Agriculture. In the area of research and extension, he published more than 50 peer-reviewed and technical papers, and established networks of organic extension specialists and scientists. He initiated the Organic Science Cluster program, which started in 2009. The program has opened the doors for $30-million in funding for organic research over 15 years.

At the University of Guelph, Dr. Martin held the Loblaw Chair in Sustainable Agriculture. He has recently published a manifesto of sorts. His book Food Security: From Excess to Enough contains everything from stories of life lessons from his family's farm to the latest food waste research. The book includes a particularly poignant story of witnessing degraded soil on the family farm, that inspired his mantra, the gospel according to Martin: "Keep your soil covered."

For more about Dr. Ralph Martin's work, you can consult his University of Guelph site:

www.plant.uoguelph.ca/rcmartin

PEPPERMINT ESSENTIAL OIL FUMIGATION FIGHTS SPOTTED WING DROSOPHILA BUT CAN HARM BENEFICIAL PARASITIC WASPS

The invasive fly, the spotted wing drosophila (SWD), is a pest of berries, brambles, grapes and tree fruits. SWD is being investigated by OSC3 researcher Dr. Juli Carrillo of University of British Columbia and her cross-Canada team. Fumigation with peppermint essential oil is an organic option for SWD management. Compounds in the gaseous peppermint oil kill SWD pupae. However, the treatment can harm parasitic wasps that are growing inside the SWD pupae. This study found that if fumigation does not occur during active parasitism, the wasps can survive within their host, whether the host is alive or dead, and later emerge to continue their biological control job. If farmers are using biological control, it is important to observe the stage of parasitism, as it may be possible to time fumigation to avoid harming the helpful parasitic wasps.

Source: Gowton, C.M. et al., 2020. Peppermint essential oil inhibits Drosophila suzukii *emergence but reduces Pachycrepoideus vindemmiae parasitism rates. https://doi.org/10.1038/s41598-020-65189-5*

HONEYBEES EXPOSED TO BIOPESTICIDE BECOME LESS EFFECTIVE IN NECTAR FORAGING

The fungus Beauveria bassiana is used as a biopesticide to protect honeybees against mites and other invertebrate pests. It is generally believed that this fungus does not infect or harm honeybees. A number of Beauveria products are permitted by OMRI for organic production systems. In a recent study, honeybees that were exposed to the fungus became "overly sensitive" to sucrose. This can be a problem for a colony's nectar-foraging efficiency because an overly sensitive bee may lead other bees to a location where the nectar is less abundant (compared to less sensitive bees that lead bees only to sites with abundant nectar). Organic farmers who produce honey or who maintain bees for pollination should always consider the behavioural effects of biopesticides on their bees. Even if the bees survive in the short term, more subtle behavioural effects can compromise a colony's ability to survive.

Source: Carlesso et al., 2020. Exposure to a biopesticide interferes with sucrose responsiveness and learning in honey bees. https://doi.org/10.1038/s41598-020-76852-2

Snippets

Wheat is one of the highest value export crops that the organic sector produces in Canada. (Photo by Dr. Andrew Hammermeister)

SUCCESS OF ORGANIC WHEAT AND OAT BREEDING DEPENDS ON UPTAKE BY FARMERS

Research has shown that breeding wheat, oats and soybean under organic management conditions can produce cultivars that are better suited to organic management conditions. Ultimately however, the success of these cultivars depends on uptake by farmers and processors.

Dr. Jennifer Mitchell-Fetch at AAFC Brandon was the lead breeder who has produced two cultivars of organic oats, AAC Oravena and AAC Kongsore. Both cultivars are licensed to Grain Millers Canada Corp. with distribution through Fedoruk Seeds Ltd. The development of these cultivars was funded in part by AAFC and industry partners through the national Organic Science Cluster program.

"We have had lots of interest in Oravena and now growing interest in Kongsore. It's just the seed production has been the challenge and the limiting factor in their uptake." says Mike Fedoruk of Fedoruk Seeds Ltd. "We had bad luck for a few years with the seed production due to weather, so It was hard to get Oravena going. I think it was in 2018 that we finally had a decent supply of seed that we could start retailing it. Fedoruk indicates that he is hoping AAC Kongsore will be available in spring 2020. "It is challenging growing seed under organic management but I do believe there is an opportunity especially with more growers transitioning to organic and more interest in products that are suited towards them."

The Organic Science Cluster program also supported the development of AAC Tradition spring wheat under organic management (bred by Dr. Mitchell-Fetch and Dr. Stephen Fox). "It is nice to have a cultivar of wheat available that is suited to low-input and organic management systems." says Todd Hyra of SeCan which holds the license to AAC Tradition. Unfortunately, despite its good agronomics, AAC Tradition was just under the gluten strength threshold for top grade milling quality in the recent reclassification of Canadian Western Red Spring Wheat. Despite this, "it still makes a great loaf of bread," says Hyra. "The success of this cultivar now depends on farmer uptake." Hyra indicates he would be interested in talking with seed distributors about taking on AAC Tradition.

Breeding of grains under organic management supports not only organic growers but also conventional low-input growers. However, the considerable investment of time and resources into developing genetics under and for organic management must be justifiable to the breeders. Producers must support organic breeders by using these organically produced cultivars!

SOIL ORGANIC MATTER CHANGES ON ORGANIC MIXED VEGETABLE FARMS

The levels and changes of soil organic matter (SOM) on 30 certified organic mixed vegetable farms were compared with each other and with 10 non-organic benchmarks in a recent study by the University of Michigan. Overall, the SOM of organic operations was more than twice as high as their regional non-organic benchmarks. However, not all organic farms experienced a trend of increasing SOM. Those with declining SOM had started farming organically with high initial SOM (relative to other farms), had farmed organically for a shorter period of time, and used deeper tillage depth. Organic farms that had increasing levels of SOM were more likely to be applying compost and using cover crops, especially leguminous cover crops. The combination of cover crops and compost seemed to have a synergistic effect (i.e., greater than the sum of each effect). The authors suggested further research is needed to explore these trends beyond the lower peninsula of Michigan and with other cropping systems.

Kaufman, M.M. et al., 2020. Sustainability of soil organic matter at organic mixed vegetable farms in Michigan, USA. https://doi.org/10.1007/s13165-020-00310-6

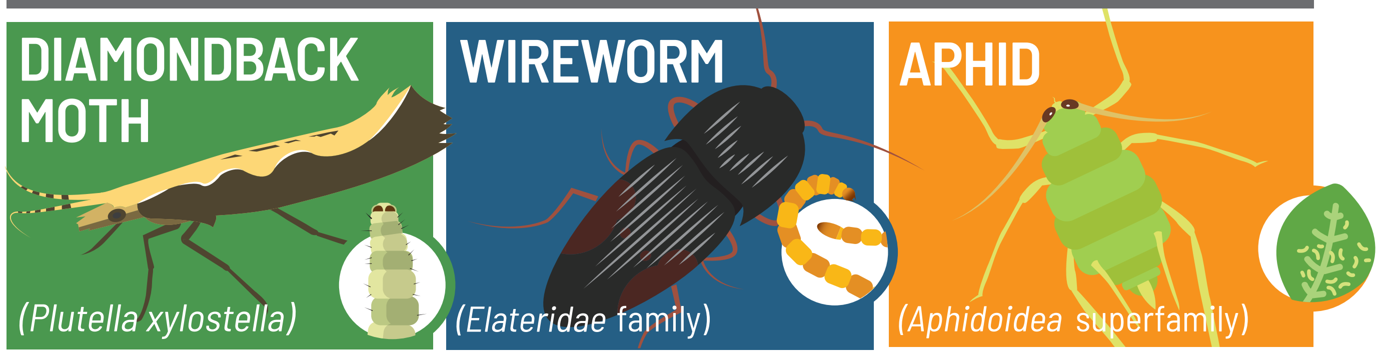
Managing Fruit & Vegetable Insect Pests

A GLIMPSE AT THE RESEARCH ON SELECTED FRUIT & VEGETABLE INSECT PESTS FROM THE ORGANIC SCIENCE CLUSTER (OSC) 2 AND 3

For more information and resources on organic research, visit the Organic Science Cluster website (www.dal.ca/oacc/OSC) and follow us on Twitter (@OrganicAgCanada).

VEGETABLE PESTS

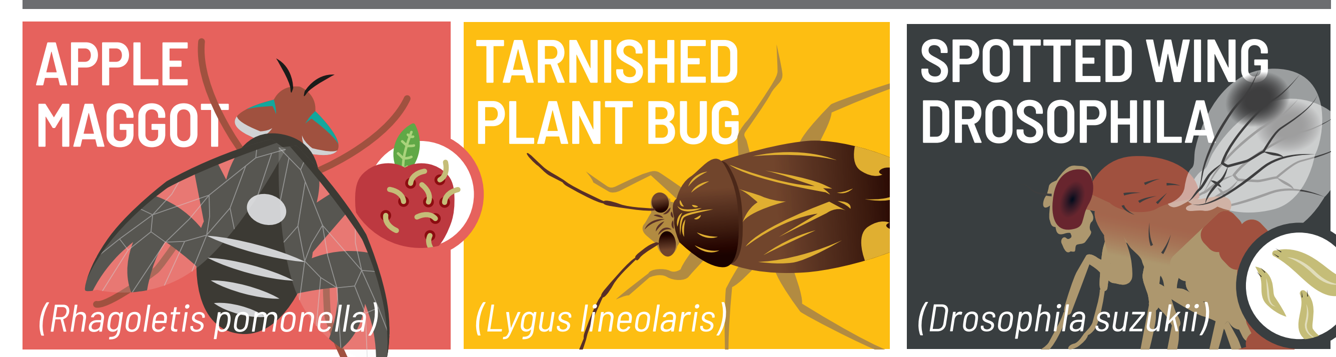
WHO AM I?



	Diamondback Moth	Wireworm	Aphid
WHAT DO I LOOK LIKE?	Adult: 9 mm long, wings of have wavy cream-coloured margin forming three diamonds when folded. Larvae: pale green, up to 12 mm long at maturity, cigar-shaped with forked posterior.	Adult: Click beetle species may be black, brown or grey, slender 10-18 mm long. Larvae: up to 40 mm long, yellow to copper colour, segmented wiry body, 3 pairs of legs.	Adult: Less than 6 mm long with pear-shaped bodies, long antennae and two short tubes projecting from hind end. Larvae: Often nearly invisible to the naked eye, baby clones are often found surrounding the mother aphid.
WHAT CROPS DO I INVADE?	BRASSICAS (CABBAGE, BROCCOLI)	VARIOUS VEGETABLES	SQUASH, CUCUMBER, PUMPKIN
WHAT DAMAGE CAN I DO?	Larvae feed on crop leaves between the large veins and midribs, creating a "window paning" effect on leaf surface.	Larvae damage and stunt seedlings of many crops in spring by feeding on roots and seeds. In fall, larvae tunnel into root crops, reducing marketability and storability.	Mouth parts that are designed for piercing the plant and sucking sap cause yellowing or browning leaves, stunted growth, curled leaves, low yields and even death in plants.
HOW ARE RESEARCHERS HELPING FARMERS?	Dr. Deborah Henderson (Kwantlen Polytechnic University) has registered a viral biopesticide to control caterpillar pests (like diamondback moth) on organic brassica farms (OSC2, Activity C.30).	Todd Kabaluk (AAFC Agassiz) is assessing cultural and mechanical practices for managing wireworm populations (OSC3, Activity 21).	Dr. Simon Lachance (University of Guelph) is investigating the use of naturally occurring saponins as a pest management practice in organic greenhouses (OSC3, Activity 19).

FRUIT PESTS

WHO AM I?



	Apple Maggot	Tarnished Plant Bug	Spotted Wing Drosophila
WHAT DO I LOOK LIKE?	Adult: Slightly smaller than a housefly, 5-7 mm long and have conspicuous black bands running across the transparent wings. Larvae: White, tapered maggots approximately 5-7 mm in length.	5-7 mm in length, brown mottled with yellow, bronze, or reddish marks. Each wing is black-tipped with a yellow triangle.	Adult: 2-3 mm long may be seen on outside of fruit. Males have a distinctive dot on each wing; females have serrated ovipositor. Larvae: Up to 6 mm long, legless, headless, white or transparent.
WHAT CROPS DO I INVADE?	APPLES	VARIOUS FRUITS & VEGETABLES	BERRIES & GRAPES
WHAT DAMAGE CAN I DO?	Blemishes on the fruit appear as a result of eggs inserted beneath the skin of the apple. Larvae tunnel through the fruit flesh, leaving brown tunnels behind.	Attacks buds of developing fruit by piercing and sucking the plant tissue, killing buds or scarring fruit. Fruit may have deformed leaves, scarred and discolored stems.	Females use a serrated ovipositor to lay eggs under the skin of the fruit, causing it to be soft and unmarketable. Small larvae may be observed in fruit or crawling.
HOW ARE RESEARCHERS HELPING FARMERS?	Dr. Gérald Chouinard (IRDA) has investigated the use of a row by row exclusion netting system, consisting of nets with an added impermeable rainproof coating (OSC2, Activity B.11).	Dr. Caroline Provost (CRAM) is looking to determine the potential of predatory bugs as biocontrol agents in strawberry crops (OSC3, Activity 18).	Dr. Juli Carrillo (UBC) and Dr. Annabelle Firlej (IRDA) are developing multiple strategies for spotted wing drosophila pest management, focusing on ecological and organic methods of control (OSC3, Activity 20).

Insects, allies and enemies: Biocontrol agents at work

JANET WALLACE

Ground beetles attack pests that live just above or below the soil surface, including slugs. (Photo by Janet Wallace)

In a perfect world, pests are controlled by farm ecosystems, not the farmers. However, farmers play a pivotal role in setting the scene for the drama to unfold. They can provide habitat for "biocontrol allies," which are enemies of pests. Farmers can also ensure crops receive a balanced supply of nutrients to help plants resist pest damage. A whole cast of players – from microorganisms to spiders to birds – is involved.

Biological pest control resembles a Shakespearean tragedy more than a simple food chain. In nature and on farms, food webs are much more complex, sometimes even circular. For example, beetles eat mites, but mites eat beetle larvae. Intricate interactions between pests and their enemies have been studied by Canadian researchers since 2009 as part of the Organic Science Cluster (OSC). In all three OSCs, scientists have explored how farmers can create habitat to support beneficial insects including predators of pests, use trap crops to pull pests away from crops, and release biological controls of crop pests.

HABITAT MANIPULATION (IF YOU BUILD IT, THEY WILL COME)

Organic farms tend to have a greater abundance and diversity of biocontrol agents than non-organic farms.[1] To keep a strong and stable community of such allies, farmers can provide 'SNAP' - shelter, nectar, alternative prey and pollen by planting flowering strips (insectary strips) or leaving wild areas.

Wild areas and flowering strips can provide habitat for pollinators, which can lead to higher crop yields. Also, insectary strips and wild areas fulfill the new biodiversity requirement of the 2020 Canadian Organic Standards to take "measures to promote and protect ecosystem health on the operation."[2]

OSC3, Activity 28: Flowers for beneficials

Dr. Jason Gibbs (University of Manitoba) and his team have been exploring the benefits of providing flowering habitats on field margins to support beneficial organisms. He found more than three times the number of ground beetles in flowering strips compared to grassy edges of control fields. Ground beetles consume many pests, including aphids, mites, beetle larvae, slugs and even weed seeds.

It can be challenging, however, to establish flowering strips and maintain the desired species composition. Perennials need to survive the winters and spread. Annuals must self-seed. Aggressive plants, or undesirable plants such as weeds should not be allowed to dominate the plant community.

THE CAST

Biocontrol (biological control) agents – living organisms that are introduced, supported or encouraged by humans with the intent to harm pests of crops. Biocontrol agents are sometimes called "enemies" because they attack pests, but they are really the allies of farmers. Biocontrol agents include:

- predators - eat the pests;
- parasitoids - lay eggs in pests and the larvae eat pests;
- parasites - feed on living pests;
- pathogens - cause disease in pests.

Beneficial organisms – organisms that help crops, including pollinators, symbiotic soil life and biocontrol agents.

Pests – this article focuses on invertebrates that damage crops, but a pest is defined in the Canadian Organic Standard as an "organism causing damage to humans or to resources used by humans, such as certain viruses, bacteria, fungi, weeds, parasites, arthropods and rodents." This ranges from fungi that inhibit germination, to deer that eat crops, to mice that consume organic products in storage.

"We've been reseeding to help keep these going, which might be practical if you're using purely domesticated plants with relatively cheap seeds," says Gibbs. Native perennials "hopefully persist and require less input over time. My main takeaway with perennial plantings is to do it very deliberately and take your time. If I was a grower, I'd probably spend a couple of years just preparing the site to make sure it's weed free."

OSC1, Activity D1: Flowers for bicontrol agents

Dr. Josée Boisclair (Institut de Recherche et de Développement en agroenvironement) studied the link between flowering strips, pests and their predators. Her team found the most ladybird beetles (ladybugs) in marigolds, nasturtiums, cosmos and yarrow (in that order) compared to coriander, sweet alyssum, alfalfa, petunia, phacelia and white mustard. Ladybird beetles voraciously consume soft-bodied pests, including aphids, mealybugs, whiteflies and thrips.

However, the flowers also attracted pests, including tarnished plant bug in phacelia and flea beetles in sweet alyssum, white mustard and nasturtiums.

"The use of flowering strips to encourage natural enemies around their crops will surely increase biodiversity on their farms but the actual impact of this practice on insect pest control is yet not well understood," Boisclair concluded. "As an example, certain plant species have been shown to favour the presence and activity of natural enemies, such as predators and parasitoids. However, consideration should be taken to make sure that these same plant species do not become a reservoir for insect pests."

TRAP CROPS

If a certain plant attracts pests, farmers can use this to their advantage. So-called "trap crops" divert pest pressure from crops. They also concentrate the pest population. Farmers can then destroy the pests by cutting or tilling the trap crop or applying a botanical pesticide.

Lady beetles and their larvae consume aphids, which have damaged this faba plant (also called a fava bean or broad bean). Fabas are sometimes used as trap crops for aphids. At the same time, fabas (which are known for their high rates of nitrogen fixation) can be used as a green manure. (Photo by Janet Wallace)

OSC3, Activity 12: Trap crops and baby greens

To reduce flea beetle damage in organic baby greens, Dr. Annabelle Firlej (Institut de Recherche et de Développement en agroenvironement) planted trap crops of flowers and a mix of amaranth, rapeseed and mustard. Preliminary results show these flowering plants attract flea beetles more than the other plants and (most importantly) more than the spinach. The more diverse the trap crop, the more pests it attracted.

In weedy or dry conditions, however, the trap crop struggled to get established. Even when the trap crop was robust, it was less effective in weedy conditions because the pests preferred certain weeds over the trap crop. The researchers conclude it is important to have good weed management and irrigation to use trap crops to control pests.

OSC3, Activity 18: Trap crops for strawberries

OSC researchers are exploring various ways to reduce tarnished plant bug (Lygus) damage on strawberries. Lygus is a significant pest in many fruits and vegetables and can cause stunted and deformed strawberries. Lygus damage is a serious barrier to transition to organic strawberry production.

Non-organic producers use broad-spectrum insecticides to control Lygus. However, as Dr. Caroline Provost (Centre de recherche agroalimentaire de Mirabel) explains, these insecticides also kill the predatory mites that naturally control levels of other pests. "Killing predatory mites doubles the number of pests. This is a vicious circle that shows that insecticide is really not a preferred option."

TIPS FOR PROVIDING HABITAT FOR BIOCONTROL AGENTS:

1. Be on the edge. The greatest diversity and abundance of beneficials is found on field borders where cultivated and wild areas meet.

2. Small is beautiful. The smaller the fields, the more "fringe benefits" (above) in terms of greater species richness and numbers of insects that attack pests. Farmers can reduce the distance beneficials need to travel from wild areas to crops.

3. Plant flowers. Flowers provide parasitoids and predators of pests with food (pollen, nectar and prey). The ideal flowering strip has different types of flowers blooming throughout the growing season.

Dr. François Dumont (Centre de recherche agroalimentaire de Mirabel) "observed that buckwheat, mustard and canola are good summer trap crops, whereas mullein and sunflower are good autumn hosts. We suggest using both summer and autumn trap crops to act on Lygus population for an extended period of time."

Certain trap crops, such as mullein, are also hosts for predators of Lygus, such as damsel bugs. These trap crops also provide habitat for its predators. Damsel bugs appear to be more effective at controlling Lygus in the trap crops compared to the strawberry plants. The trap crops draw the pests away from the strawberries – once lured into the trap crops, Lygus is attacked by damsel bugs.

RELEASING BIOCONTROL AGENTS

OSC researchers have conducted field releases of biocontrol agents, including in the strawberry-Lygus study.

OSC3 Activity 18: Predation in strawberry fields

To control the tarnished plant bug (Lygus) in strawberry fields, Drs. Provost and Dumont released two predators: damsel bugs and minute pirate bugs. After the releases, the population of Lygus dropped for two weeks.

Both predators eat a variety of species, including other pests. The damsel bug attacks aphids and the minute pirate bug feeds on thrips, spider mites, whiteflies. Their general diet allows the predators to survive even when Lygus isn't abundant.

Even though these predators are common on organic farms, the researchers conclude that a series of well-timed releases is the most effective way to control Lygus. The damsel bugs attack adult and larval Lygus. Pirate bugs consume eggs and small nymphs. The scientists also used the damsel bug to successfully control Lygus on greenhouse cucumbers.

In organic strawberry fields, the researchers are developing strategies to defeat Lygus. Dumont concludes, "We can envisage building an environment favourable to predators, estimating that these predators will kill 85% of the pest population, and that the remaining 15% will cause damage at a low level that can be controlled."

MICROBIAL INTRODUCTIONS

OSC2 Activity C30: Viral pesticides

While Dumont compared the attack of a damsel bug on Lygus to a "tiger attacking a sheep," Dr. Deborah Henderson (Kwantlen Polytechnic University) is investigating a less dramatic form of biological control using microorganisms to control caterpillar pests in brassicas (cabbage, broccoli, kale, etc.).

Currently, many organic growers use *Bacillus thuringiensis* (Bt), a commercial product containing soil bacteria, to control the diamondback moth, cabbage looper and imported cabbageworm. Unfortunately, many pests have developed resistance to Bt.

Applications of certain viruses and fungi (e.g., *Beauveria bassiana*) that naturally affect caterpillars can control caterpillar pests, as revealed by Henderson's research.

OSC3 Activity 21: Wireworms and Metarhizium

Dr. Todd Kabaluk (Agriculture and Agri-Food Canada) studies wireworms (click beetle larvae). These pests feed on the roots and tubers of crops including cereals, carrots, potatoes, lettuce and peas leading to death of seedlings in the spring, and damage to root crops in the fall affecting quality and storability.

Kabaluk found a strain of a soil fungus that kills wireworms. He cultured the strain, *Metarhizium brunneum* LRC112, and tested it on organic farms.

Amara Farm, a certified organic vegetable and fruit farm on Vancouver Island, has "incredibly high wireworm pressure" that makes it difficult to grow many crops, even head lettuce. According to the farmer, Arzeena Hamir, applications of Metarhizium led to greater survival of lettuce and bok choi and much less damage in Japanese turnips.

"We actually had damage-free potatoes," Hamir says. Before, wireworm damage was so bad that they couldn't harvest a decent crop of potatoes.

When asked if they would continue to use Metarhizium, Hamir replies "Absolutely!!! This treatment has given us a lot of hope that we can now include these crops in our farm plan."

Kabaluk is fine-tuning the application with an "attract and kill technique." He developed granules of pheromones, chemicals that attract the adult click beetles, and combined these with *M. brunneum* LRC112. This disrupts mating behaviour and may lead to greater uptake of the lethal fungus.

CONCLUSION

Based on the OSC research findings, the key to successful biological control of pests appears to be a multi-pronged approach. If providing habitat through insectary strips isn't sufficient, consider introducing organisms that attack pests. If that isn't enough, consider pheromone disruption or plant-based pesticides.

"The integration of biological control as a preventative approach should be a priority in order to minimize pest problems," Josée Boisclair concludes. "A better knowledge of the impact of landscape on natural enemies' abundance and activity on farms is needed to improve the impact of conservation biological control."

For more information about the research projects mentioned in this article, see www.dal.ca/oacc/OSC.

SOURCE

[1] Lichtenberg et al., 2017. A global synthesis of the effects of diversified farming systems on arthropod diversity within fields and across agricultural landscapes. https://doi.org/10.1111/gcb.13714

[2] Organic production systems: General principles and management standards CAN/CGSB-32.310-2020. Subclause 5.2.4. https://www.inspection.gc.ca/organic-products/standards/eng/1300368619837/1300368673172

REVISED 2020 CANADA ORGANIC STANDARDS WILL INFLUENCE FUTURE RESEARCH

NICOLE BOUDREAU
ORGANIC FEDERATION OF CANADA

In December 2020, a new version of the Canadian Organic Standards (COS) was published. It was revised, as required every five years. The changes to the COS provide more research opportunities for the Organic Science Cluster.

Unsurprisingly, the ban on genetic engineering has been maintained. The revised definition of genetic engineering (GE) includes the famous CRISPR, which has been rejected by the entire international organic community.

However, the organic sector does not escape the grip of genetic engineering. There are exceptions to the GE ban. Organic livestock farmers are permitted to use (as a last resort) certain essential substances, such as amino acids, vaccines and phytase, that have been manufactured using GE bacteria or substrates, or contain residues of GE substrates. These exceptions were granted in recognition of the need to (i) supplement animal feed during the winter, (ii) prevent disease, and (iii) minimize the risk of water pollution from excessive nutrient loads. With the expectation that manufacturers will offer non-GE substances in the near future, this compromise does not aim to 'weaken' the COS, which in many ways, have been strengthened by the review.

The 2020 COS introduce a requirement for concrete measures to promote biodiversity. Farmers will have to demonstrate how they increase biodiversity, such as maintaining wilderness areas, diverse shelterbelts or strips of flowering plants between crop rows.

Animal welfare is in the spotlight in the COS 2020: electric trainers (cattle prods) are completely banned. Tie stalls, which are still tolerated under certain conditions, will be eliminated from organic production in 2030. But the most significant changes affect poultry. When they can't go outside due to bad weather, barn-raised layers will have access to enriched verandas-- uninsulated and unheated 'playgrounds' with enrichments, such as perches, hay bales or pecking objects, with a surface area equal to 1/3rd the size of the henhouse. Natural behaviours, such as scratching and dust bathing, will be encouraged by having a floor made of sand or soil, or covered with litter. The introduction of this concept is accompanied by a few exceptions and delays to facilitate adoption by farmers.

Access to the outdoors for broiler chickens is clarified: the 2020 COS requires that operators provide access for all birds to go outside (when weather permits) with the goal of having at least 15% of these birds outdoors when the weather is good. This 'low' number of 15% might not seem to align with organic principles; so the COS proposes (without imposing) measures to improve this percentage: using hardy breeds with slower growth, feeding low-protein diets to slow growth, or slaughtering birds at 60+ days of age instead of 40 days. Operators can use mobile units and make pastures more inviting by adding overhead cover, perches, water and feed outside. Research is needed to identify the most effective strategies.

In a related issue, do our vulnerable bees need sugar reserves to withstand Canadian winters? Some beekeepers recommend allowing bees to consume their own honey, while others recommend feeding with refined sugar, which would would reduce the risk of health problems. The 2020 COS compromise allows providing bees with reserves of organic honey, organic sugar, non-organic honey and, as last resort, non-organic sugar, in descending preference. This issue will be reconsidered in 2025, hopefully with greater knowledge on bee survival in cold countries.

Greenhouse production under natural light continues, with artificial lighting permitted as a supplement, after long discussions on a proposal that 100% artificial lighting be permitted for crops harvested within 60 days of planting. More research is needed on the nutritional qualities of fruits and vegetables produced exclusively under artificial lighting.

Climate change influenced the standards. In a forage shortage caused, for example, by drought, non-organic forage may make up to 25% of a ruminant herd's forage ration. This is allowed only after breeding stock has been fed non-organic forage and the farmer has developed a plan to deal with future shortages (6.4.7c). The organic status of the meat or milk of these animals will not be affected.

Finally, the Permitted Substances Lists have been simplified and clarified. Struvite that has not been precipitated from sewage sludge was added as an input for crop production.

Organic operators must comply with the COS 2020 by December 2021. The working groups and Canada General Standards Board (CGSB) Technical Committee on Organic Agriculture will consider scientific research findings to refine and improve the COS in the 2025 review.

For more information:
www.organicfederation.ca

Using plant-based biopesticides to combat greenhouse pests

EMMA GELDART

ORGANIC AGRICULTURE CENTRE OF CANADA, DALHOUSIE UNIVERSITY

Lygus lineolaris, also know as the tarnished plant bug. (Photo by Melanie Charbonneau, 2020)

It's a farmer's worst nightmare: a healthy and promising crop devastated. A flourishing crop is ravaged by pests. The farmer struggles to combat the invasion while maintaining organic integrity.

Insects, weeds and plant disease are common pests that farmers battle to ensure a prosperous and healthy crop. Under organic production, farmers often turn to biological control or plant-based solutions to combat these threats to their crops. In recent years, these pest control methods have experienced remarkable growth around the world. Despite this promising growth, many plant-based pest control treatments are not registered for use in greenhouse or field crops. A team of researchers working in Organic Science Cluster 3 are working to change that.

Dr. Simon Lachance, a researcher at the University of Guelph, and his team are looking for biopesticides to control greenhouse pests. Also known as biological pesticides, biopesticides are based on chemicals derived from natural sources, such as bacteria, fungi, viruses, plants, animals and minerals. Biopesticides are generally more environmentally friendly than synthetic pesticides and most are acceptable under organic management standards.

"The goal is to extract biopesticides and then use them to control insect pests, particularly in greenhouses," Dr. Lachance explains. "Our research is focused on greenhouses as there is extensive production of greenhouse vegetables in southwestern Ontario."

Dr. Lachance's research focuses specifically on extracting saponins from tomato residue. Saponins are chemical compounds produced by many plants, including tomatoes. These organic molecules produce a foamy quality when agitated in water and also have a bitter taste.

"In our work, we extract the saponin molecule from tomatoes, specifically from agricultural residues that are not used, such as tomato peels from tomato processing industries," Dr. Lachance explains.

Another source of saponin is the leaves, stems and crop waste from tomato greenhouses. Since tomato vines are slow to compost, many greenhouses send them to landfills. Using the vines for saponin extraction has the added benefit of diverting organic waste from landfills.

"It has been known for quite a long time that saponins can be used as an antifungal agent to control certain fungi, including pathogenic fungi, and certain insects, such as aphids," Dr. Lachance says. "One goal of our project is to reuse crop residues and agricultural waste, add value to them, and extract saponins to control insect pests in greenhouses."

Once extracted, the saponin solution is applied to plants in various doses by drenching the soil if it is to be used as a biofungicide, or by spraying the foliage as a bioinsecticide. Currently, Dr. Lachance's research team is analyzing its effects on tomatoes, cucumbers and peppers. Plants treated with saponins are then assessed for their effect at controlling insect pests.

"Part of the project is also to see if the plant responds by producing more defense proteins so it's better protected, more resistant, against insect pests," Dr. Lachance explains. "Saponins also have a repellent and toxic effect against certain insect pests. So, a foliar application has a biopesticide aspect that will probably prevent insects from feeding on the leaves and may also affect directly the insects present on the leaves."

Dr. Lachance's saponin research is currently targeting the tarnished plant bug, the melon aphid and mealybugs. In the lab, the team places approximately 10 insects on the leaves treated with saponin and observes what happens. They record whether the insects feed on the leaf and also record mortality rates to determine if there is a repellent or toxic effect of the saponin.

"We count the number of insects on the leaves every hour for about 24 to 48 hours," Dr. Lachance explains. "Right now, we're doing lab tests on leaves that are detached from the plants we grow in the greenhouse If there isn't much of an effect in the first few hours or in the first 24 hours, there probably won't be any long-term effect. If it works well, we will do more long-term testing, and in a greenhouse environment."

Shredded dried tomato vines (Submitted photo)

Tomato peels (Submitted photo)

As their research enters the third year of the five-year research activity, Dr. Lachance notes that they have uncovered promising results. In the laboratory testing stage, the team has recorded positive results of saponin extract that can partially repel the melon aphid. They are beginning testing on the mealybug. They've tested saponin extracted from tomato peels and residue from the shredded vines, leaves and stems. They also are planning to test potential synergistic effect of adding an essential oil with the saponin, and try various formulations that could increase efficacy.

While the goal is to manage pests, it's essential to ensure that the plants aren't harmed. Dr. Lachance explains that they conducted tests "to make sure that the biopesticide is not toxic to the plant. We apply the saponins on the leaves of greenhouse crops, and are measuring phytotoxicity over several days."

The concept of saponin as a biopesticide isn't entirely new. There is currently a registered saponin to control certain fungi in potatoes, soybeans and dry beans. While it is a registered biopesticide product, this saponin does not come from crop residues like the one Dr. Lachance is investigating

The ultimate goal of Dr. Lachance's research is to register the saponin extract as a biopesticide for use under organic greenhouse production. He aims to eventually submit a product to the Pest Management Regulatory Agency for registration. Although this process takes time, Dr. Lachance and his team are on their way to providing a solution for helping organic crop farmers manage destructive pests using plant-based extracts.

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With great appreciation, we would like to acknowledge the following industry partners for their contributions in support of Organic Science Cluster 3.

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Manuka oil remains on the sidelines as potential organic herbicide

HEATHER M. BEACH
DALHOUSIE UNIVERSITY

Organic farmers are keen to have access to new weed management techniques and share knowledge with each other. Researchers around the world are working to address this challenge, including those supported by Canada's Organic Science Cluster program. One tool that is missing from the organic weed management toolbox is a cost-effective herbicide that is organically acceptable. Can this gap be filled by the essential oil of manuka (Leptospermum scoparium), a shrub native to Australia and New Zealand?

Naturally derived herbicides can be an acceptable option under Canadian organic standards, with approval on a case-by-case basis. Products such as acetic acid and pine oil have been tested previously as contact herbicides but have not been sufficiently cost-effective to warrant commercialization for organic agricultural production. However, manuka oil had been identified as having potential as an organically acceptable herbicide. Canadian researchers began to further explore manuka oil as an organic herbicide under Organic Science Cluster 2 (2013-2018).

Activity Leader Rene Van Acker and his research team (University of Guelph, Ontario) conducted research in 2015 to "evaluate manuka oil on selected broadleaf and grass weeds for its effect on weed control and determine its pre- and post- weed emergence activity and its synergy/additive effects with other new and currently approved organic weed control products."

Essential oils permitted in organic production (lemongrass, clove, cinnamon) tend to be fast-acting but not long-lasting. Manuka oil is attracting worldwide attention because it works systemically to harm the plant and remains active in the soil longer than other essential oil products. Rather than "burning down" weeds, manuka oil enters the plant through its roots and interferes with photosynthesis and the creation of chlorophyll, resulting in "bleached" tissues before plant death.

In field studies at Simcoe and Ridgetown, ON, mixtures of manuka oil and other essential oils (cinnamon-clove or citrus) sprayed once reduced weed incidence in corn and tomato plots by 63-97%. An application of manuka oil added to vinegar reduced weeds by 97%. Mixtures were significantly more effective than essential oils applied alone.

While this trial did not find manuka oil had weed control effects when applied prior to weed emergence, other studies have. A previous American study in a lab setting detected bleaching effects of manuka oil on later emerging weeds. These researchers determined that the active ingredient in manuka oil persisted in soil for up to 7 days after application.

Rachel Riddle, who oversaw research in this study conducted at Simcoe, weighs the pros and cons: activity longevity increases weed control effectiveness and decreases the demand for multiple applications, but it may also harm crops planted during that time, if they are sensitive to manuka oil.

Similar to many natural herbicides, manuka oil has non-selective effects on weeds, affecting broadleaf and grass weeds of Canada, including pigweed, crabgrass, cleaver, ryegrass and sterile oat.

For organic wild blueberry and vegetable farmer Wayne Edgar, of North of Nuttby Farm near Tatamagouche, Nova Scotia, grass weed species in particular demand a lot of labour to control sufficiently. Currently, Edgar uses methods such as hand weeding, burning, and organic pH modification used to battle weeds on his 8 acres of wild blueberry. He is working to expand blueberry production area. Weed management will need to improve so he can keep up with an increase in area.

Edgar says he would be interested in such a product as a manuka oil mixture. "I would expect that a thorough scientific review of manuka products would guarantee that there would be no detrimental effects on the ecology and environment of a farm."

Natural chemical weed controls like essential oils might be less ecologically harmful than synthetic chemicals because microorganisms recognize and quickly degrade them in the environment. While the relatively long activity time of manuka oil makes it effective and attractive as a herbicide, would there be concerns relating to this mode of action? Does manuka oil pose additional environmental risk due to its longer residency in soil? Does its longevity increase its risk of harming non-target organisms? All pesticides must be reviewed by the Pesticide Management Regulatory Agency; however, further review is also needed to be permitted under organic standards.

The organic standards also require farmers to adopt preventative practices (such as using clean seed) and cultural practices (such as crop rotation, planting timing, seeding rate) before adopting physical (cultivation) and then chemical controls.

Weed control effects of manuka oil treatments on pepper plants in 2015 research study in Ontario: 1. Manuka Oil & Vinegar; 2. Only manuka oil; 3. Non-weeded control (Photo by O'Sullivan et al., 2016)

However, progress toward commercialization of manuka oil herbicides has stalled. Riddle sees cost as the major reason for a stall in further Canadian research. "Since manuka oil [is] marketed for pharmaceuticals, the cost of using this in agriculture makes no sense. If you could… significantly reduce the cost, then maybe there would be consideration for organic certification and registration."

Riddle believes that research into manuka oil should continue if growers show interest in it. "To continue to look at manuka oil, there should be a discussion with companies that produce the product to see if there is interest in making this product available in large amounts for a lower price."

Due to the enhanced weed control effects observed with mixtures of essential oils, Riddle adds, "Perhaps [the] next research objectives would be to look at products that are currently available and how they might work in combination with each other."

Research on organic herbicides also leads to other questions. Close attention is being paid to the environmental performance of organic agriculture and the tradeoffs that exist among practices. For example, what are the tradeoffs among mechanical tillage, synthetic mulches, natural mulches, and a herbicide such as manuka oil in terms of efficacy, crop productivity, and cost (e.g. net carbon emissions, and financial)?

If its costs can be reduced sufficiently, would you as a producer be interested in incorporating this product into your organic weed management plan? If you chose to apply manuka oil, how would you integrate it into your current practices so that your weed management plan supports organic ecological principles?

For more information, visit OSC2 Activity C.37 at www.dal.ca/oacc/oscii

Producing pesticide-free apples: Canadian researchers are tackling this daunting challenge

GÉRALD CHOUINARD

INSTITUT DE RECHERCHE ET DE DÉVELOPPEMENT EN AGROENVIRONNEMENT (IRDA)

Unrealistic. Out of touch. Impossible. These are words that are often heard when the question of pesticide-free agriculture is raised. Especially when it comes to apples, since many dozens of pests and diseases can (and will!) plague our orchards as soon as applications of phytosanitary products cease. Even in organic production, pesticides are needed to protect the apples, although synthetic pesticides are prohibited of course.

And yet, a block of a few thousand apples trees in the Mont-Saint-Bruno orchard, south of Montreal, has been producing magnificent and delicious Honeycrisp apples for more than six years now, with no pesticide applications. By what miracle?

The apple trees there are growing in a complete pest exclusion system, developed by Gérald Chouinard and his team at the Research and Development Institute for the Agri-Environment (IRDA). Inspired by the systems developed in Europe for use against the codling moth, the researcher and his colleagues proposed a similar system adapted to manage the range of pests encountered in Canadian apple orchards. They then studied the effects of the system, which consists of nets deployed over the crop row by row. Their studies focused on parameters such as tree health, fruit quality, and, protection against damage caused by insects. As well, they analyzed protection against damage caused by diseases, birds, hail and any other possible form of attack on foliage and fruit.

The findings were a surprise. After all these years, not only did the nets protect apples from attacks by all the major apple tree pests in Eastern Canada (plum curculio, apple maggot, tarnished plant bug, codling moth), but they also afforded protection against several secondary pests (leafhopper, scarab beetle, apple bug – the latter a family that includes the dreaded brown marmorated stink bug). In addition, the incidence of a number of diseases (scab, fly speck, sooty blotch, rust) was also reduced. The system also provided effective protection against hail with no significant effects on apple tree health (photosynthesis) or fruit quality (colour, size, firmness, sugar content). Moreover, contrary to widespread preconceptions, neither temperature nor relative humidity was affected by the presence of the netting, apart from a 1°C increase in temperature for one or two hours when the sun was at its zenith.

Naturally, the researchers also encountered a few difficulties along the way. The structures supporting the nets were damaged by violent winds during the first year, but more resistant materials used thereafter held up well in subsequent weather events. To allow bee pollination, the nets needed to be opened for two to three days during bloom. This was a laborious operation given that the system was not mechanized. On the other hand, the nets did limit over-pollination, which reduced the cost of fruit thinning operations. Lastly, a secondary insect pest (obliquebanded leafroller) ran rampant for a few years, and aphids, relatively unaffected by the nets, were an occasional problem as well.

Nets are raised for a few days during bloom to allow and control pollination. (Submitted photo)

On the whole, the complete exclusion system showed great potential. The following factors should be taken into account when installing this system in an orchard:

1) Use a cultivar resistant to apple scab (or very tolerant, such as Honeycrisp);

2) Keep netting in place from bud break to harvest;

3) Choose a mesh size (1 x 2mm in Quebec trials) based on the pests that need to be excluded, while aiming for the largest mesh size possible to allow entry to small predatory insects and parasites;

4) Close the nets above ground level to interrupt the life cycle of pests that complete their development in the soil;

5) If many rows need to be covered, a system that allows for easy and quick raising and lowering of the nets is recommended;

6) Plan to be able to spray if required (e.g., nutrients or pest control agents to protect against fire blight).

Dr. Chouinard and his team are currently working to solve the problems encountered during the initial project, but one conclusion stands out: it is indeed possible to grow apples without pesticides.

For more information, visit OSC2 Activity B.11 at www.dal.ca/oacc/oscii

Tiny yet mighty: Attracting parasitic wasps

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A fairyfly in the family Mymaridae. This parasitic wasp is about half a millimeter long and was attached to a yellow sticky card from one of our insect surveys. (Photo by Kasia Zgurzynski)

When farmers consider cover crops in vineyards, they likely look at plants, such as clover or rye, growing between rows of vines. These, and other common cover crops, are known to provide farmers with many benefits, including reducing soil erosion, nutrient cycling and weed inhibition. It is, however, possible to grow cover crops that are attractive to beneficial insects right in the rows of vines. In doing so, farmers may encourage beneficial organisms, such as parasitoids (i.e., parasitic wasps) to target the pests feeding on the grapevines.

Here at Brock University in Niagara, Ontario, we are currently testing cover crops that could be planted in vine rows. One of these is sweet alyssum (*Lobularia maritima*). This plant may attract more parasitoids to the vine rows than common cover crops. Studies in the United States and New Zealand suggest that alyssum may increase parasitism of pest insects when planted under the vines and, thereby, reduce the number of pests. Understanding how individual species of cover crops interact with the surrounding agroecosystem is a small, yet integral, part of our project: "Unique Cover Crops, Rootstocks, and Irrigation Techniques for Canadian Vineyards."

Parasitoids are insects that lay eggs into the bodies of other insects, such as leafhoppers. Parasitoids mainly belong to two insect orders: Hymenoptera (including wasps and bees) and Diptera (true flies). Hymenoptera boasts the largest assemblage of parasitoids with thousands of species in more than 40 families. Most parasitic wasps are smaller than a centimetre and some as tiny as a fraction of a millimetre long. Mymaridae, the family of parasitic wasps also known as fairyflies, includes the smallest insects known to science. They are important to agriculture because members of this family parasitize pests, particularly leafhoppers. Trichogrammatidae is a family of particular importance to viticulture, as some of these wasps parasitize the grape berry moth (*Paralobesia viteana*), a common pest of grape vines. Parasitic wasps can significantly affect pest insect populations and this is why they need to be studied. Note that even though parasitic wasps can ravage insect pest populations, they don't bite or sting humans.

> Studies in the United States and New Zealand suggest that alyssum may increase parasitism of pest insects when planted under the vines and, thereby, reduce the number of pests.

When we think of a parasite, we may think of something that harms but does not kill the host. This is not the case with parasitic wasps: they are parasitoids rather than true parasites. They nearly always end up killing the host during their lifecycle. The females will lay their eggs inside a host, where the larvae will feed before it pupates and becomes an adult. Different wasps target different life stages of the pest insect, and can lay their eggs into an egg, larva or adult. The wasp larvae usually start by eating the nonessential tissue and slowly move on to consume vital organs of the pest. This way, the wasp larvae are sustained throughout their growing period. Then they pupate either inside the host or in a cocoon attached on or near the host, before emerging as adults.

It is easy to take these wasps for granted. They occur naturally throughout the landscape but are so small that we are more likely to see the parasitized pests than the wasps themselves. Some farmers choose to buy adult wasps and spread them in their fields. The introduction of beneficial insects is referred to as classical biological control. This can be an important part of an effective and sustainable integrated pest management program. Conservation biological control, on the other hand, involves creating the right conditions in the landscape to attract naturally occurring beneficial insects. Whether the population is natural or released, farmers can support and encourage the beneficials by providing them with nectar and pollen, which are food sources for the adults.

Sweet alyssum (Lobularia maritima) blooming in the vineyard under the rows of vines. (Photo by Kasia Zgurzynski)

This is where sweet alyssum comes to play. This popular horticultural plant provides a floral display, as well as sustenance for beneficial insects. The flowers on alyssum are wide and shallow enough that parasitic wasps, which often have small mouthparts, can feed on them effectively. Many flowering plants may be good food sources for larger beneficial insects, such as pollinators, but might not be a suitable choice for parasitic wasps if the pollen and nectar are out of reach, for example, in a deep flower.

Another common plant used to attract beneficial insects in agriculture is buckwheat. A study done in China suggests that while both alyssum and buckwheat may attract beneficial insects, buckwheat, unfortunately, is likely to attract the pest insects as well. Depending on the pest species you want to target, it is important to consider how selectively the cover crop attracts insects (i.e., does it attract just beneficials or beneficials and pests). Other studies have shown that alyssum may be as effective as certain native plants in attracting beneficial insects selectively. It is important for us to understand what types of insects alyssum attracts and in what numbers before we can truly understand if it is a useful plant for vineyard managers.

The flowers of alyssum attract parasitoids and therefore the plant mainly serves its purpose while in bloom. Since it grows as a hardy annual in Ontario, it usually needs to be seeded every year and does not necessarily provide the kind of winter habitat that is important for many beneficial insects. We continue to work with our vineyard growers to better understand their seasonal needs and how alyssum may fit into the broader management scheme. Our next steps will be to identify and quantify the numbers of parasitoids attracted to the vineyard alyssum.

Alternatives to pesticides based on conservation biological control are gaining momentum and expanding, and are especially important for organic vineyards like ours. Research is needed to learn which plants can better attract beneficial insects, such as parasitic wasps, and to help farmers make more informed decisions about their approach to pest control. Farm management and climate change, especially extreme weather events such as flooding and droughts, may affect the performance of alyssum and other cover crops. This may indirectly affect populations of parasitic wasps, which are sensitive little creatures. It is important to understand how all these various factors may affect performance of plants and parasitoids. This is all part of our research work here at Brock University.

Global greenhouse gas emissions: how well do organic cropping systems perform?

A Q&A WITH DR. PETER TYEDMERS

> Food systems are responsible for a large share of global greenhouse gas emissions. But what about organic production systems?

Dr. Peter Tyedmers (Dalhousie University) leads a team of researchers across Canada trying to estimate the level of greenhouse gas emissions of Canadian organic field crop production systems. In June 2020, Dr. Andrew Hammermeister, Director of the Organic Agriculture Centre of Canada sat down with Dr. Tyedmers to learn more about their research.

What kind of research have you been doing at Dalhousie University?

Much of my work has revolved around food systems through a lens or motivation to understand their material and energy performance, questions like how much fossil fuel energy or electricity are we investing into these food systems? How do investments of material and energy translate into concerns we have around the environment, like eutrophication (the over-delivery of nutrients into ecosystems) or greenhouse gas emissions?

Can you tell us about the project?

The project is part of the Organic Science Cluster 3. In conjunction with two colleagues, Dr. Goretty Dias at the University of Waterloo, and Dr. Nathan Pelletier at UBC in Okanagan, we're working to understand the net greenhouse gas emissions associated with organic field crop production. We're trying to gather as much data as we can about many field crops, like corn, soy, canola, wheat and potatoes, and their net greenhouse gas emissions under organic management practices.

It seems like a huge job to assess all the greenhouse gas emissions from a farm; do you start at a whole farm level or start looking at the production system associated with a single crop?

We're looking for two sets of insights from the farmers. First, we want to meet with farmers to get an understanding about key inputs in their farming operations and the results of these. We want farmers to tell us about their rotation over the last three or four years, average rates of fertilizer inputs, fuel inputs, what energy they're using to irrigate and other key operating inputs. We're trying to get as much information about what was invested in inputs this past year, and going back in time to see what resulted from past inputs (such as how much corn, wheat or soy was produced in those years). We want to capture these details for the Life Cycle Analysis (LCA).

Secondly, we need to understand where the farm is located, the nature of the soil profile, the history of the soil… is it near its carbon sequestration capacity? Is it a highly carbon-depleted soil, and then likely to be sequestering more carbon? What is the rate of precipitation? Is it irrigated? … All these factors can influence the relative flux (the relative change) in carbon and nitrous oxide into the atmosphere or into the soil.

If you look at conventional agriculture, we often hear that 40% or even 50% of the energy cost of the farming system, is related to manufacturing nitrogen fertilizers. In organic agriculture, we might be looking at alternative sources such as pelletized poultry manure or compost. Would you be evaluating the amount of pelletized poultry manure or compost being used and assessing potential greenhouse gas costs and emissions from those practices?

That's right! They are nutrient dense, they have real value, and they support the productivity of a farm. Without them, yields would be far lower. These are critical inputs, but they also don't appear through magic fairy dust. They are generated through real physical processes somewhere else in the world. They may be on a farm next door, or at a distance away. Their production resulted in greenhouse gas emissions somewhere. We will absolutely be interested in knowing how much of these nutrient carriers were used, and how we're going to characterize the emissions associated with making poultry manure available.

Clearly, this research depends on the data you collected from the farmers, which leads me to ask, how can farmers get involved in your project?

The best thing is to contact the team by using **tinyurl.com/organicsurvey2020**.

Note: Sections of this interview have been removed to accommodate space within the magazine. To read or listen to the full interview, visit **www.dal.ca/oacc/podcasts**

Dr. Peter Tyedmers assists a student in a wild blueberry field. (Submitted photo)

The farmers would work with us by sharing data about their inputs and outputs. The more detail, the better, but it's okay if the farmers don't have complete detailed records. In my experience, farmers and other resource producers, like fishermen, can ballpark pretty well. So even if farmers don't know how many tonnes of pelletized manure was used, but they know how many truckloads came onto the farm, we can work with that. We will work with any level of detail that farmers are able to make available as long as they are willing to participate.

How do you think your research will impact organic agriculture in Canada?

The benefit of our project will be providing an understanding of how organic field crop practices in Canada contribute to climate change. What is the scale of that contribution? Does it vary tremendously with region, with years of experience or with how long the soil has been in organic management?

We suspect that it may vary with these sorts of phenomena, certainly regionally because of differences of soil type and precipitation. But the benefit, I believe, comes from being better able to be part of the conversation in Canada about what the organic sector represents in terms of where it is now on this globally important issue [of climate change].

If we understand enough about the diversity of organic management practices in Canada, it will ideally highlight the practices that are less emitting than others. That could highlight strategies that might encourage other farmers to adopt such practices.

You can't change where your farm is located or the broad composition of your soil (except on a more incremental basis through efforts to improve soil fertility). But there are a lot of management practices that are absolutely within the domain of control of the producers. If they are relatively neutral from a revenue perspective [i.e., no net cost], we could point out some really important opportunities for emission reductions.

Thanks Peter! We need to first understand these systems and their contribution to greenhouse gas emissions and as a carbon sink before we can start adopting new practices. We are chronically lacking data in the organic sector in Canada that would help inform our decision-making and recommendations to improve practices.

I think that this research is really, really important and will have a big impact on the sector in terms of guiding us down a pathway to greater sustainability, which is what organics is all about. I look forward to talking with you again when we have some more results coming in.

To take part in this important research, visit **tinyurl.com/organicsurvey2020**

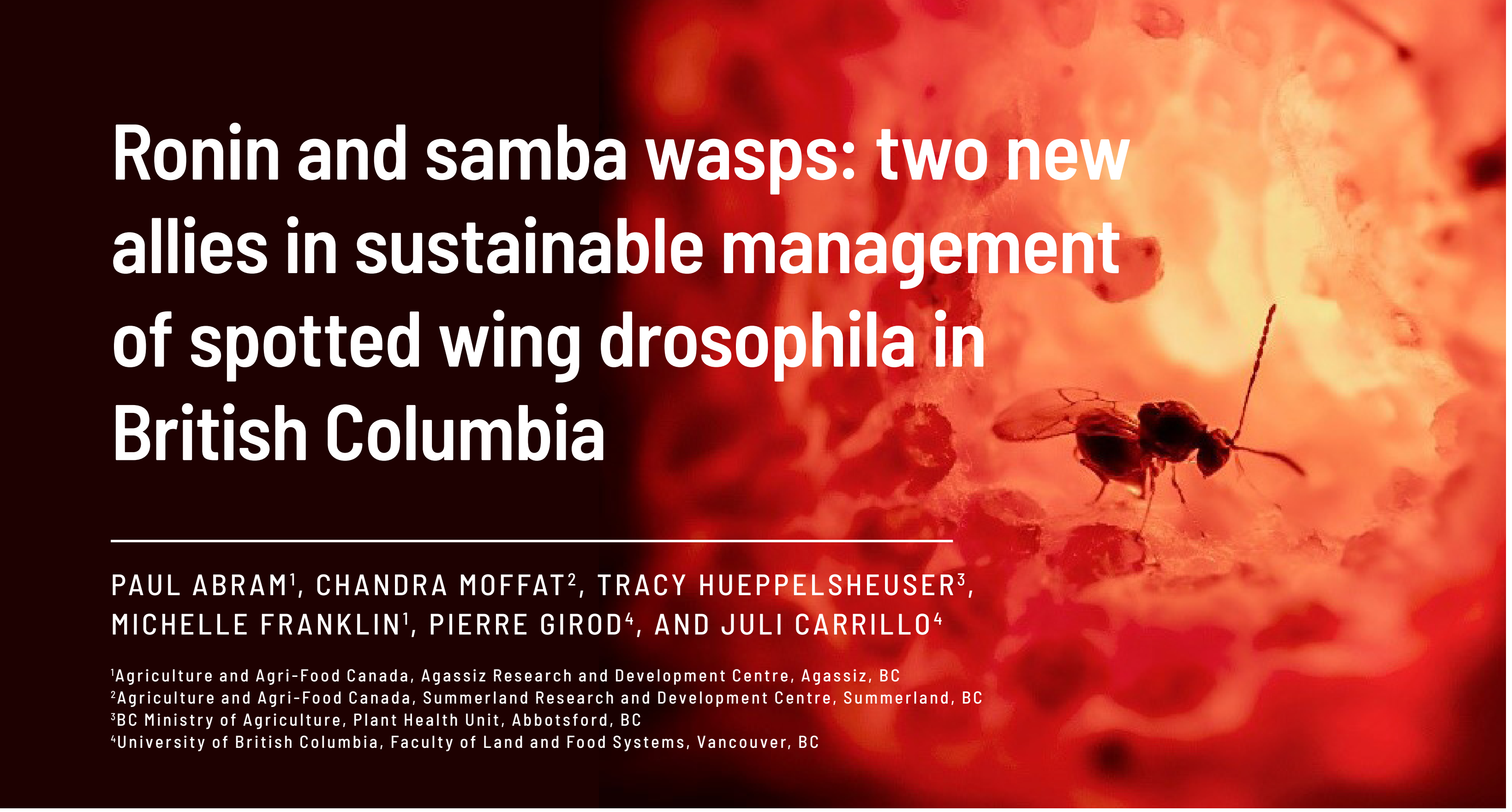
DEFINITIONS

Carbon sequestration – the process of long-term removal of carbon dioxide from the atmosphere and storage in plants, animals, oceans or geological formations. In agricultural systems, carbon would be stored in large molecules of organic materials (such as plants) that are not easily decomposed. Agricultural practices that increase soil organic matter help to sequester carbon, but this carbon may also be released through practices that disturb the soil.

Carbon flux – the balance and flow of carbon between the atmosphere, living organisms and soil or water. In agricultural systems, the soil is a major "pool" of carbon which can be influenced by management practices that add or destroy soil organic matter.

Greenhouse gases – the gases in the atmosphere that absorb and reflect infrared radiation (i.e., heat) back to the earth's surface. The primary greenhouse gasses associated with agriculture are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O).

Life Cycle Assessment (LCA) – a method of assessing the environmental impacts associated with all stages of the life cycle of a product. In Dr. Tyedmers' research, greenhouse gas emissions are being studied from the energy used to manufacture equipment through to the fuel used to harvest a crop.



Ronin and samba wasps: two new allies in sustainable management of spotted wing drosophila in British Columbia

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A female ronin wasp (Leptopilina japonica) using its specialized egg-laying tube to lay an egg inside a SWD larva inside a raspberry. The wasp's egg will then hatch and feed within the Drosophila pest larva, killing it in the process. (Photo by Warren H.L. Wong)

Spotted wing drosophila (SWD) is one of the most persistent, invasive pests in Canadian soft fruit production. This small but prolific fly first arrived in Canada from Asia in 2009. SWD is infamous for laying eggs inside ripening fruit where its larvae later feed, causing premature rot. For fruit producers, SWD requires intensive management often including regular insecticide applications, strict sanitation regimes and frequent monitoring. Fortunately, help has arrived in the form of two tiny parasitic wasps.

SWD typically overwinters in natural habitats, such as forests and hedgerows bordering crop fields. In spring and early summer, SWD reproduces in early-season, wild fruiting plants (e.g., salmonberry in BC). SWD then moves into cultivated raspberry, cherry and blueberry fields as fruit ripens. Later, SWD takes advantage of crop and non-crop plants, like wild and cultivated blackberries, before the adults move to overwintering sites.

Unfortunately, SWD can't be easily managed in natural habitats. Insecticide sprays only kill the flies that are in crop fields during spraying. Later, other flies can invade fields. Tackling SWD requires management across the landscape, within crop fields and surrounding overwintering natural habitats.

This is where biological control can play a role. Natural enemies that kill SWD – such as predators, pathogens and parasitic wasps – may help to slow the growth of SWD populations in natural habitats and, in turn, reduce pressure on crops. However, when SWD invaded North America from Asia, its specific natural enemies were left behind. Most predators and parasitoids native to Canada have only very modest impacts on SWD. For example, native parasitic wasps, typically the most effective biological control agents for insect pests, killed less than 3% of SWD in most studies.

Researchers in the USA and Europe looked at what organisms attack SWD in Asia to see if effective, natural enemies specific to SWD could be introduced to North America. These could provide long-term management in natural habitats, with the goal of reducing the number of SWD that move into crop fields. To receive permits to release foreign biological control agents requires years of research to demonstrate that the agents would be effective and pose no adverse risk to native organisms. Thorough research found two potential candidates from China, Japan and Korea: the samba wasp (*Ganaspis brasiliensis*) and ronin wasp (*Leptopilina japonica*). These tiny (~3 mm), black, parasitic wasps specialize in laying eggs in SWD larvae inside fresh fruit. The wasp offspring feed on and kill SWD larva, then develop into adult parasitic wasps which will then attack SWD.

Researchers have concluded that neither ronin nor samba wasps lay eggs in any insect (or animal) other than vinegar files (in the genus Drosophila). The samba wasp was found to be a particularly promising candidate as it attacked very few species of vinegar flies other than SWD. Fortunately, like most parasitic wasps, neither species stings humans.

The regulatory process to request an intentional release of the samba wasp in the USA has begun. Our Canadian team initiated an OSC3 project to develop a suite of ecological pest management strategies for SWD. Research on the safety and efficacy of the wasps to provide long-term, self-sustaining SWD control could support a petition to release one or both in Canada.

Our researchers made a surprising discovery when conducting routine SWD natural enemy surveys in the BC's Fraser Valley, east of Vancouver. Both samba and ronin wasps were attacking SWD even though there had been no intentional releases. In 2020, we found these wasps are very common across most of south-coastal BC and routinely killed at least 8-20% of SWD larvae in natural habitats. The two wasps usually acted together – killing SWD on at least 13 species of crop and non-crop fruiting plants. However, surveys in British Columbia (Kelowna area), southern Ontario and Nova Scotia in 2020 did not find these wasps.

It is unknown how the wasps arrived in Canada. Genetic relationships among SWD populations reveal a history of multiple accidental SWD introductions to North America. It's possible that some introductions from Asia contained SWD individuals that were parasitized by samba and ronin wasps.

The consequences of these parasitic wasps establishing in BC won't be known for a few years. But, there are a few things we can say with some confidence about the role they may play in organic SWD management in Canada.

First, these wasps will not be a silver bullet that eliminates SWD as a pest. While they clearly have potential to have a self-sustaining impact on SWD populations, they will not kill all the SWD in an area. Hopefully, combined with other natural enemies having smaller impacts, the wasps will reduce SWD populations enough that producers will be able to spray insecticides less frequently or delay initial sprays until later in the season.

Second, these wasps kill SWD larvae only when they have damaged fruit; unlike an insecticide, they don't provide immediate crop protection. Rather, they kill SWD that would later cause damage to other fruit. Because the greatest benefits of these wasps will be achieved from their activity in natural areas and they are highly susceptible to even organic insecticides, there is no anticipated benefit of releasing wasps into crop fields. Rather, we can just enjoy the "free" service they provide in reducing overall SWD pressure.

The establishment of samba and ronin wasps means that, for the first time, natural enemies are specifically targeting SWD across the landscape, at least in south-coastal BC. We anticipate that these natural enemies could become important components of integrated management strategies against SWD. For example, we might make simple changes to habitats surrounding crop fields to enhance these natural enemies. This will be a research focus in years to come.

We have a unique opportunity to study how these parasitic wasps disperse across the landscape and their impact on SWD over time. Ultimately, the results observed in the Fraser Valley will lay the groundwork to consider releases of these wasps in other regions of Canada. To achieve this, we continue our work to forecast the safety and efficacy of the wasps in other areas. Our goal is to develop and submit a petition to the Canadian Food Inspection Agency to consider releasing these biological control agents into other Canadian regions to provide long-term, self-sustaining control of SWD. In the meantime, our researchers will monitor other fruit-growing regions to determine if these parasitic wasps arrive on their own.

Striving for excellence in organic greenhouses: Spotlight on the work of Dr. Martine Dorais

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Cherry tomatoes. (Photo by Jedidiah Gordon-Moran)

The organic greenhouse sector continues to be a nexus of debate and advancement. Lighting, nutrient sources, soil substrate, energy use and effluent management have been the subject of much discussion and research. Alongside these production considerations, consumer demand for organically produced vegetables is steadily rising. From 2014 to 2018, sales in the greenhouse vegetable industry grew by 5% per year, and much of this demand is not met by Canadian production.

There are some barriers to upscaling production. In the fine-tuned, high-yielding environment of greenhouses, the yield gap between organic and conventional production can be particularly pronounced. At the same time, the organic environmental ethos raises questions around groundwater pollution and fossil fuel use for heat in northern climates. Organic greenhouse growers are looking to scientific research for ways to increase yields and meet consumer expectations with more intensive production.

Spearheading scientific investigation into these issues is Laval University's Dr. Martine Dorais, a renowned figure in organic greenhouse research. She and her research team, students and collaborators have played a key role in propelling organic greenhouse vegetable production toward more efficient systems. This important work has been supported by all three Organic Science Clusters since 2009.

For Dr. Dorais, achieving the twin goals of productivity and sustainability in organic greenhouses depends on:

- Improving soil nutrition to better nourish plants by managing the root environment (i.e., choice of substrate, irrigation methods, fertilization regime, nutrient sources)
- Optimizing use of water and nutrients, and recycling drainage water.

MANAGING THE ROOT ENVIRONMENT

One of the major issues for organic greenhouse production is the management of nitrogen – supply and timing of availability. Hydroponic greenhouses can manage nitrogen supply comparatively easily to meet the plants' changing requirements as it grows. Organic producers don't have the same maneuverability, given the complex exchanges between soil particles, roots and soil life.

This contrast is the primary source of the large and variable yield gap between organic and conventional crops in both fruit and vegetables. Dr. Dorais' work has shown, however, that organic yields can be similar or superior to conventional crops, including hydroponic ones. The key is mastering the cornerstone of organic greenhouse systems – the root environment – no matter the soil type or growing media.

The environmental impact is another important consideration. Groundwater pollution and emission of greenhouse gases from nutrient leaching and volatilization (nutrient loss to the air) are major issues that go hand-in-hand with fertility management.

Dr. Dorais and her collaborators demonstrated the importance of:

- Choosing the best soil to incorporate into the growing medium if a container system is used (muck soil was found to perform well)
- Using the same growing medium for a number of years to develop biological activity and nutrient cycling
- Minimizing long-term salt accumulation

Dr. Martine Dorais

- Ensuring oxygenation in the root zone; this is essential for water and nutrient absorption and crop health
- Providing a balanced supply of nutrients; this takes into account the plant requirements and losses to the environment
- Adapting irrigation management (frequency and quantity) for different soil types to stimulate biological activity in the soil while ensuring an adequate water supply for the plant

A set of tensiometers can be a magic bullet for managing the root environment. Essentially, a tensiometer is a water-filled tube with a vacuum gauge and a ceramic tip that is inserted in the soil. It measures the amount of water tension, or the suction it takes to pull water out of the soil, which shows how much water is accessible to the plant roots. The vacuum gauge can be read by a person, or by a high-tech data logging system, which allows the irrigation to be set to automatically maintain a specific water tension. The tensiometer system accounts for multiple factors such as air-drying capacity (moisture deficit in the air, vapour pressure deficit), air velocity, soil electrical conductivity and plant stress (e.g., due to high temperature, soil disease). Tightly regulated irrigation is a primary way to reduce leaching of nutrients into the groundwater.

Synchronizing nutrient availability with the crop's needs helps address the dual problem of yield limitations and nutrient discharge to the environment. Dr. Dorais' work suggests that a good strategy is to use dehydrated (pelletized) poultry manure for rapid supply of nutrients, and alfalfa meal, manure or compost for a slower nutrient release.

Researchers found that fertilizers with higher carbon to nitrogen ratios (e.g., alfalfa meal, shrimp meal and pelletized poultry manure) had lower nitrogen mineralization rates, meaning that less of the nitrogen was available for the plants. The higher carbon content, however, promoted greater microbial diversity. Composted manure or compost have even more carbon and less readily available nitrogen than alfalfa meal. Feather meal and blood meal, which have lower carbon to nitrogen ratios, had more readily available nitrogen, but didn't stimulate the soil microbiome. Dr. Dorais recommends using a mix of different inputs, like the organic fertilizers described above, to stimulate an active and biodiverse soil microbial community, to provide nitrogen at the right time, and to contribute other important nutrients (e.g., phosphorus, potassium and calcium).

The key is mastering the cornerstone of organic greenhouse systems – the root environment – no matter the soil type or growing media.

A promising way to optimize the root environment is to add biochar. It can increase the soil's ability to retain nutrients in a similar way to clay, without the challenges of managing moisture in clay soil. It has also been widely touted as a way to decrease emissions of nitrous oxide, a potent greenhouse gas, from soil. Biochar is similar to charcoal, but produced through the process of biomass pyrolysis: the decomposition of organic material (wood) in the presence of very high heat and absence of oxygen. It is usually alkaline and can therefore increase soil pH.

Table 1: Physical and chemical characteristics of various biochar products. M400 and W400 were ineffective soil amendments; whereas the lower pH of P700 limited its usefulness to buffer soil acidity, and its ability to mitigate N_2O emissions from the soil. Adapted from Lévesque et al. 2018, Mitigation of CO_2, CH_4 and N_2O from a fertigated horticultural growing medium amended with biochars and a compost. https://doi.org/10.1016/j.apsoil.2018.02.021

	Type of biochar				
Parameter	M400	M550	M700	P700	W400
Raw material	Sugar maple bark			Pine chips	Willow chips
Pyrolysis temperature	400°C	550°C	700° C	700°C	400°C
pH (H_2O)	10.1	11.3	11.1	7.4	8.2
EC1 (mS/cm)	0.6	1.4	1.1	0.1	0.4
% Base saturation	100	100	100	32.7	100
Dry matter %	96.5	95.8	96.6	93.2	95.7
Ash content (%)	15.8	23.6	20.1	4.8	7.5
Volatile material (%)	36.6	29.4	33.7	15.8	17.7
C/N ratio	57.99	58.68	85.78	61.36	95.51
Bulk density (g/cm3)	0.42	0.42	0.39	0.17	0.26
Total porosity (cm3/cm3)	0.75	0.76	0.77	0.9	0.83
Water content at -1kPa (%)	47	62	48	78	

1- EC: electrical conductivity

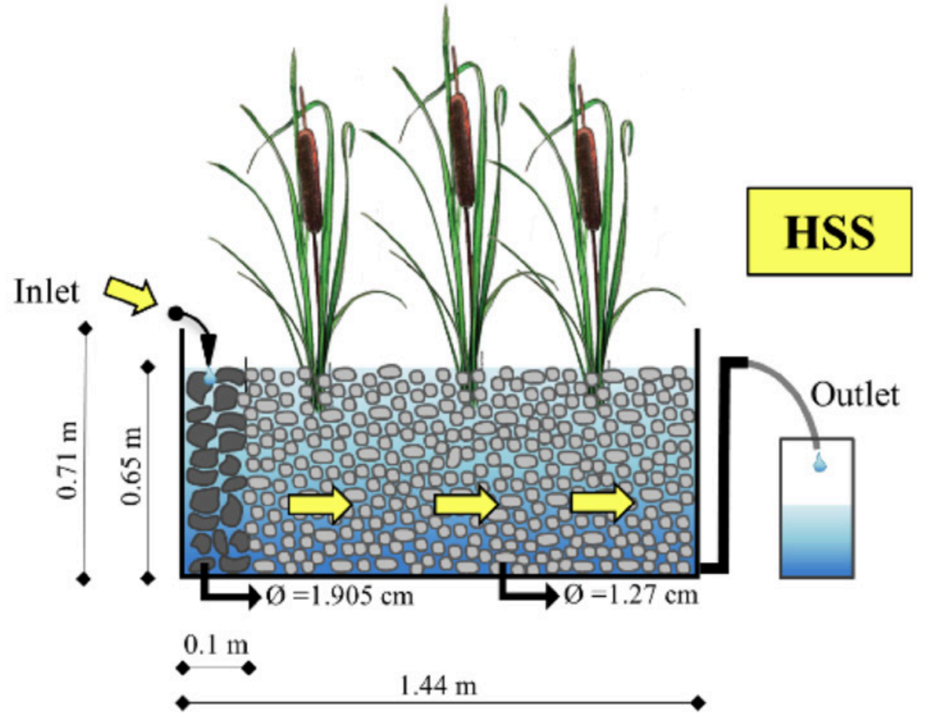

Figure 1: The design of a horizontal subsurface flow constructed wetland. Adapted from Lévesque et al. 2020, Type of constructed wetlands influence nutrient removal and nitrous oxide emissions from greenhouse wastewater. https://doi.org/10.17660/eJHS.2020/85.1.1

Biochar varies widely in its characteristics based on biomass source, temperature, speed of temperature increase, and how thoroughly oxygen was excluded. Quality is important – if it leaves your hands black, it's not a good sign! Dr. Dorais' team looked at five different biochar products as an amendment to peat-based growing media (Table 1, previous page). 5-15% biochar that was produced at or above 550°F reduced leaching of N, P, Mg and Ca, and substantially improved water and nutrient use efficiency. The biochar produced at temperatures lower than 550°F either reduced root zone aeration due to the small size of biochar particles (with the willow chips), or partially tied up nitrogen (with the maple bark). As a result, these are less suitable as amendments for a peat-based growing medium.

Another exciting research result for organic greenhouse producers is the use of wollastonite (an alkaline calcium-silicate rock) to protect against powdery mildew. The addition of 8 g/L of wollastonite to a peat-based growing medium improved plant growth by 6.5%.

MANAGING GREENHOUSE EFFLUENT

Greenhouse effluent management strategies are aimed primarily at reducing the pollutant load of irrigation wastewater (particularly nitrates, phosphates and sulphates). If the goal is to reuse the irrigation water, it is also important to eliminate pathogens and other compounds that can be toxic to plants. Dr. Dorais and her team have concentrated on constructed wetland technologies to manage effluent, due mainly to their low cost and their capacity to reduce pathogen levels.

Biofiltration is a procedure comprising a precise sequence of physical, chemical and biological reactions. A series of distinct ecological niches must be set up in a specific order to support microbial activity. The microbes will then be able to carry out the reaction chains required to eliminate pollutants and pathogens. The ecological niches include low and high pH environments, aerobic and anaerobic zones, and, specifically for greenhouse effluent, must include diverse sources of carbon to allow microorganisms to break down the pollutants.

According to Dr. Dorais, one of the best choices for constructed wetland biofiltration is a horizontal subsurface flow system with an extra carbon source in addition to the plant roots growing in gravel (Figure 1). The researchers added either sugar (a simple carbon) or compost (a more complex carbon source). This system meets environmental criteria by significantly reducing phosphate, sulphate and nitrate levels in effluent and greatly reducing nitrous oxide emissions. A constructed wetland as small as 10% of the greenhouse surface area is required to purify heavy summer runoff, making this system a practical and economical option.

Both pozzolana and biochar are very effective filtering media that can be added to the gravel bed of a constructed wetland to increase the efficiency of the system. Pozzolana is a porous volcanic mineral commonly used as part of cement. In the constructed wetland, the researchers used pieces of pozzolana 10-15 mm in diameter to replace all or part of the gravel; note that pozzolana can be an expensive material.

This research also shows that treated greenhouse wastewater can be reused from the horizontal subsurface flow biofiltration systems. Plant pathogens, such as *Pythium ultimum*, which causes root rot, were nearly completely eliminated (99.99%) from the wastewater.

More than ten years of progressive organic greenhouse research by Dr. Martine Dorais, under the Organic Science Clusters and beyond, has provided the sector with new, effective production methods. Her research continues, working to untangle the many factors at play. The organic greenhouse industry is heading toward a bright and responsible future.

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