

ORGANIC SCIENCE CANADA

SCIENCE FOR PRODUCERS | ISSUE #1 | MARCH 2018



HOW IS RESEARCH IN
CANADA TACKLING THE
CHALLENGES IN ORGANIC
PRODUCTION?



Created in 2007, the Organic Federation of Canada (OFC) is a national association responsible for the maintenance and interpretation (Standards Interpretation Committee) of the Canadian Organic Standards and the management of the Science Cluster Program, including the Organic Science Clusters I and II, and applying for Organic Science Cluster III Project in collaboration with the Organic Agriculture Center of Canada. Located in Montreal, the OFC is composed of ten organic associations representing nine provinces and one territory and who, all together, promote the development of the Canadian organic industry across the country. The OFC is a member of the Organic Value Chain Roundtable.

The OFC connects with the industry with its website www.organicfederation.ca, and its monthly newsletter InfoBlo.



The Organic Agriculture Center of Canada (OACC) is a national organization, based at the Dalhousie Agricultural Campus in Truro, Nova Scotia. Founded in 2001, OACC aims to serve Canada's organic sector through science and education. OACC facilitates and leads research and education supporting organic producers, consumers and other organic stakeholders to foster sustainable communities.

OACC aims to “link organic knowledge” through the OACC website and our monthly e-zine that is distributed in English and French. OACC is a member of the Organic Value Chain Round Table, and leads the national research prioritization process in organic science in Canada. We also offer an online Certificate of Specialization in Organic Agriculture through Dalhousie University that is available to interested students and professionals.

The Dalhousie University Faculty of Agriculture is dedicated to elevating an understanding of the breadth and depth of agriculture within our community while preparing the next generation of leaders who will help find solutions for feeding our world. The Dalhousie Agricultural Campus is home to a working farm, almost 1,000 acres of research fields, gardens and greenhouses and is built on a proud history of industry-leading education and research since 1905.

DAL.CA/OACC/OSCII



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WELCOME TO THE ORGANIC SCIENCE CANADA MAGAZINE!

We are delighted to bring you this collection of articles that highlight the many sectors, regions, and people that are part of the Canadian Organic Science Cluster II (OSCII) research program.

OSCII spans both the country and the organic sector, consisting of 37 research activities that fall into five broad themes: field crops, horticultural crops, crop pest management, livestock, and value adding. OSCII funding was provided by over 65 organic sector partners and the AgriInnovation Program of Agriculture and Agri-Food Canada's *Growing Forward 2* (GF2) Policy Framework. Linking 200 scientists and students at more than 45 research institutions across Canada with organic stakeholders, OSCII drives research and development to strengthen the science of organic agriculture.

This magazine is an introduction, merely scratching the surface of the ambitious work underway through researcher-industry partnerships in OSCII. Each article provides an overview of how researchers addressed the challenges that face Canadian organic production. This magazine targets producers and extension workers in hopes of leading them to practical outcomes that could be put to use on organic operations across the country. More detailed information is available at WWW.DAL.CA/OACC/OSCII, which will be updated as the latest research results and outcomes roll in over the coming month as OSCII draws to a close.

It brings a great sense of pride to us, the organizers of OSCII, and hopefully to the community as whole, to see just how many scientists, students, farmers and industry partners that have been engaged in advancing the science of organic agriculture in Canada over these past five years.

We hope that you will enjoy reading the OSCII Magazine as much as we care about transferring knowledge to the community that develops and supports the organic industry. Organic is a science: we are only starting to uncover the secrets of the sustainable agriculture that will benefit our whole country.

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BY ORGANIC, FOR ORGANIC: FARMERS HELP BREED ORGANIC VARIETIES

A photograph of a man, identified as a farmer-breeder, standing in a field of tall, golden wheat. He is wearing a dark t-shirt with a logo, blue jeans, and a baseball cap. He is holding a small object in his hands, possibly a seed or a small plant. The background shows a vast field under a cloudy sky.

A farmer-breeder in his participatory wheat breeding plots in Swift Current, SK.

In Canada and across the world, improved performance in organic production systems has been demonstrated when varieties bred under organic conditions are used.

This cross-Canada research aims to actively involve farmers in the selection process to generate diverse breeding lines for wheat, oat and potato that are locally adapted to organic production systems.

Organic growers often have limited choices when buying seed, with the majority of major crop varieties having been bred and selected for conventional agriculture, where fertility is abundant and pest pressures are well controlled. Yet, past research has demonstrated that when varieties bred under organic conditions are grown on organic farms, productivity is increased.

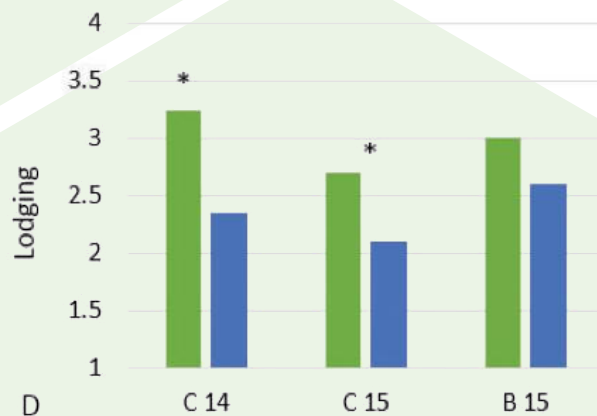
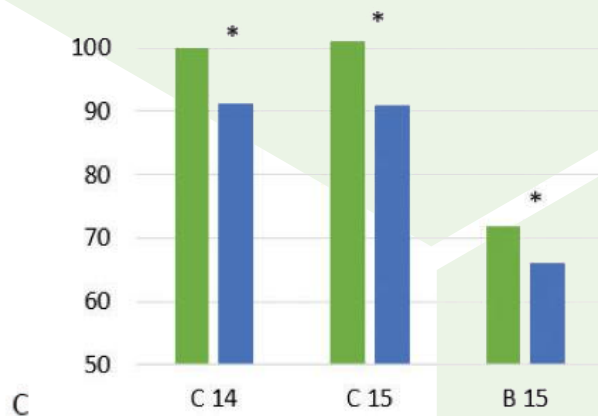
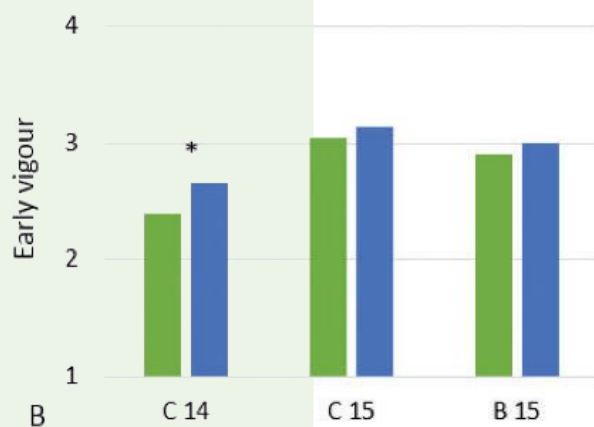
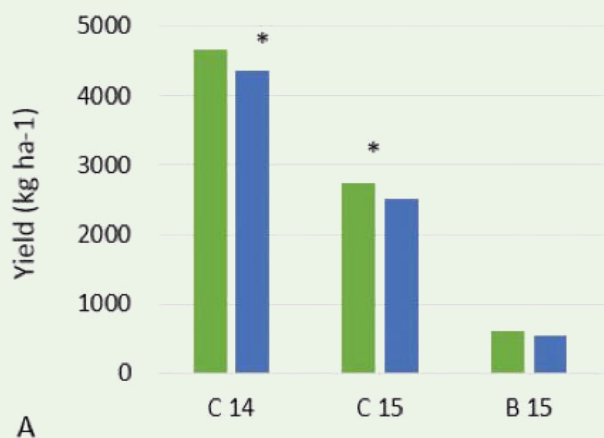
Participatory plant breeding brings together farmers and breeders. Engaging farmers in the breeding process provides them with opportunities to build unique skills and knowledge while gaining more control over seed resources. Farmer engagement can also speed up the typically slow and expensive breeding process, all while allowing selection to occur under organic farming environments.

FARMERS, BREEDERS AND RESEARCHERS WORKING TOGETHER

Led by Dr. Martin Entz and the University of Manitoba, and supported by regional coordinators from the Bauta Family Initiative on Canadian Seed Security, breeders based at the University of Manitoba and Agriculture and Agri-Food Canada provided early generation seeds (populations) from crosses to farmers across the country. The selection of parental lines for the initial crosses were informed by participating farmers, and aimed to combine varieties with desirable characteristics.

The farmers planted their populations in small plots on their farms. They then select the best spikes, panicles, or tubers out of that population to carry forward to the next year, with support from the research team. After 3 years of selection, the farmers sent their selected materials back to the researchers. Organic yield trials were then conducted at the University of Manitoba, comparing the farmer-selected lines with standard crop varieties.

Beyond developing new, organically-selected lines, the researchers were also interested in whether farmers would select lines that have increased productivity in organic production conditions. They were also interested in what other characteristics farmers were selecting, either directly or indirectly.



ABOVE: Farmer selected populations (green bars) compared to the conventionally selected check varieties (blue bars) at Carman in 2014 (C 14) and 2015 (C 15) and Brandon in 2015 (B 15) for: A) yield (kg/ha), B) early season vigour (visually rated with a 1-4 rating scale with 4 being the most vigorous) C) plant height, and D) lodging (1-9 rating scale with a higher number indicating more lodging). A star above the bars indicates a significant difference between the farmer-selected and conventionally selected check varieties at that site.

Farmers did, indeed, select for productivity in organic production conditions. Farmer selected cereal lines yielding an average of 300 and 230 kg/ha more than the conventional check varieties that they were grown alongside in 2014 and 2015, respectively. Farmers also selected for other characteristics, including early season vigour and height. In addition, potato populations following farmer selection performed on par or better than registered varieties, with similar early and mid-season vigour, disease ratings and yield.

In instances where the same initial cereal seed population was sent to multiple farmer-breeders, the characteristics of the selected populations shifted over the

three-year period of on-farm selection. While the selected lines in the end showed similar yield and leaf disease, differences arose in early season vigour, height, days to maturity and lodging. This indicates that selection by the farmer shaped the population to the prevailing farm conditions and preferences of the farmer.

CONCLUSION

Including farmers in a participatory plant breeding process can be successful in developing new lines that are well suited to their production conditions. Farmer-selected varieties perform at least as well as, and often better than, the standard, conventionally bred varieties that are widely available. ●

ACTIVITY TITLE Participatory plant breeding and seed production approaches for Canadian organic crop production

RESEARCHERS Martin Entz (University of Manitoba), Benoit Bizimungu (AAFC Fredericton), Jennifer Mitchell Fetch (AAFC Brandon), Maude Forté (La Coop Agrobio Quebec), Lana Reid (AAFC Ottawa)

PARTNERS Growing Forward 2, USC Canada



Organic oat breeding lines competing with weeds in the organic plots at the University of Manitoba.

Organic producers typically have to rely on oat cultivars that have been bred under non-organic management conditions. This Prairie-based program aims to select oat breeding lines under organic management to develop an oat cultivar that will perform optimally under organic growing conditions.

ORGANIC OATS: NEW CULTIVARS FOR GRAIN PRODUCERS

The organic sector is seeing unprecedented demand for high-quality, food grade oats for use in cereals and snack bars. Organic growers need cultivars adapted to lower fertility conditions, have larger kernels for excellent milling, are competitive with weeds and emphasize good resistance to insects and diseases. Breeding under organic management can provide producers with better-suited cultivars.

BUILDING ON SUCCESS

This research follows on the success of research conducted during the first Organic Science Cluster. Spearheaded by Dr. Jennifer Mitchell Fetch with Agriculture and Agri-Food Canada, the Prairie-based research team began to work on the development of a new, organically adapted oat cultivar. The work resulted in the registration of an organically adapted oat cultivar, AAC Oravena. This cultivar has attractive milling qualities, disease resistance and performs well under organic production conditions.

PATIENCE AND PERSISTENCE

Breeding and selecting new cultivars begins with crosses between promising cultivars and breeding lines. The children of these crosses, also called progeny or breeding lines, were then evaluated on organically managed land at the University of Manitoba. Seeds were selected from the highest yielding lines with resistance to rusts and smut for the next generation of testing. This process was repeated for five growing seasons. In each round of selection, researchers used the plumpest seeds of each line to plant the next generation, helping the plants to grow quickly and increasing their competitiveness against weeds. The seed from successful lines was increased in New Zealand during the Canadian winter.

The successful lines were planted in yield trials on organically and non-organically managed land to evaluate their performance over a wide range of environments. The best yielding lines were then evaluated for their milling qualities; those with acceptable oil content, good protein and betaglukan levels were then planted alongside standard cultivars at nine organically managed locations across the Prairies. Those lines that performed as well as, or better than, the standard cultivars were then moved on to a registration trial.

GREAT EXPECTATIONS

Thanks to the support and collaboration of the oat producers and millers, continued breeding efforts show promise that another organically bred and selected cultivar with high test weight, plump seed and high protein content may soon be registered and available for growers. ●

ACTIVITY TITLE Organic oat breeding

RESEARCHERS Jennifer Mitchell Fetch (AAFC Brandon), Martin Entz (University of Manitoba), Dean Spaner (University of Alberta)

PARTNERS Growing Forward 2, Clif Bar & Company, Grain Millers Canada Corp.

Organic growers in the dry Brown soil zone of the Prairies rely largely on cereal-based rotations with summer fallow and mechanical tillage. Can growers diversify their cropping system and reduce tillage?

Although there has been an increase in the use of legume green manures, crop rotations, and reduced tillage in the Prairies, many producers still rely on summer fallow for water conservation and intensive tillage for weed control. This is particularly the case in the driest of the Prairie soil zones, the Brown. Here, water usage by a green manure crop can offset the benefits of the nitrogen they supply. However, the reliance on tillage can also contribute to soil drying and degradation of these soils that are already low in soil organic matter. Alternative cropping systems and tillage methods for growers in the most arid of the Prairie soil zones are needed, as producers seek information on the best methods for optimizing their production while minimizing their environmental impact.

Led by Agriculture and Agri-Food Canada's Myriam Fernandez, the Prairie-based research team wanted to explore whether reduced tillage and diversified crop rotations are viable options for crop production in the water-constrained and variable environmental conditions of the Brown soil zone. They were particularly interested in whether these tactics can keep weeds at low levels, maintain soil fertility, produce healthy crops, and be profitable.

Trials at AAFC Swift Current were designed to explore two main factors: diversity of the crop rotation and tillage intensity. Plots were established with all combinations of simplified (forage pea green manure – wheat) or diversified (forage pea green manure – oilseed – pulse – wheat) rotations with either high (worked before planting and forage peas terminated by tillage) or low (plots worked once before planting and peas terminated by mowing) tillage. The scientists then monitored soils, weeds, crop diseases, grain yield and quality.

Soil nitrogen levels in the spring were at their highest when plots were managed with high tillage and the

rotation was simplified. Meanwhile, soil phosphorus levels did not differ whether tillage was high or low, or the rotation was simple or diverse. Soil organic carbon tended to be the highest in the low tillage plots.

Researchers observed that wheat yields decreased over the course of the experiment. Yields were, however, consistently highest under high tillage and in the simplified rotation. Weeds tended to be more problematic in the low tillage treatment, with perennial thistles increasing their presence each year. The decreased yields were not found to be a direct result of weed pressure, but were instead attributed to precipitation and soil nitrate levels. Overall, yields under low tillage were about 75% of the yields of a no-till conventionally-grown wheat. Protein concentration in wheat grain varied among years and was overall similar or higher than in conventional wheat. Protein did not follow the same trend as yield, and there was no negative association between them, which might be explained by the release of mineralized N throughout the season from a previous green manure or pulse crop.

CAN REDUCED TILLAGE WORK IN PRAIRIE SOIL?

Tillage and Rotation	Wheat yield (kg/ha)					
	2011	2012	2013	2014	2015	Average over all years
High Tillage, Simplified Rotation	3420 ^a	2671 ^a	2345 ^a	2302 ^a	1972.4 ^a	2542 ^a
High Tillage, Diversified Rotation	3171 ^a	1927 ^b	2460 ^a	1424 ^b	1129.4 ^b	2022 ^b
Low Tillage, Simplified Rotation	3533 ^a	1805 ^b	2015 ^a	1532 ^b	825.5 ^c	1942 ^{bc}
Low Tillage, Diversified Rotation	2493 ^b	957 ^c	1947 ^a	1190 ^b	920.4 ^{bc}	1501 ^c

Average wheat yield with varying tillage and rotation treatments in an organic trial at Swift Current, SK.

WEATHER-DEPENDENT CONCLUSION

Precipitation was higher than average in this typically dry region during the trial period (2010-2015). Overall, the researchers concluded that, low-till production is not a viable option for organic grain producers in the Brown soil zone in years with above-average precipitation due to increasing Canada thistle populations. Had conditions been drier, as is typical for this region, the outcome may have differed. ●

ACTIVITY TITLE Impacts of reduced tillage and diversified cropping sequences under organic management in the semi-arid Brown Soil Zone

RESEARCHERS Myriam Fernandez, Robert Zentner, Mike Schellenberg, Julia Leeson (AAFC Saskatoon), Brian McConkey, Olanike Aladenola, Mervin St. Luce, Newton Lupwayi (AAFC Lethbridge), Shannon Chant (SK Ministry of Agriculture)

PARTNERS Growing Forward 2, Organic Research Advisory Council, Western Grains Research Foundation

Many long standing, organic Prairie farms do not practice nutrient returns or manure applications to their fields, causing crop productivity loss due to lack of phosphorus (P) and soil carbon in the system. Can compost restore the productivity of depleted soils?

RESTORING YIELDS? HOW COMPOSTED MANURE IS REJUVENATING ORGANIC SOILS

Prairie organic farmers traditionally do not add manure to their soil to replace important nutrients that are removed when crops are harvested. This is especially crucial in organic farms where perennial alfalfa or alfalfa/grass hay crops are included in crop rotations to limit weeds such as wild oats and Canada thistle. When alfalfa is harvested, it removes larger quantities of soil nutrients such as phosphorus, potassium, and sulfur than grain crops. Alfalfa crops are important in crop rotations due to their ability

to fix nitrogen in the soil, however, if they are growing poorly, soil nitrogen and soil carbon are both reduced.

This depletion of soil nutrients results in poor crop growth, high yield losses (up to 40% in wheat crops), and unhealthy soil. Composted cow manure could be a potential solution to this problem. Composted manure is high in organic materials and rich in nutrients necessary for healthy crop growth and soils. Proper treatments and application rates could increase soil phosphorus, carbon, and micronutrients, which could in turn rejuvenate soil health, and return or increase yields.

The Manitoba based research team lead by Martin Entz worked on long-term organically managed land at the Glenlea Research Station and an organic farm near Libau, Manitoba. Three application rates of composted beef manure was tested at each site: i) a low rate applied at 14kg P/ha every year, ii) a high rate of 100kg P/ha applied only once in four years, and iii) the last was left untreated. The study then examined parameters such as soil organic carbon, soil phosphorus, alfalfa yields, and grain yields to determine the best application rates and soil rejuvenation.



In the foreground is alfalfa plots with manure added, in the background is alfalfa with no manure added.

Adopting nutrient replacement practices using composted manure can be an essential tool for organic Prairie farmers using long-term crop rotations. The most effective method for application was a one-time, 60kg P/ha rate every 4 years. This application rate showed increase in soil carbon in surface, and subsurface soils, and more importantly, provided a complete restoration of crop yields.

Adding phosphorus through composted manures also restored alfalfa yields and resulted in more nitrogen fixation in the soil, thus increasing wheat yields grown after the alfalfa rotation. Rejuvenating soil productivity did increase weed growth, which is important in considering weed management tools for future crop systems. Long-term studies such as this one are made possible with long standing organic rotations such as the one at Glenlea.

A FERTILE CONCLUSION

Adding composted manure at phosphorus replacement rates once every 4 years completely restored crop yields after 9 years, and increased soil carbon in surface and subsurface soils. ●

ACTIVITY TITLE Restoring yield productivity and C sequestration in organic farming systems on the Prairies: The role of composted manure in long-term studies

RESEARCHERS Martin Entz (University of Manitoba)

PARTNERS Growing Forward 2, Western Grains Research Foundation

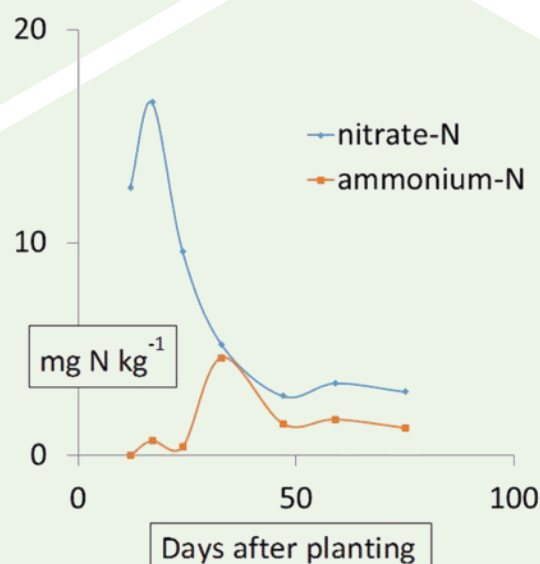
There are many prosperous, thriving organic grain farms on the Prairies. However, there is often a lack of understanding as to what underlies their success, especially how nitrogen and phosphorus are supplied in these systems with limited inputs. With an end goal of developing application recommendations, this Manitoba based team examined the impact of varying rates of composted manure application on soil and plant nutrients and crop yields.

Howpark Farms in southwestern Manitoba is a long-term, successful organic beef cattle and field crop operation. They began their transition to organic farming in 1999. The farm follows a seven-year rotation, consisting of a sequence of three years of alfalfa, flax, oats, green manure cover crop, and wheat. Cattle manure from the winter barn is composted, to prevent weed seed germination, before being applied in the fall in all phases of the rotation following the final year of alfalfa. Together, the field area available to spread the composted manure and the herd size dictate an application rate of 375 kg dry mass manure compost per hectare.

Dr. Terence McGonigle of Brandon University wanted to explore the contribution that composted manure makes to the mineral nutrition of the crops on Howpark Farm, in hopes of optimizing the production system on this farm and providing recommendations to others. In a field scale trial at Howpark Farm, compost application rate was altered by adjusting the traffic speed of the spreader to apply half the regular rate the farmer normally applies, the regular rate, and double rate, while other plots received no compost. Compost was applied to the plots from the Fall of 2013 to the Fall of 2016 resulting in a cumulative application of 56 kg of total nitrogen per hectare in the double rate treatment. Soil nutrient levels, especially mineral nitrogen and phosphorus, nitrogen and phosphorus levels within the crops, and final yields were monitored over the course of the experiment.

While soil levels of mineral nitrogen were typical for agricultural fields in the region, as illustrated in the

figure below, no response to the application of composted manure at any application rate was evident. Meanwhile, soil phosphorus levels showed only a small increase from composted manure. Yields of flax and oats did not differ between plots that received no compost or those that received the highest rate.



Concentrations in soil of extractible mineral N at Howpark Farm under flax in 2014. Means are taken across manure compost treatments, and show trends typical of agricultural production in the region.

THE BOTTOM LINE

Composted manure application at the rates examined here are insufficient to provide an immediate boost in soil or plant nitrogen or phosphorus, and does not impact crop yields. Rather, composted manure may contribute more to the long-term fertility of the farm, while legumes in the rotation satisfy the nitrogen needs of following crops. Further research is being conducted now to explore the impacts of composted manure applications up to twenty times higher than the regular rate used at Howpark Farm. ●

ACTIVITY TITLE Well-established commercial organic farming: Effect of rate of composted manure application on soil mineral nutrients, yield, and crop nutrient uptake

RESEARCHERS Terence McGonigle (Brandon University), Ian Grossart (Howpark Farm)

PARTNERS Growing Forward 2, Howpark Farm

BETTER TOGETHER: NUTRIENT TRACKING, GREEN MANURES AND BIOFERTILIZERS FOR ORGANIC GRAIN PRODUCTION

Organic grain farms face the challenge of managing and maintaining nutrient levels to ensure grain productivity and quality. The cross-Canada research team set out to explore how the productivity of organic spring wheat and malting barley is impacted by green manure management (type and tillage intensity) with or without the addition of biofertilizers.

Soil amendments permitted for use in organic agriculture can be costly. Organic grain farms, in many cases, export nutrients with their crop without an accessible means for replacement. Biofertilizers, such as pelletized poultry manures or other organically-permitted and naturally sourced fertility inputs, may be an affordable solution to this problem when used strategically in the crop rotation. A nutrient assessment tool that can provide insight on when rotations require a fertility boost can aid farmers in efficiently and effectively supplementing their rotations with fertility inputs.

THE RISE IN POPULARITY OF GREEN MANURES

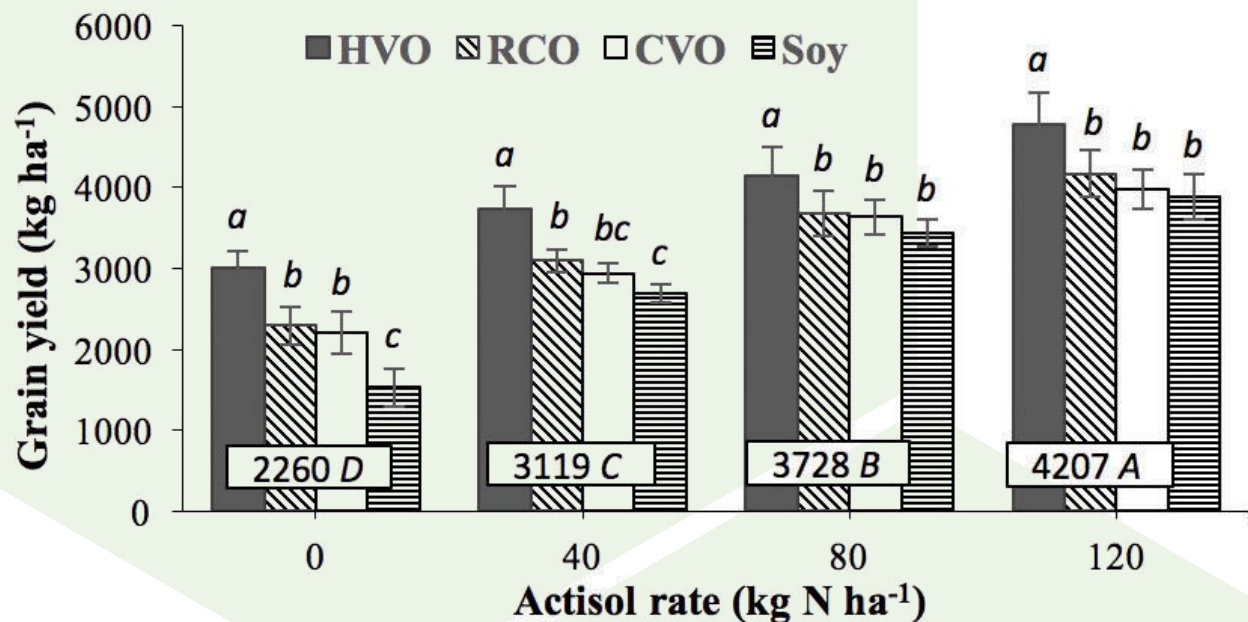
Green manures are legumes planted for soil nutrients rather than for harvest, and are an attractive means of building soil nitrogen. Green manure use on organic

Inter-cropped barley and hairy vetch

farms is gaining popularity, revealing an opportunity to explore novel green manures that may fit well in organic grain production systems. Green manures also provide an opportunity to introduce a phase of reduced tillage into rotations, a relatively new approach that merits further exploration, especially in Eastern Canada.

Trials were conducted at research stations in Nova Scotia (Dalhousie University), Quebec (CEROM), Ontario (College d'Alfred) and Manitoba (University of Manitoba). These trials evaluated the effects of green manure type, the timing of green manure tillage, soil fertility, and tillage regime on organic wheat and malting barley. Researchers monitored grain productivity and quality, soil quality, and soil health under these various treatments. In addition, 10 organic farms in the Prairies participated in a nutrient assessment process for the development of a nutrient budget and green manure bioassay tool.

The research team developed a nutrient assessment tool that focuses on sampling the tissue of a green manure crop. This tool is already being used by Prairie producers and agronomists to better understand nutrient levels on organic grain operations. The tool revealed that many organic farms are losing phosphorus, potassium and sulfur, unless they import manure.



Spring wheat grain yield as affected by rotation and pre-plant application of Actisol pelletized poultry manure. HVO=hairy vetch and oats; RCO=Red Clover and oats; CVO= Common Vetch and oats; Soy = Soybean.

Researchers in Eastern Canada found that all green manures benefited wheat grain yields, but hairy vetch outperformed common vetch and red clover in its ability to biologically fix and supply nitrogen (increasing yields and grain protein). Meanwhile, the combination of an annual green manure and Actisol biofertilizer at up to 80 kg N ha⁻¹ further increased the yield and quality of wheat and malting barley. However, the no-till termination of an oat and hairy vetch green manure in Eastern Canada reduced wheat yields. This is in contrast to the successful use of no-till termination in the Prairies, which is largely attributed to the more extensive breakdown of the no-till mulch that occurred over the winter in Eastern Canada. No-till termination did, however, have beneficial effects on soil health: more earthworms were found in no-till terminated plots than those where green manures were terminated by tillage in either the fall or the spring.



Density of earthworms in spring wheat over three years as influenced by tillage of a hairy vetch and oats green manure pre-crop. Reference refers to an undisturbed adjacent fence row.

THE BOTTOM LINE

Nutrient management for organic grain farms can be optimized through a strategy that combines tracking nutrient status with the use of regionally-adapted green manures supplemented with biofertilizers. Such an approach both maximizes productivity while benefiting soil health. ●

ACTIVITY TITLE Optimizing green manure and fertility management for organic cereal production

RESEARCHERS Derek Lynch (Dalhousie University), Valérie Bélanger and Anne Vanasse (Université Laval), Gilles Tremblay (CEROM), Martin Entz (University of Manitoba), Simon Lachance (University of Guelph)

PARTNERS Growing Forward 2, Acti-Sol Inc., Homestead Organics Ltd., Horton Ridge Malt and Grain Company Ltd., Organic Valley

Organic grain production on the Canadian Prairies is often viewed as limited by phosphorus, as this nutrient is exported in grains without a means of replacement. A Prairie-based research team aimed to determine whether phosphorus is indeed limiting in Prairie organic grain production systems, and evaluate other soil amendments.

IS PHOSPHORUS LIMITING PRAIRIE ORGANIC GRAIN PRODUCTION?

THE IMPORTANCE OF PHOSPHORUS

If you were to test the soils of many organic grain farms in the Prairies, you would discover many of the tests reveal low soil phosphorus (P). When the abundant grain harvests from the Prairies are shipped to other locations, phosphorus is taken away with each shipment. Without a means

to replace this phosphorus in the soil, there is a gradual degradation of phosphorus in Prairie soils. This can, in turn, lead to reduced crop yields. Arbuscular mycorrhizal fungi (AMF) are special soil fungi that benefit plants by helping them take up nutrients such as phosphorus, however more insight is needed to see if AMF can improve phosphorus conditions in Prairie soils.

A team of researchers led by Dr. Chantal Hamel of Agriculture and Agri-Food Canada (AAFC) set out to explore potential sources of soil phosphorus for Prairie organic growers. Field trials took place at AAFC research sites in Beaverlodge, AB and Swift Current, SK, as well as two commercial organic farms in SK. In these trials, the researchers evaluated the use of composted manure and rock phosphate to supply phosphorus for lentil and pea production in a pulse-flax rotation.

In addition, the research team combined these two phosphorus sources with inoculation of AMF, to gauge whether the AMF may work to improve the effectiveness of the amendments. The AMF inoculant was applied in either the pulse, the flax, or both the pulse and flax phases of the rotation, or not applied at all. Meanwhile, the phosphorus amendments were applied



Application of organic fertilizers before seeding.

at either 0%, 75%, or 150% of the recommended rate. To deepen their understanding, the researchers also explored the effect of inoculation with AMF on native soil biology.

Adding composted manure or rock phosphate to an organic pulse-flax rotation had only moderate to no effect on pea or lentil yields, in spite of low soil phosphorus levels. This suggests that other factors, likely moisture, were limiting yields during the trials.

The use of an AMF inoculant had mixed effects on crops, improving lentil biomass on one organic farm, but not impacting the yield of flax or pulses at the research farms. The researchers suggest that the AMF inoculant used may not have been well matched with local soils or environmental conditions, or that healthy native populations of AMF were already in place. Researchers did, however, find evidence in the soils that the AMF community shifted when the inoculant was added alongside P amendments.

THE BOTTOM LINE

Locally available amendments and inoculation with AMF may improve the phosphorus conditions on organic farms, but is not always sufficient to improve yields. ●

ACTIVITY TITLE Applying ecology for simple, nutrient use efficient pulse-based cropping systems: Phosphorus sources for organic growers of the Prairie, and agronomic strategies for effective soil microbiology to make better use of these P sources

RESEARCHERS Chantal Hamel (AAFC Quebec), Yantai Gan (AAFC Swift Current), Miranda Hart (UBC), Newton Lupwayi (AAFC Lethbridge), Ramon Rivera (Instituto Nacional de Ciencias Agrícolas), Marc St-Arnaud (Université de Montréal)

PARTNERS Growing Forward 2, International Plant Nutrition Network, Premier Tech Biotechnologies, Saskatchewan Organic Directorate, Saskatchewan Pulse Growers, Western Ag Innovations

Fungal inoculants, or biofertilizers, are often used in perennial fruit crops, but their impact on these plants and their surrounding soil ecosystem is largely unknown. A British Columbia-based research team explored how different types and timing of biofertilizers affected both grape crops, and the surrounding soil environment.

COULD FUNGI CREATE TERROIR WINES?

Grapes, and many other perennial fruit crops often need a boost when planted to help get them off to the right start. This boost typically comes from inoculation with soil microbes, such as arbuscular mycorrhizal fungi (AMF). AMF are a type of important beneficial soil organisms that can improve plant nutrition, protect against pathogens, and improve soil conditions. Grapes, typically grown in stressful conditions with limited moisture and poor soils, could benefit greatly from AMF associations. AMF may also contribute to terroir, or the distinct qualities of resulting wines. With all of these potential benefits, it should come as no surprise that AMF are now commonly used as inoculants, or “biofertilizers”.

Soil microbial ecologist Dr. Miranda Hart of the University of British Columbia, Okanagan and her team set out to explore the impacts of inoculating grape vines with commercially available AMF inoculants, as well as those isolated from soils growing grapes.

A series of greenhouse trials were conducted at the Summerland Research and Development Centre and field trials at two Okanagan Valley vineyards, Kalala Estate Vineyard and Summerhill Pyramid Winery. The research team explored the impacts of using either commercial or soil-derived biofertilizers on grape rootstocks before planting, at planting, or a year after planting. The research team then looked at how well the grapes performed, by measuring grape establishment, vigour and berry quality.

The researchers also developed DNA-based molecular tracking tools that allowed them to gauge whether the AMF in the biofertilizers were able to establish themselves in the soil, and whether they persisted and expanded.



VARYING SUCCESS IN AMF ESTABLISHMENT

Preliminary results suggest that AMF in biofertilizers vary in how well they are able to colonize grape roots and soils, and that they are not always able to do successfully. In this aspect, biofertilizers derived from natural sources, or other grape-growing soils, fared better than those available commercially.

Applying the biofertilizers to grapevines before planting resulted in better establishment of AMF populations than when used at or after planting. This was especially true in commercial vineyards, where the plants tend to be under stress.

The researchers are currently studying their collected data to determine whether the biofertilizers exert any positive effects on the grape plants themselves, and to see how far the AMF in the biofertilizers may expand.

The researchers add that plants grown in conditions where AMF may not be abundant, such as in greenhouses, or in areas that have recently been cleared for production, may benefit the most from biofertilizers. Meanwhile, organic producers may have a leg up, as organic production practices typically promote and maintain healthy soils that may not need to rely on biofertilizers to the same extent.

THE BOTTOM LINE

Fungal biofertilizers vary in their ability to establish. Natural sources of fungi may be more effective as biofertilizers than commercial sources, but organic production also supports healthy soil biology. ●

HEALTHY SOIL FOR HEALTHY VINEYARDS

ACTIVITY TITLE Microbial management in organic viticulture: Pre-inoculating vines with arbuscular mycorrhizal fungal inoculants

RESEARCHERS Miranda Hart (UBC Okanagan), Patricia Bowen (AAFC Summerland)

PARTNERS Growing Forward 2, BioSyneterra Solutions Inc., Summerhill Pyramid Winery, Kalala Estate Vineyard

QUASSIA EXTRACT: A BOON FOR ORGANIC APPLE PRODUCERS IN THE MARITIMES?

Organic apple producers in Atlantic and Eastern Canada are experiencing crop losses from an introduced insect pest: The European Apple Sawfly. A group of researchers investigate the use of Quassia for European Apple Sawfly damage to fruit.

PESTS AND POLLINATORS

The European Apple Sawfly is a relatively new pest of apple crops in Eastern and Atlantic Canada. This introduced pest does not have any natural predators in these regions, and so can destroy a significant portion of apple crops.

The lifecycle of this pest makes its control particularly challenging: it emerges early in the spring and lays its eggs in apple blossoms at the same time that pollinators are actively foraging. Managing this pest without harming pollinators can be challenging. Larva causes cosmetic damage (spiral scars) to apples when they chew just underneath the skin of an apple. Later, developed larvae cause further

damage when they burrow into the apple, consuming the seeds and causing fruits to abort.

While there are currently no registered organic products to control the European Apple Sawfly in Canada, apple growers in Europe have turned to a pollinator-friendly aqueous extract of Quassia which is derived from shrubs in the family Simaroubaceae. Quassia extract is non-toxic to bees or other beneficial insects, mammals, and fish, and has been approved as a food additive for human consumption.

A team of researchers, headed by Dr. Julia Reekie of Agriculture and Agri-Food Canada, investigated the use of Quassia Extract MD (TriFolio-M GmbH) to control the European Apple Sawfly in apple orchards in Nova Scotia and Ontario over four growing seasons. Trials

were carried out in research orchards, as well as in commercial organic and non-organic orchards.

In one set of trials, Quassia was evaluated at varying concentrations of 0, 3, 6, and 9 g quassin/ha. In another set of trials, Quassia application timings was evaluated, with sprays applied either early (at approximately 10 days after the first capture of the pest) or late (5-7 days after the early application) timings. In each trial, the efficacy of the extract was examined, and apple injury by the European Apple Sawfly was evaluated at fruit set and fruit harvest.



Primary (spiral scar) and secondary (tunnel) damage to apples caused by feeding of the European Apple Sawfly.

Quassia was found to be effective in the control of European Apple Sawflies in Ontario and Nova Scotia apple orchards. The researchers suggest that the concentration of Quassia used should be adjusted based on the level of infestation, with higher concentrations recommended as pest pressures increase. As an added benefit, Quassia was also found to suppress populations of another insect pest of apple, the rosy apple aphid.

The researchers anticipate that the data collected from this research will be helpful in supporting the registration of Quassia for European Apple Sawfly control in Canadian apple orchards.

RESULTS SUGGEST A NEW TOOL

Quassia is a promising product for managing the European Apple Sawfly to reduce apple crop losses in Canadian orchards. This pollinator-friendly pest management product could greatly benefit both organic and non-organic apple growers in Canada. ●

ACTIVITY TITLE Integrated organic practices in apple orchard management

RESEARCHERS Julia Reekie and Pervaiz Abbasi (AAFC Kentville), Margaret Appleby and Kristy Grigg-McGuffin (OMAFRA), Andrew Hammermeister (Dalhousie University), Mehdi Sharifi (AAFC Summerland).

PARTNERS Growing Forward 2, Boates Farm, Nova Scotia Tree Fruit Research Foundation, Ontario Apple Growers

Apple production in Eastern Canada is plagued by dozens of types of insect pests and diseases that cause crop damage. A Quebec-based research team explored the use of exclusion nets installed over apple rows for their ability to limit insect damage while maintaining apple quality.

OVER-BURDENED ORCHARDS

Organic apple production in Eastern Canada is limited by the need to manage multiple insect pests and diseases that thrive in that area, limiting yield or affecting fruit quality. Yet, demand for local, organic apples continues to grow. Organic orchards are particularly challenged by the over abundance of pests, and fewer effective pest management tools than their conventional counter-parts. There is a need to explore novel production practices to encourage expansion of the organic apple industry.

Exclusion nets to limit apple damage by pests and diseases are one such innovative approach. These nets have been used successfully in France and other European countries, but had yet to be tested in Eastern Canada. The net is meant to prevent the entry of pests, without drastic impacts on the growing environment.

TIMING IT JUST RIGHT

Row-by-row exclusion nets were installed over a high-density planting of Honeycrisp apples at the Institut de recherche et de développement en agroenvironnement (IRDA) research orchard in Saint-Bruno-de-Montarville, QC. These exclusion nets, which also excluded soil by wrapping around the tree trunks, were in place from bud-break until harvest, but were opened in the peak pollination period. A similar installation was put in place over various apple varieties in Victoriaville, QC. The research team monitored the damage done to apples, fruit quality, pest populations, pollination, the usability and durability of the nets, and the environmental conditions under the nets.

The research team, led by Dr. Gérald Chouinard of IRDA, found many positive outcomes when studying the use of exclusion nets. The nets were found to effectively exclude many of the key insect pests of apple crops



A row of Honeycrisp apple trees under exclusions nets, showing the apple harvest product without any pesticides in the fall of 2017.

in Eastern Canada, including apple maggot, plum curculio, codling moth and tarnished plant bug. Apples grown under nets hence showed much lower insect-related damage. At the same time, the nets did not have any negative effects on the yield or quality of the apples that they shielded. In fact, the nets also provided protection from damage related to hail. In addition, the research team found that opening the nets for only two or three days for pollination allowed them to limit fruit overload on the trees.

However, some insects were still able to access and damage apples under the exclusion nets, particularly if they were present in the orchard when the nets were put in place. For example, the oblique-banded leafroller was able to prosper under the nets in Saint-Bruno.

THE BOTTOM LINE

Exclusion nets allow the production of quality apples that are effectively sheltered from damage by many of the key pests of apple crops in Eastern Canada, opening the door to expanded organic apple production in the region. ●

**NO PESTS
ALLOWED:
ORGANIC
APPLES UNDER
EXCLUSION
NETS**

ACTIVITY TITLE Exclusion nets for organic apple production in Eastern Canada

RESEARCHERS Gérald Chouinard, Luc Belzile and Vincent Phillon (IRDA), Mirella Aoun and Jean Duval (CE-TAB+), Gaétan Bourgeois (AAFC Saint-Jean-sur-Richelieu), Éric Ménard (Dubois Agrinovation), Mélanie Noel (Producteurs de pommes du Québec), Gregory Patience and Jason Tavares (École Polytechnique de Montréal)

PARTNERS Growing Forward 2, Dubois Agrinovation, Producteurs de pommes du Québec

Regulating the greenhouse environment (e.g. humidity, carbon dioxide (CO₂) levels, temperature) while maintaining optimal growth conditions is a constant challenge for greenhouse producers. This project explores the use of geothermal and heat exchanger systems to provide better climate control in commercial greenhouses, optimize productivity, and reduce heating costs.

VENTING PROBLEMS? HOW GEOTHERMAL SYSTEMS MAY HELP ORGANIC GREENHOUSE MANAGEMENT

Complete climate control in greenhouses is difficult and complex: humidity, CO₂ levels, and temperature are all things needed to create optimal growing environments. Canada's seasonal changes in temperature present an additional difficulty as cooling measures are needed in the summer months, and heating is required in the winter. Many northern greenhouses reduce heat in the summer through natural ventilation systems. Vents or windows in the greenhouses rely on wind and thermal buoyancy to move air, instead of a powered fan. However, natural ventilation can increase heating costs by up to 10%, and

deplete CO₂ levels necessary for ideal growth conditions. Therefore, many ventilated greenhouses incur extra costs by needing to provide supplemental CO₂.

BUILDING ON PREVIOUS KNOWLEDGE

Geothermal cooling systems and heat exchangers may be a way to reduce heating costs, and dehumidify greenhouses without natural ventilation. Geothermal heat pumps work by using seasonal thermal energy stores. The abundant heat created in the summer can be removed from overly hot greenhouses, and stored in a thermal bank in the soil, reducing the need to ventilate and loose crucial CO₂ levels. Organic Science Cluster I data also showed that water pumped from a high ground water table can dehumidify greenhouses; however, a more water efficient method is needed for larger scale, commercial greenhouses.

Dr. Damien De Halleux of Université Laval along with Dr. Martine Dorais of AAFC set up trials at the greenhouses of Serres Jardin Nature in New Richmond, QC and L'Abris Végétal in Compton, QC. Trials were set up in natural ventilation cooled greenhouses and heat-pump-cooled semi-closed greenhouses. The trials were to examine and compare the fruit quality from tomato plants, growth data, dehumidification strategies, CO₂ levels, and greenhouse climate.

Cold water from the water table was used as a source for cooling for the natural ventilation and the semi-closed greenhouses at Serres Jardin Nature. At L'Abris Végétal, the source for cooling was the neighbouring soil of the greenhouses.



Using geothermal and heat exchanger systems, it was possible to limit the amount of ventilation needed in the semi-open greenhouses. This reduction in ventilation allowed for better climate management, and increased the productivity of the crops. Reducing the amount of ventilation also reduced the loss of CO₂ from the greenhouse atmosphere. Cooling in the control greenhouses resulted in 421ppm of CO₂ in the greenhouse atmosphere versus 652-654ppm of CO₂ in the experimental greenhouses, which was an improvement toward optimal growth conditions.

COMBINING OLD AND NEW TECHNIQUES

Geothermal and heat exchanger systems limit the need to ventilate greenhouses, allowing for better climate control, however humidity control still remains a major issue. At this time, it is deemed appropriate to continue using traditional, natural ventilation during critical dehumidification times to reduce susceptibility of crops to fungus and disease. ●

ACTIVITY TITLE Optimization of a non traditional cooling and dehumidifying method for a semi-closed organic tomato greenhouse

RESEARCHERS Damien De Halleux (Université Laval), Martine Dorais (AAFC - Université Laval)

PARTNERS Growing Forward 2, L'Abris Végétal, Serres Jardin Nature

Improving Canada's organic greenhouse production and crop yields could reduce organic food imports from other countries, and create a competitive, organic greenhouse industry. Dr. Martine Dorais and team set out to study intra-canopy LED lighting systems, organic fertilizers, and biostimulants to improve nutritional values of greenhouse crops.

GROWING DEMAND FOR ORGANIC FOOD IN CANADA

Many Canadian organic producers use commercial greenhouses due to the growing demand of fruits and vegetable year-round. Despite this, 75% of all organic food products in Canada are still imported from the United States and Mexico outside of the summer growing season. Yields in organic greenhouses can be up to 40% lower, compared to their conventional counterparts, mainly due to soil-borne pathogens. The combination of lower organic greenhouse yields, and organic food importation highlights the need to improve and optimize the Canadian organic greenhouse industry.

In Nordic countries, with a winter season comparable to Canada, many greenhouses use supplemental lighting from October to March to increase photosynthesis rates. This allows fruits and vegetables to be harvested on a year round basis, from local sources. This activity looked into the use of intra-canopy 3-D LED lighting to increase crop yields, and year-round sustainable crop growth. Other objectives were to determine if organic fertilization management, biostimulants, and alternative cropping systems provided any improvements to fruit productivity, nutritional value, and quality.

A team led by Martine Dorais (AAFC – Université Laval) conducted a 3-year study involving multiple trials at the AAFC/Université Laval and Les Serres Lefort in Sainte-Clotilde-de-Châteauguay, Quebec. There were four main factors that were investigated in this study that were all given intensive assessment parameters to effectively measure results.

First, the fertilization management of organic greenhouse vegetables was examined for the productivity and quality of the vegetables, specifically cucumbers, peppers and tomatoes. This included looking into



application intervals, application of different nitrogen (N) forms (organic vs. mineral, which have varying availability of N), and application rates. Secondly, the use of biostimulants such as Si-wollastonite, vermicompost and seaweed extracts were monitored for their effects on plant resilience, productivity and plant quality. Comparisons of cropping systems with and without cover crops were examined for cultivar responses. Finally, LED intra-canopy lighting was studied for effectiveness on yield improvements, crop productivity and fruit quality.

Fertilization in the commercial growing conditions showed no difference between 2, 3, or 4-week application events versus weekly fertilization applications in regard to nutrient availability or fruit quality. Based on the mineralization rate of solid organic fertilizers, reduced fertilizer applications still provide the nutrients needed and ensure high productivity, thus the suggested rate was every 3 to 4-weeks. Although organic fertilizer available nitrogen improved the diversity and abundance of soil microbes, it had no direct effect on fruit yield and quality.

A NEW SET OF TOOLS FOR ORGANIC GREENHOUSES

Intra-canopy LED supplemental lighting increased crop productivity by 20%, as well as improving fruit quality, colour, and firmness. Fruit quality parameters increased by 25-40% depending on the cultivar. Reduction in organic fertilizer application did not reduce crop productivity, and the use of biostimulants (such as silicon) helped increase crop resilience. ●

LIGHTEN UP! LED LIGHTING IMPROVES GREENHOUSE VEGETABLE YIELDS

ACTIVITY NAME Increased productivity and better quality of greenhouse grown organic vegetables

RESEARCHERS Martine Dorais (AAFC – Université Laval) and Steeve Pepin (Université Laval)

PARTNERS Growing Forward 2, Les Serres LeFort Inc.

Canadian climates can be challenging for the growth of valuable vegetable crops, including those that may have nutraceutical potential. An Ontario-based research team set out to develop and evaluate the use of high tunnel growing systems for organic production.

HIGH TUNNELS FOR HIGHER YIELDS AND LONGER GROWING SEASONS

CREATING A LONGER SEASON

While high tunnel technologies have been used in the USA and other countries, and are used for some fruit production in Canada, their potential for the production of high value vegetable crops in Canada was largely unexplored. In Canada, high tunnels have the potential to extend the growing season

both in the early spring and late fall. Fresh vegetables, especially high value crops such as cherry tomatoes and pea shoots, can command a high price when the growing season does not allow their production in the field. High tunnels can also protect tender plants from extreme weather events, and may be of particular interest to organic growers for their ability to reduce insect pests and diseases. Given the climate variability across Canada, it is best that these technologies be tested region by region.

NEW MARKETS FOR VEGETABLES DEVELOPING IN CANADA

Some vegetable crops are attractive because of the health and nutritional properties that they possess, providing them with potential use as nutraceuticals. One such example is the bitter melon, a popular vegetable for many cultural groups that has promise when used to manage some of the symptoms of Type II diabetes. Canadian field growing conditions limit the growth and production of this crop domestically, providing an opportunity for local, high tunnel-based organic production.

Dr. Youbin Zheng of the University of Guelph led a research team that conducted research on a 1-acre parcel of certified organic farmland on the University of Guelph campus at the Guelph Centre for Urban Organic Agriculture. This land was divided into nine, equal sized plots. Of these nine plots, three were left open, three had standard high tunnels installed, and the remaining three were furnished with high tunnels that included insect nets installed on the roll-up sides and end doors.

These plots were planted with organic tomatoes, bitter melons, pea shoots, pea pods and edible chrysanthemums. The research team then explored how well the various crops performed under the different growing conditions in terms of yield and quality. They also evaluated how the three growing systems impacted the air and soil environment by looking at temperature, humidity, air flow and light levels.



High tunnel and open field plots at the University of Guelph.

HIGH POTENTIAL FOR HIGH TUNNELS

High tunnels can be used in cold climate regions, such as Ontario, to produce high-value vegetables. This is possible through extending the growing season by up to two months, as the tunnels offer protection from cold temperatures in the fall. The yields of these crops can be several times higher in high tunnels than in open fields, up to 12 times higher for bitter melon yields. Additional technologies, such as anti-insect nets and shade nets, may further improve production in high tunnels, as they also protect from disease, and reduce types and total numbers of insect pests. ●

ACTIVITY TITLE Using high tunnels to produce high-value organic vegetable and nutraceutical crops in Canadian climates

RESEARCHERS Youbin Zheng, Yun Kong, Dave Llewellyn, Martha Gay Scroggins, Ralph Martin, Mary Ruth McDonald and Rene Van Acker (University of Guelph), Evan Elford (OMAFRA).

PARTNERS Growing Forward 2, Loblaw Chair in Sustainable Food Production, DeCloet Greenhouse Manufacturing Ltd., Ralph Martin, Van Acker Horticulture Industry Fund

Consumers frequently state that a key reason behind their purchase of organic products is that they are healthier or tastier. Can management practices be used to improve the quality of the carrot? An Ontario-based research team set out to evaluate the impact of soil fertility management practices and carrot variety on the flavour, yield and phytochemical content of carrots.

Organic production systems may promote the production of secondary compounds in plants. These compounds are not needed for the growth and development of a plant, but rather serve purposes such as plant defense or nutrient acquisition. These are the same compounds, such as carotenoids, polyacetylenes, and phenolic acids, that are often attributed health benefits.

Plants grown in a low-input system, such as organic, are often more reliant on these compounds. While it is expected that organic practices lead to healthy soils, and that healthy soils lead to nutritious foods, little research has been done to evaluate how organic soil management practices might be optimized to improve the taste and nutritional value of the produce.

This Ontario based research team, led by Dr. Marica Bakovic and PhD candidate Amanda Stefanson, studied two different carrot varieties under different soil and nutrient regimens. Emperor carrots, grown largely for food processing, and Nantes carrots, grown more commonly for small markets, were studied, and both types of carrots were grown for two years at two sites in Ontario. One site was a garden field with a history of organic management that had high soil fertility (HFS), the other a nearby non-organic hay field of the same soil type that had low soil fertility (LFS). In this way, the University of Guelph-based researchers aimed to control many of the underlying variables that could affect the nutrition or health properties of the carrots, varying only those that they wished to study.

Each carrot variety was grown under varying agronomic treatments. These included compost, an optimized

organic treatment that included compost along with soil- and foliar- applied micronutrients, or synthetic fertilizer. The impact of these varying agronomic regimens on the content of health-promoting phytochemicals in the carrots, including carotenoids, polyacetylenes, and phenolic acids, was then examined. A consumer taste test was used to determine if management practices influenced carrot flavour.

The agronomic regimens had limited impacts on the yield, mineral content, or phytochemical content of either carrot variety, however, carrot yields were higher at the low fertility site (LFS). The research team suggests that the higher yields in the LFS may be due to soil microbial activity or differences in nutrient cycling. Overall, the agronomic treatments for the carrots had little impact on how “healthy” the carrots were, but fertility status of the soil did. Carotenoids were higher in the LFS for both varieties; chlorogenic acid (the main polyphenol in carrot) was higher in the high fertility site (HFS) for both varieties.

The Emperor variety contained higher levels of many phytochemicals and minerals and had higher antioxidant capacity, while the Nantes variety had higher levels of carotenoids. Levels of carotenoids were higher in carrots grown at the LFS, while polyphenol levels were higher at the HFS.

Consumers preferred the Nantes carrot over the Emperor variety, finding this variety to be sweeter and have an overall better flavour. Consumers were not, however, able to discern a taste difference between carrots cultivated under the various management strategies.

THE BOTTOM LINE

The soil fertility treatments under which carrots were cultivated had little impact on the health compounds or taste of the carrots, however, health compounds were influenced by the background fertility status or growing conditions by different sites. ●

GROWING A HEALTHIER CARROT?

ACTIVITY TITLE The health benefits of soil management techniques to improve flavor and phytochemical content of carrot: Linking healthy soil, healthy plants & healthy people

RESEARCHERS Marica Bakovic, Amanda Stefanson, Lisa Duizer, Ralph Martin (University of Guelph), David Cohlmeier (Sustainable Good Food Consulting)

PARTNERS Growing Forward 2, Carrot Cache Community Resources Inc., Ralph Martin

CAN ORGANIC FERTILIZERS AND COVER CROPS IMPROVE CARROT PRODUCTION IN MUCK SOIL?

Organic vegetable producers that work in muck soils in Canada can find it challenging to balance their management of soil microbes, fertilization, yields, shelf life, and food safety of their crops. The goal of this activity is to determine which system generates better soil fertility and microbial activity for superior organic carrots.

Organic carrots are a major crop currently produced in Canada; it is also one of the largest imported crops. Increasing yields and optimizing agronomic practices could help create more economically sound organic carrot production in Canadian muck soils.

Many organic producers in Canada are moving towards pelletized nitrogen, which can resemble synthetic nitrogen fertilizers because it can be applied directly, and is absorbed quickly. Using cover crops and organic fertilizers may offer an alternative to producers to manage their impacts on soil microbial communities, and still contribute nutrients to the soil to optimize quality and yields.

A team lead by Caroline Côté (Institut de recherche et de développement en agroenvironnement – IRDA) embarked on a 3-year research project at the Plateforme d'innovation en agriculture biologique at IRDA in Saint-Bruno-de-Montarville, QC. Every autumn cover crops of forage pea, oat and a control (no cover crop) were established in muck soils. Each year in the spring, three fertilization treatments were given to each cover crop. The organic fertilizers consisted of composted bovine manure, poultry manure pellets, and a control (without fertilizer).

Before and after treatments, soil samples were taken to monitor diversity and richness of bacteria and

eukaryotes. Ion exchange membranes were used to show nitrate, ammonium and potassium changes in the soil. Economical analysis of carrot yields was done for total and marketable yields at the end of each growing season. Subsamples of the carrots were stored to determine the quality and shelf life by checking for fungal and diseases symptoms monthly for five months.

Using compost to fertilize organic carrots had a market-



Carrot experimental plots in Saint-Bruno-de-Montarville (QC)

able yield increase compared to other fertilization techniques. This was especially true for yield comparisons between forage pea cover crop, compared to the control with no cover crop. Levels of available potassium and soil microbe diversity were increased, which positively influenced yields. Incidences of fungal disease in stored carrots were increased, but only after 3 months, therefore there is not much impact on short-term stored carrots.

Forage pea cover crop increased the available nitrate to plants, whereas oat cover crop had the highest available potassium to plants. Using cover crops is also an important sustainable agricultural practice, and can reduce the degradation of muck soils.

THE BOTTOM LINE

Using organic fertilizers increased marketable yields of organic carrots, and increased soil microbial activity in muck soils. ●

ACTIVITY TITLE Impact of green and organic fertilizers on the yield and safety of organic carrots in muck soil

RESEARCHERS Caroline Côté, Luc Belzile, Richard Hogue, and Christine Landry (IRDA), Denis La France and Anne Weill (Centre d'expertise et de transfert en agriculture biologique et de proximité – CETAB+), and Linda Roberge (Phytodata)

PARTNERS Growing Forward 2, Les Fermes R&R et Fils Inc., Union des producteurs agricoles

Growing organic herbs is difficult when growth regulators used in conventional ornamental production are unavailable to organic producers. Using LED lighting under different wavelengths, researchers aimed to determine optimal growth regimes in greenhouses to produce high quality organic herbs and ornamentals.

Organic ornamental and herb plants are gaining popularity among Canadian consumers. Although the market is not quite on par with European or U.S markets, Canadians are increasingly searching for plants to suit their lifestyles, such as ornamental, or house plants.

LIGHTING THE WAY FOR MORE GROWTH

Many ornamental producers use growth regulators alongside climate regulation measures. Growth regulators are unavailable to organic ornamental and herb producers. Also, some climate regulation measures such as increasing and decreasing temperatures, venting, and multiple different lamps for different plant species are extremely energy consuming and expensive. LED lights with multiple spectrums may be an integral tool for organic ornamental producers to help reduce some of these costs, as well as provide a growth tool in replacement of growth regulators.

In 2017, this Quebec based research team, led by Dr. Martine Dorais (AAFC - Université Laval) in collaboration with Frank Nicolas Zyromski (Les Serres Frank Zyromski), studied 20 herb species and cultivars under two different light treatments for plant growth and quality. The 20-herb species and cultivars were assembled into 7 sets of 3 different species (known as trios). The trios were then exposed to LED supplemental lighting, with no supplemental lighting as the control. LED lighting was offered at different spectrums (15% blue and 85% red) and provided to the plants for a 12-hour photoperiod. Similar trials were conducted using ornamental plants in experimental and commercial settings from 2014-2016 to determine the effects of supplemental LED lighting on plant growth and quality.

The LED lighting increased total dry shoot biomass across all species on an average of 1.4 times. Lemon thyme (*T. citriodorus*) and Common Sage (*S. offic-*



nalis) biomass increased 2-fold using the LED lighting. Dry leaf biomass also increased an average of 1.7 times, with apple mint (*M. suaveolens*) dry leaf biomass increasing up to 3.2 times.

Plant phenols are often directly associated with the quality and freshness of produce, and are therefore an important measurement of value for herb plants. An accumulation of 2.2 times more phenols were found in plants with LED lighting versus those grown in the control group. Rosemary (*R. officinalis*) phenols increased to 6.4 times those in the control group. Overall, supplemental LED lighting could be an incredibly useful growth tool for organic producers of ornamental and herb plants.

AN ENLIGHTENING RESULT

LED supplemental lighting increased plant biomass and total phenol accumulation of the organically grown herb plants. Total dry shoot biomass was increased by 1.4 times on average, and plant phenols (which are indicators of plant quality and value) increased 1.7 times on average when grown with LED supplemental lighting. ●

CAN LED LIGHTING OPTIMIZE ORGANIC ORNAMENTALS AND HERBS?

ACTIVITY TITLE Production of organic mother plants under LED artificial light for the production of cuttings and potted flowering plants

RESEARCHERS Martine Dorais (AAFC – Agassiz, BC), Blanche Dansereau, Steeve Pépin (Université Laval)

PARTNERS Growing Forward 2, Les Serres Frank Zyromski

STRONG HOPS? ORGANIC MANAGEMENT FOR NUTRACEUTICAL COMPOUNDS IN HOPS



Organic hops are gaining momentum in Canada, however, hops are nutrient and input intensive. This study aimed to develop an effective organic management plan for hops destined for the nutraceutical industry.

VALUE IN MORE THAN ONE MARKET

Hops have long been known for their medicinal value, and have been used to treat health concerns such as anxiety and inflammation. There is a growing demand in Canada for the production of organic hops for both the nutraceutical, as well as brewing companies; increasing yields for the nutraceutical industry could help meet the needs of microbreweries.

Hops are an extremely input intensive crop, especially when considering nitrogen (N). Hops can use up to 4.5 kg N/ha/day, meaning it is incredibly important to have a balanced nutrient plan, and to carefully consider the mineralization rates of soil amendments.

The research team, led by Dr. Martine Dorais (AAFC – Université Laval), conducted six trials at Houblonnière Gosselin from Ste-Sophie d'Halifax, QC, between 2014 and 2017. Establishing two fertilization rates in the first year was essential for determining an optimal nitrogen rate for the crop. In the first year, hops were also intercropped with white and red clover. Biochar

was used as a soil amendment and was observed for its effectiveness (soil properties and crop agronomic performance). Over the next 3 years the impact of intercropping with clover and fertilization rates were assessed to determine the impact on yield and nutraceutical compounds.

HOW BEST TO CONTROL THE WEEDS?

Weed control quickly became a noticeable problem in the hops, and four different management methods were compared between 2016 and 2017. Hand weeding, coir weed mat, coconut mulch, and a natural contact product (for research purposes only) were all tested to determine their effectiveness of weed control. Coir weed mats are a coconut mulch waste product used for weed suppression that are popular in New Zealand. Finally, biostimulants and silicon (wollastonite) were also tested and observed for influences on yield and nutraceutical compounds.

COMBINING TECHNIQUES FOR BEST RESULTS

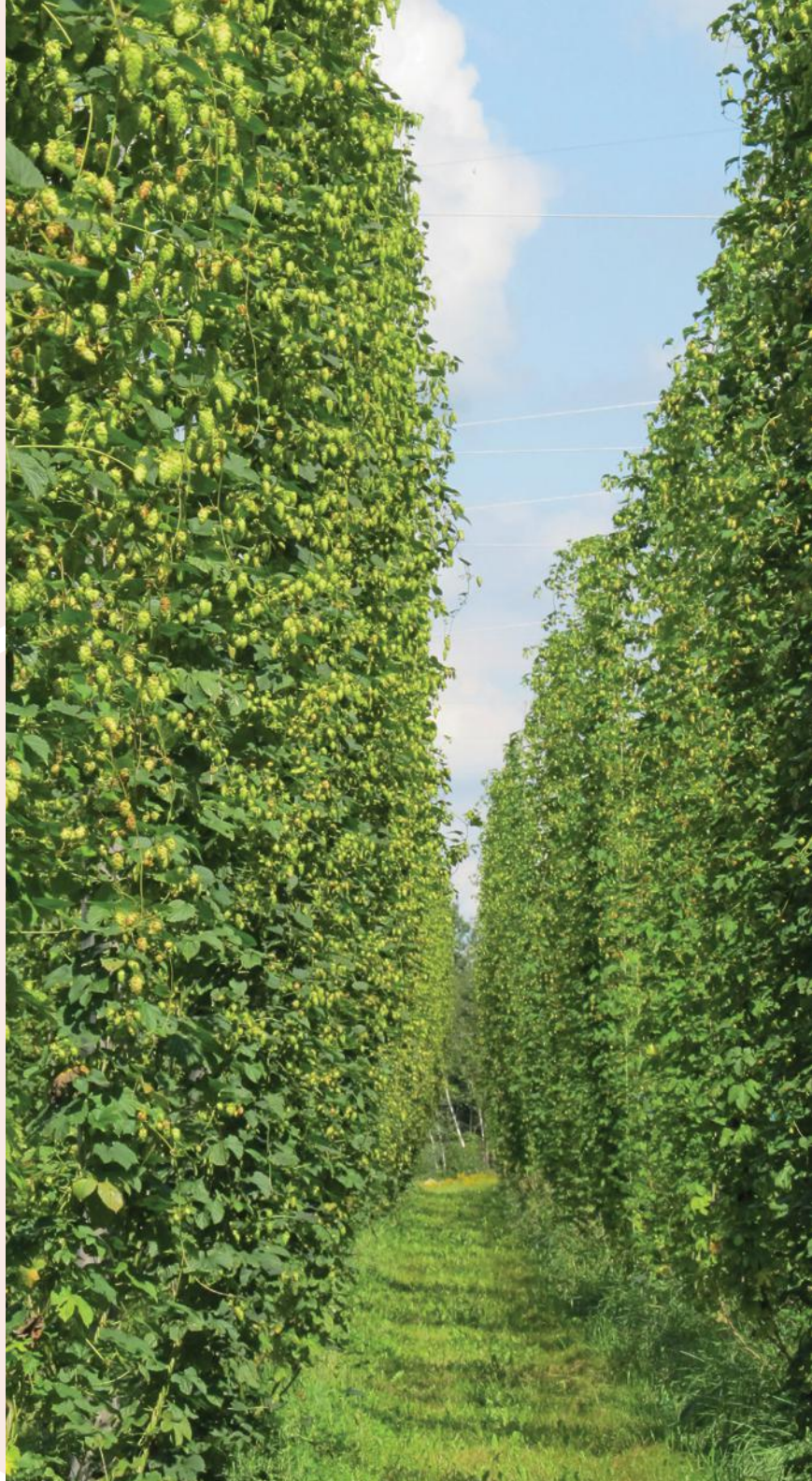
Hand weeding and coir mulch provided 10-20% better yields, while the control of the secondary hop stems between May and July resulted in fresh cone yield increase around 50% higher than controls. Combining weed control and secondary stems is believed to sharply increase yields.



Hops inter-cropped with red clover.

As expected, hops are an incredibly nitrogen intensive crop. The study was able to establish an organic fertilization plan for crops that is based mostly on compost, pelletized poultry manure, feather meal, and bone meal. No negative impacts were found on the nutraceutical compounds with nitrogen applications rates at 170 kg/ha. This application rate also resulted in 50% higher yields compared to 110 kg/ha application rate in the Cascade variety. Cascade showed better resistance to the climatic conditions and viability under organic management with higher yields and better cone quality, as well as little to no browning caused by mildew.

A critical aspect of hop production for organic farmers occurs before the hops are in the ground due to the intense nitrogen requirements of the crop. Appropriate soil management before crop establishment, and adding cover crop and intercrops that will contribute weed control and fertility could be a key element in hop production for organic farmers. ●



ACTIVITY TITLE Impact of organic fertilization on growth and yield of secondary hop compounds intended for food and nutraceutical processing

RESEARCHERS Martine Dorais (AAFC – Université Laval), Yves Desjardin and André Gosselin (Université Laval)

PARTNERS Growing Forward 2, Les Serres Frank Zyromski



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SEEKING THE SOLUTION FROM WITHIN: ISOLATING APPLE SCAB BIOCONTROLS



Apple scab on apple leaves and fruits.

Apple scab is an economically important disease for organic apple producers in Canada. While some management measures exist, there is a need for new and effective biocontrol products with low environmental risk. The Ontario-based research team aimed to isolate microorganisms with the potential to act as biological control agents against apple scab from within apple plants themselves.

Apple scab, caused by the fungal pathogen *Venturia inaequalis*, is a major challenge for organic apple production worldwide, and can result in complete crop loss. Apple scab the primary fungal disease for organic apple producers in Canada, especially during wet summers. Infection with apple scab causes apple trees to lose their leaves early, and causes fruit to become covered in scabs, eventually cracking the skin of the fruit.

While copper-based sprays are an effective fungicide allowed for use in Canadian organic production, their extensive use can result in the unwanted build up of high levels of copper in soils. Additionally, sulphur based products can cause phytotoxicity on leaves. With this in mind, there is a need for the development

of new management alternatives for fungal diseases in organic apples.

Dr. Deena Errampalli of Agriculture and Agri-Food Canada and collaborators set out to isolate and identify new potential biocontrol agents to manage apple scab. Their search focused on endophytes such as bacteria and fungi that already make their home on apple trees.

The scientists collected leaves, stems, petioles and roots from crab apples, wild apples, and apple trees in orchards. Endophytes residing in these tissues were then isolated and characterized visually and with DNA analysis. These isolated microorganisms were then monitored for their ability to suppress apple scab, both through laboratory testing and in greenhouses on apple seedlings inoculated with apple scab.

A number of bacterial and fungal endophytes were isolated from the apples in three different locations, some of which show promise in their ability to suppress apple scab. Although this research has identified potential products with activity against this important disease, further research is required to develop these into biocontrol products that can be used by apple producers in Canada. Work continues toward the development of a commercial biocontrol product that will be of great value to organic and non-organic apple producers alike.

WORK STILL TO BE DONE

While researchers were successful in identifying and isolating potential biocontrol agents that have promise in the management of apple scab, work remains to be done before new products are available for organic apple producers. ●

ACTIVITY TITLE Development of organic control strategies for apple scab

RESEARCHERS Deena Errampalli (AAFC London), Kerik Cox (Cornell University), Paul Goodwin (University of Guelph), John Molenhuis (OMAFRA)

PARTNERS Growing Forward 2, Hewgill Orchards Inc., Ontario Apple Growers, Vergers Leahy Inc.



Powdery mildew is a common fungal disease in strawberry plants that often requires fungicidal applications, an option not available to organic strawberry producers. A Quebec team aimed to examine better ways to control fungal diseases of strawberries in high tunnel settings. This study investigated silicon as a possible organic fungal amendment against powdery mildew.

Strawberries are an important crop in Canada that have traditionally been grown in a summer-long field production. However, more strawberries are being grown in high tunnels and greenhouses for year-round production purposes. Organic strawberries are difficult to grow, given that few disease controls are regulated for organic production. There is also a lack of available data and limited understanding of practical applications of biostimulants such as silicon, and how plants like strawberries use silicon to their benefit.

Almost half (48%) of Canada's strawberries are currently grown in Quebec. Many strawberry producers are inundated with powdery mildew, a common fungal disease. Fungicide is the primary method of controlling the disease, and is particularly necessary in high tunnel settings. This option is not available to organic producers. Several studies have shown that silicon can reduce powdery mildew in multiple crops, including strawberries, and potentially increase plant resilience to more biotic and abiotic stressors.

Richard Bélanger and Martine Dorais based their project at Les Fraises de l'Île d'Orléans Inc., a strawberry producer based in Quebec. Three and six day-neutral

Left: Strawberry powdery mildew symptoms

Right: Silicon treated strawberry in poly-tunnel

cultivars were tested in 2014 and 2015, respectively. The cultivars were given silicon supplements and were exposed to powdery mildew (*P. aphanis*). They were then observed for their susceptibility to the fungal disease in a high tunnel setting. The cultivars were also tested for their absorption rate of silicon via supplement regimen to determine which cultivars are the most responsive to silicon absorption.

All cultivars tested had excellent, and similar, absorption of silicon. This was reflected in the dry weight of the treatment plants, of which 3% of the overall dry weight was silicon. In both 2014 and 2015, silicon treatments significantly reduced powdery mildew on leaves and fruits. Cultivars Verity and Charlotte showed the greatest reduction in overall powdery mildew effects.

A SWEET SUCCESS

Silicon is an incredibly successful candidate as a fungal control option for strawberry producers. Up to 80% of damage caused by powdery mildew was controlled, and plants treated with silicon produced high-grade fruits. ●

BOOSTING STRAWBERRY DISEASE RESILIENCE WITH SILICON

ACTIVITY TITLE Toward organic production of strawberry through exploitation of its natural genetic ability to absorb silicon

RESEARCHERS Richard Bélanger (Université Laval), Martine Dorais (AAFC - Université Laval)

PARTNERS Growing Forward 2, Les Fraises de l'Île-d'Orléans Inc.

The effects of pre-harvest UV-C treatment on the growth and health of strawberry plants: A. Healthy strawberry plant; B. Healthy strawberry plant treated with UV-C; C. Strawberry inoculated with *Mycosphaerella*; D. Strawberry inoculated with *Mycosphaerella* and exposed to UV-C.



Organic consumers expect the produce that they buy to be healthy, look attractive, and be free of pests and contaminants. A Quebec-based research team exposed strawberry and lettuce plants to ultraviolet-C (UV-C) light before harvest explore the ability of this treatment to reduce disease on the plants and increase healthy phytochemicals.

AN OUNCE OF PREVENTION: PRE-HARVEST ULTRAVIOLET-C LIGHT FOR HEALTHIER CROPS

Over the past 30 years, scientists have explored the impacts of treating fruits and vegetables with low doses of ultraviolet-C light (UV-C, 254 nm) after they have been harvested. While high doses of UV-C can be damaging, low doses can bring about a biological response in the plants that can have beneficial effects. In fact, past work has demonstrated the potential of this technology to reduce disease pressures, slow ripening, and enhance quality. The potential of this technology for organic agriculture is promising, and the use of this technology before a crop is harvested was largely unexplored.

A Quebec-based research team, led by Agriculture and Agri-Food Canada's Dr. Marie Thérèse Charles, wanted to explore the impacts of subjecting plants to UV-C earlier in their growth. They were particularly interested in whether this would result in plants with less disease or higher quality in terms of healthy phytochemicals,

such as antioxidants, in the harvested crop.

At the AAFC Saint-Jean-sur-Richelieu Research and Development Centre, the team choose to study strawberry and lettuce plants. Strawberry plants were treated either every day, every other day, or every third day with a dose of UV-C light. In doing so, the researchers were looking to discover what dose of UV-C provided the benefits they were seeking without causing damage to the growing plants. Meanwhile, lettuce plants were also subjected to various doses of UV-C light.

SHEDDING LIGHT ON A PROMISING NEW TOOL

The team found that lighting strawberry plants with UV-C every other day for a four-week period reduced a particular disease, *Mycosphaerella* spots, without sacrificing the growth of the strawberry. The researchers then extended the treatment period to seven weeks. While this longer exposure increased the number of deformed or aborted fruits, the overall number of strawberries and marketable yield held constant, while the levels of healthy phytochemicals, such as anthocyanins, flavanols, and ellagic acid, increased.

Work on lettuce is nearing an end, with preliminary results suggesting that there is a low UV-C dose that can reduce bacterial leaf spot disease in lettuce. However, work is still underway to determine what frequency growers could apply the UV-C to this delicate crop to reap these benefits without impacting lettuce quality.

A "LIGHT" CONCLUSION

The use of UV-C light during crop growth has the potential to serve organic fruit and vegetable growers as a pest management and quality improvement tool. ●

ACTIVITY TITLE Development of postharvest UV light therapy technology for extended preservation of fresh organic fruits and vegetables

RESEARCHERS Marie Thérèse Charles (AAFC Saint-Jean-sur-Richelieu Research and Development Centre), Joseph Arul and Russell Tweddell (Université Laval), others listed in response from Marie Therese...

PARTNERS Growing Forward 2

Peas and lentils are a common component in organic cereal rotations on the Prairies, but these crops can be vulnerable to weeds. This Saskatchewan-based research team aimed to develop recommendations for how to best control weeds in peas and lentils using mechanical and cultural methods.

BUILDING ON PREVIOUS PRACTICES

Cultural weed control methods aim to increase a crops' competitiveness against weeds. A common cultural weed management strategy is increasing seeding rates to create a denser crop with fewer openings for weeds. On the other hand, mechanical weed control physically removes weeds, and can be implemented at many stages in the crop cycle.

Pulse crops are a common and valuable part of many Prairie organic grain rotations. Pulses can fix their own nitrogen, making them a good addition to rotations that are running low on fertility. However, pulses are often slow to establish, making them particularly vulnerable to weeds.

Few studies have examined the impact of combining cultural and mechanical weed control techniques, especially in pulse crops. There may be an opportunity to create an effective integrated weed management approach for organic pulse crops.

Dr. Steve Shirtliffe of the University of Saskatchewan and collaborators initiated field trials with both peas and lentils at the Kernen Crop Research Farm and the Goodale Research Farm in 2016 and 2017. The researchers wanted to examine the individual and combined impacts of cultural and mechanical weed control strategies to maximize both weed control and crop yield.

At these sites, research plots were planted at one of two seeding rates: the standard recommended conventional seeding rates, or at higher seeding rates. Tested seed rates were 250, 500, 1000 and 2000 viable seeds per m². The plots were then subjected to either one, two, or all three of the following weed management tools: the rotary hoe, the flex tine harrow, and the inter-

row cultivation, as well as untreated and hand weeded checks. The researchers then monitored how weeds fared under these treatments, including their biomass, as well as the resulting yield of the crops.

In both crops, mechanical weed control reduced weed biomass compared with no mechanical weed control. In field peas, using rotary hoe, harrow and inter-row cultivation in any 2- or 3-tool combination reduced weed biomass by 73-86%. In lentils, combining rotary hoe with inter-row cultivation, with or without use of the harrow, reduced weed biomass to a similar extent. Meanwhile, increasing the seeding rate of peas and lentils improved yield by 13 and 23% in pea and lentil, respectively. In field peas, combining high seeding rate with any mechanical weed control method maximized yield. In lentils, only the combination of rotary hoe with inter-row cultivation at high seeding rate produced maximum yield.

It is important to use the mechanical weed management tools at the stages when weeds are most vulnerable, but the crop is resilient. For the rotary hoe, this means making a pass when weeds are at the white thread stage, or just cracking through the soil. The harrow can be used up to the cotyledon stage for weeds and up to the 4 node stage for the pulse crop. The inter-row cultivator is best used when the pulse crop is between the 4 and 10 node, but prior to canopy closure.

BRIDGING TOGETHER TECHNIQUES

Combining the cultural weed management practice of increasing seeding rates with mechanical weed control measures provides effective weed control in pea and lentil crops. ●

MANAGING WEEDS IN ORGANIC PULSE CROPS: THE INTEGRATED APPROACH

ACTIVITY TITLE Integrating weed control for organic pea and lentil production

RESEARCHERS Steve Shirtliffe, Eric Johnson and Chris Willenborg (University of Saskatchewan)

PARTNERS Growing Forward 2, Saskatchewan Pulse Growers

Outbreaks of foodborne illnesses have been linked to sprouted vegetables, yet many of the standard sanitation options are not available to organic growers. A team of four researchers evaluated options for the effective sanitation of sprouts suitable for organic production.

CLEAN SPROUTING! EFFECTIVE SANITATION TREATMENTS FOR ORGANIC SPROUTS

THE RISKS AROUND SPROUTS

Sprouts are a tasty and nutritious addition to the diet, and an attractive crop for many organic producers. Yet, sprouts have a reputation for being prone to pathogens that cause foodborne illnesses, such as Salmonella, Listeria and E. coli. While warm, damp conditions allow sprouts to thrive, the same can often be said for these bacterial pathogens. With this in mind, growers must take steps to disinfect sprouts. However, many of the treatments sanctioned by the regulatory agencies are not compliant with organic standards. The treatments may pose an occupational exposure risk due to their high concentration of sanitizing agents, such as calcium or sodium hypochlorite or hydrogen peroxide.

A British Columbia-based team of researchers, led by Dr. Siyun Wang at the University of British Columbia and Dr. Pascal Delaquis at AAFC, embarked on a study of organically permitted methods to rid organic sprouts of possible disease-causing bacteria.

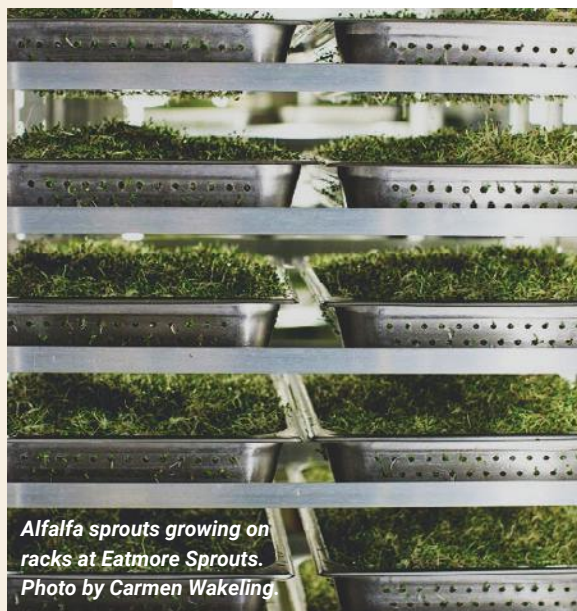
LET'S GET TO WASHING!

With research conducted at the University of British Columbia's Food Safety Lab and the AAFC Summerland Research and Development Centre, the research team began by inoculating certified organic alfalfa and mung bean seeds with known pathogens. They then subjected these seeds, either immediately after infection or after four weeks in storage, to treatments

that had the potential to rid the seeds of these bacteria. These treatments included soaking the seeds in water heated to 50-60°C for 10 to 20 minutes, followed by treatment with milder sanitizers including acetic acid and hydrogen peroxide.

After the seeds were subjected to these treatments, the scientists grew the sprouts, and measured how well they germinated and produced, while also examining whether pathogens were able to survive.

The research revealed that there are sprout treatment options available that are both effective and available to certified organic producers. The most effective method varied by seed type, and depended on the seed's shape and surface. For mung beans, the most effective treatment option was a 20-minute soak in 60°C water, followed by a 15-minute exposure to a mixture of 4% hydrogen peroxide and 0.2% vinegar. Meanwhile, alfalfa and radish seed fared best when soaked in 50°C water for 10 minutes, followed by 15 minutes in a mixture of 2% hydrogen peroxide and 0.1% vinegar.



Alfalfa sprouts growing on racks at Eatmore Sprouts.
Photo by Carmen Wakeling.

A CLEANER SOLUTION

New organically acceptable, food-safe sprouting treatments proved equally effective as the current industry standards. These new seed treatments have the potential to revolutionize the whole sprout industry. ●

ACTIVITY TITLE Development of validated seed disinfection strategies for the organic production of sprouted vegetables

RESEARCHERS Researchers: Siyun Wang (UBC), Susan Bach and Pascal Delaquis (AAFC Summerland)

PARTNERS Growing Forward 2, Eatmore Sprouts & Greens Ltd., Jonathan Sprouts Inc., Mumm's Sprouting Seeds



The red flour beetle, a common pest of stored grains and flour mills.

Few organic options exist to manage the insects that can infest grain and cereal producers' facilities and products. New methods for reducing insect pest populations in organic grain storage will benefit organic grain producers, handlers and processors.

Many insects happily make their home and find their meals in grain storage, handling and processing facilities. Among the most commonly found are rusty grain beetle, red flour beetle, confused flour beetle, Indian meal moth, warehouse beetle, rice weevil, and the granary weevil. The presence and feeding of these insects can render products unacceptable for consumers, and can result in product waste and disposal. Many of the management options available for these insect pests are not suitable for organic production. Yet, organic producers, handlers and processors need tools and techniques to keep these insect pests under control, especially when considering the value and scope of organic grain production in Canada.

The Prairie-based research team, headed by Agriculture and Agri-Food Canada's Dr. Paul Fields, set out to examine organically permissible methods to reduce insect pests in grain storage facilities.

EXTREME TEMPERATURES EFFECTIVE

Research conducted on-site in these storage facilities first examined exposure to very hot and very cold temperatures. Cold Prairie air in February was allowed to enter the packing plant of a flour mill, resulting in temperatures in the range of -4 to -22°C, and insect populations were monitored. Similarly, temperatures in grain storage facilities were artificially elevated to between 50 and 60°C, and insect populations monitored.

Red flour beetles subjected to the cold treatment showed an 85% mortality rate, while monitoring by trapping of insects in the mill showed a decline in resident populations. It should, however, be noted that to be effective, a cold treatment requires temperatures to drop substantially – such naturally low temperatures may be limited to the Prairies. Meanwhile, red flour beetles subjected to the heat treatment were completely eradicated, while trapping of insects in the mill also showed a decline.

NO BUGS IN YOUR FLOUR: MANAGING PESTS IN GRAIN STORAGE

A POSSIBLE EARTHY SOLUTION?

The research team also explored organically permitted substances for insect pest control, namely diatomaceous earth. In their laboratory, 300 kg barrels of grain were mixed with an organically permitted diatomaceous earth product. The response of rusty grain beetles and rice weevils also placed in the barrels was monitored.

The organically permitted diatomaceous earth provided over 90% control of the rusty grain beetle and rice weevil. As a result, this product has had a label expansion and is now available for use. ●

ACTIVITY TITLE Organic integrated pest management for grain storage and processing facilities

RESEARCHERS Paul Fields (AAFC Morden, MB) and Russell Hynes (AAFC Saskatoon, SK)

PARTNERS Growing Forward 2, Absorbent Products Ltd., Gardex Chemicals Ltd.

While consumers at home and worldwide may love to snack on organic blueberries, the expansion of organic wild blueberry production is hampered by the need for management options for insect pests. A Nova Scotia-based research team aimed to explore the potential of essential oils for their ability to control insect pests in organic wild blueberry production.

Wild blueberries have several insect pests that can decrease berry production or quality, including blueberry spanworm, blueberry flea beetle, and spotted wing drosophila. Management of these insect pests is particularly challenging for organic producers, who have few tools to cope with infestations.

CAN ESSENTIAL OILS PROVIDE BLUEBERRY PEST CONTROL?

AN ESSENTIAL TOOL IN ESSENTIAL OILS?

A potential tool for organic producers are plant-derived essential oils. Many essential oils have natural pesticide properties, while also typically having low impacts on pollinators and natural enemies. Essential oils for pest management have been explored against some insect pests, but their use against common blueberry pests was, to date, unexplored.

Lab studies, led by Dalhousie University's Dr. Chris Cutler, began with the collection of blueberry insect pests in the field. Pests studied included the blueberry spanworm, blueberry flea beetle, and spotted wing drosophila. The researchers were interested in evaluating the ability of essential oils to deter, repel or kill pest insects when used alone, or in combination with other essential oils or other organically permitted pesticides, namely spinosad and Bt. Commercially available essential oils known to have biological activity against a range of insect pests, including rosewood and thyme, were evaluated. The blueberry insect pests were sprayed with varying concentrations and combinations of the essential oils, spinosad and Bt, and their responses monitored.

The researchers also studied the impacts of essential oils on the diamondback moth. Commercially available essential oils from balsam fir, eucalyptus, black pepper, garlic, rosewood, and thyme were tested in lab trials, as were essential oils derived from locally abundant plants in the aster family. The activity of these oils against diamondback moth eggs, larvae and adults, as well as the oils effect on the rearing crop (cabbage – *B. oleracea* Linnaeus) were examined.

The essential oils studied were largely ineffective against blueberry spanworm and blueberry flea beetle. Neither rosewood essential oil nor an isolation of one of its main components, linalool, were able to kill the blueberry pests even at concentrations as high as 10%. While thyme essential oil showed some ability to impact the pests, its effectiveness was quite low. Combining the essential oils with other organically permitted pesticides was not found to increase their effectiveness.

In diamondback moth, essential oils reduced the number of larvae that emerged from treated eggs, particularly those treated with garlic and rosewood. Many of the essential oils, especially at the highest concentration tested (5%) also decreased the number of larvae surviving treatment, with the exception of balsam fir, eucalyptus and tansy. In addition, adults tended to choose not to lay their eggs on leaves treated with essential oils, with black pepper, rosewood and thyme being the most effective at deterring egg laying, especially at the highest concentration tested. This concentration may, however, have adverse effects on the cabbage crop.

THE BOTTOM LINE

Some plant-derived essential oils can effectively kill or deter insect pests. However, not all essential oils are effective against all pests. While the research team found evidence that some essential oils can be used against diamondback moth, their explorations of essential oils for use against some of the main insect pests of the wild blueberry found them to be largely ineffective. ●

ACTIVITY TITLE Evaluation of plant essential oils for protection against blueberry insect pests

RESEARCHERS Chris Cutler and Nicoletta Faraone (Dalhousie University), Kirk Hillier (Acadia University), Jatinder Sangha (AAFC)

PARTNERS Growing Forward 2, Bleuets NB Blueberries, Prince Edward Island Wild Blueberry Growers Association, Wild Blueberry Producers Association of Nova Scotia, Atlantic Innovation Fund, Natural Sciences and Engineering Research Council (NSERC)

Organic producers of brassica crops, such as cabbage, kale, cauliflower and broccoli, have few tools available to manage insect pests that can impact crop yields and quality. Led by Dr. Deborah Henderson of Kwantlen Polytechnic University, a British Columbia-based research team set out to explore new biopesticides and integrated pest management approaches for organic brassica producers.

Biopesticides using naturally occurring viruses that infect insect pests are a promising, yet often underutilized, pest management tool. Viral biopesticides that attack insects, also known as baculoviruses, typically target a specific group of insects and are non-toxic to other organisms. These viral biopesticides are also generally suitable for organic farming.

Insect pests, such as the diamondback moth, cabbage looper and alfalfa looper, can seriously damage brassica crops, reducing yields and marketability. These insect pests are an attractive target for baculovirus-based biopesticides. The other main organically-permitted substances that target these insect pests, *Bacillus thuringiensis* (also known as Bt) and spinosad, are effective, but pest populations can develop resistance.

The research team began their explorations with a baculovirus product newly registered for greenhouse production that targets cabbage looper pests, Loopex. The team hoped to find evidence that would support a label expansion for Loopex to include field-based brassica production.

In two years of raised-bed experiments, the researchers compared Loopex to a Bt product for the control of cabbage loopers. Kale and broccoli plants were populated with reared cabbage looper larvae, then treated with the biopesticides. The looper larvae were then monitored for mortality.

EXPANDING THE SCOPE

This work then extended to an organic farm in an effort to develop an integrated pest management strategy for looper and diamondback moth populations in cabbage and broccoli. Here, researchers examined a number of potential management strategies, including season-



Kale plots at Kwantlen Polytechnic University are inoculated with looper larvae before being treated with biopesticides. Larvae were counted and taken out to the plots in plastic cups, then gently placed on the kale plants. The plots were then covered to exclude predators.

long row cover, weekly Loopex applications, weekly Bt applications, alternating Loopex and Bt applications, and a mixed application of Loopex and Bt. Pest population levels were monitored weekly, crops were examined for pest-related damage, and marketable yield of the cabbage and broccoli crops was assessed.

Loopex shows promise as a biopesticide for field-based brassica production. The raised bed trials demonstrated that Loopex performed as well as Bt, with an added benefit of increased mortality during pupation. Sylvar Technologies Inc. has submitted a registration expansion request to the Pest Management Regulatory Agency, and hopes to soon have this product approved and available for use in field vegetable production. Conversely, naturally-occurring baculoviruses were not found in the sampled native caterpillar populations, providing the researchers with no new materials for formulating additional biopesticides at this time.

A PROMISING OUTCOME

A new biological pest control product will be registered in Canada that can effectively manage some of the main insect pests of brassica crops. It will soon be available for organic vegetable growers. An integrated pest management strategy for organic brassicas is also being developed, and will be shared with the organic community when the final data has been analyzed and interpreted. ●

LEAVE OUR KALE ALONE: NEW BIOCONTROL PRODUCTS FOR LOOPER IN ORGANIC BRASSICAS

ACTIVITY TITLE Development of integrated pest management strategies for new viral biopesticides in organic crops

RESEARCHERS Deborah Henderson and Michelle Franklin (Kwantlen Polytechnic University), Martin Erlandson (AAFC Saskatoon)

PARTNERS Growing Forward 2, E.S. Cropconsult Ltd., Sylvar Technologies Inc.

Flax is a highly valuable organic crop, but yields are often severely limited by weeds. This Saskatchewan-based research team is investigating mechanical and cultural weed control techniques, alone and in combination, for their impacts on weed populations and flax yield under organic management.

SEED, SEED, SEED! MANAGING WEEDS AND REDUCING YIELD LOSS IN FLAX

NOT A STRONG COMPETITOR

Of all major field crops grown in western Canada, flax is the least competitive with weeds. In fact, flax yield loss in excess of 80% has been recorded under heavy weed pressure. Flax's poor competition with weeds is particularly problematic in organic systems, where effective weed management strategies are lacking.

Cultural weed control methods that increase the crop's competitiveness with weeds, and mechanical weed control that physically removes weeds, have individually been proven to lessen the negative impacts of weeds on the crop. Yet, their use in combination was largely unexplored.

The research team, led by the University of Saskatchewan's Dr. Steve Shirtliffe, conducted field trials in central Saskatchewan per year from 2014-2017. Plots were located at the University of Saskatchewan Kernen Crop Research Farm, Goodale Research Farm, and organic producers' fields near Vonda and Osler.

In 2014 and 2015, the trials tested the use of the rotary hoe and inter-row cultivation as mechanical control in flax, alone and in combination, compared with an untreated (weedy) control. In 2016 and 2017, the factor of crop seeding rate was added to the study, with each mechanical weed control regime being tested at four different flax seeding rates: 250, 500, 1000, and 2000 targeted plants/m². Conventional growers typically target flax populations in the range of 500-800 plants/m².

When considering seeding rate alone, flax seeded at the highest rate (2000 plants/m²) was most successful, a 55% reduction in weed biomass was observed in the plots seeded at the highest rate in comparison to those plots seeded at the lowest rate.

WORKING TOGETHER MAKES IT BETTER

Combining a high seeding rate with mechanical weed control was also beneficial. Flax yielded up to 22% more when plots seeded at the highest rate were also subjected to rotary hoe followed by inter-row cultivation. Overall, the research team found that the combination of high seeding rate with a single pass with rotary hoe and later inter-row cultivation maximized flax yields under organic management.

As a word of caution, flax stands can suffer when the rotary hoe is used. The timing for the use of this tool is challenging, as it can thin or bury the crop, leaving holes in the canopy that can be filled by weeds. The researchers' advice: 1. avoid using this piece of equipment if the flax is seeded at a low seeding rate, and 2. avoid repeated rotary hoe applications in flax. Supplementing use of the rotary hoe with high crop seeding rate and inter-row cultivation enhanced the weed control efficacy of a single pass of rotary hoe, while avoiding excessive crop thinning.



FINAL RECOMMENDATIONS

The research team recommends seeding organic flax at a high seeding rate of 2000 viable seeds per square meter, with a single rotary hoe application, followed by later cultivation between flax rows with an inter-row cultivator at the appropriate crop and weed stages. Together, these practices can maximize flax yield and weed suppression. ●

ACTIVITY TITLE Novel cultural and mechanical weed control for flax

RESEARCHERS Steve Shirtliffe (University of Saskatchewan), Andrew Hammermeister (Dalhousie University)

PARTNERS Growing Forward 2, Western Grain Research Foundation



Harvest of organic cranberries.

Quebec is a world leader in organic cranberry production, but weed management remains a challenge. This activity explores various irrigation strategies in both productive and newly planted cranberry fields in Quebec, with an aim of finding a balance for the irrigation of organic cranberries that promotes crop growth without increasing weed populations.

WATER IS VITALLY IMPORTANT FOR CRANBERRY PRODUCTION

It is used for irrigation during growth, to flood the field for harvest, for frost protection in the spring and fall, and for heat protection in the summer. However, all of this water also has a downside – it is used in large quantities and can promote weeds, especially more problematic perennial weeds.

Weed management is one of highest production costs in organic cranberry production, as weeds are managed either with hand weeding or by mowing flowering weeds above the cranberry crop. Weeds have been noted to reduce cranberry yields by as much as 25% by competing with the crop for space, interfering

with pollination, and delaying fruiting by shading the crop.

Given this high level of water use and the potential for promoting weeds, irrigation strategies are needed to optimize organic cranberry yields.

The Quebec-based research team, led by CETAB+'s Dr. Mirella Aoun, wanted to compare different irrigation strategies for organic cranberry production. Using trials at both a commercial farm and in a closed setting, the team compared three irrigation strategies (dry, intermediate and wet) in an established cranberry field, and also compared two irrigation strategies (dry and wet) in an establishing cranberry field.

In each trial, irrigation was applied based on how far down the groundwater was located below the soil's surface. For the dry treatment, groundwater was 70 cm below the soil surface, while the groundwater was 55 and 40 cm below the soil surface for the intermediate and dry treatments, respectively. The scientists then looked at weed suppression, cranberry establishment and growth, cranberry yield, and water use under these different irrigation schemes.

Preliminary results suggest that less irrigation reduces both the diversity and abundance of weeds in comparison to the irrigation strategies that used more water. Weeds established more rapidly in the wet and intermediate treatments than in dry treatment. In addition, the reduction of irrigation did not reduce cranberry establishment. The establishment of cranberry in dry treatment began more slowly than in the intermediate and wet treatments, but were equivalent at the end of the growing season.

WATER SAVING CONCLUSION

Reducing irrigation in organic cranberry has the potential to promote cranberry establishment while reducing weed pressure. ●

CONTROLLING WEEDS WHILE SAVING WATER: OPTIMIZING ORGANIC CRANBERRY PRODUCTION

ACTIVITY TITLE Effect of irrigation regimes on weed control in organic cranberry production.

RESEARCHERS Mirella Aoun, Sam Chauvette, Noémie Gagnon-Lupien, Xavier Villeneuve-Desjardins (CETAB+), Jean Caron (Université Laval), Jacques Painchaud (MAPAQ), Marie-Josée Simard (AAFC Saint-Jean-sur-Richelieu)

PARTNERS Growing Forward 2, Hortau, Nature Canneberge, Cannerberges du Roy

Weed management remains a key challenge for organic producers. Biofumigation is a promising option, yet needs further exploration. A Quebec-based research group used greenhouse and field trials to examine the impacts of biofumigation with a mustard cover crop on weed populations.

MUSTARD CROPS AS WEED CONTROL? A LOOK AT BIOFUMIGATION TOOLS

Brassicas, particularly mustards, release a special set of compounds known as isothiocyanates when they degrade in soils. These compounds have been reported to control pathogens in soils, and may also impact weed seeds in soils.

PRODUCERS IN THE WEEDS

The weed seed bank is a reserve of viable weed seeds in the soil that can persist for several years before germinating. Integrating mustard cover crops into an organic crop rotation, in order to expose the weed seed bank to biofumigation, holds promise in reducing weed populations. This may reduce the labour requirement for hand weeding and enhance profitability for organic vegetable producers.

A research team led by Dr. Maryse Leblanc and based at Institut de recherche et de développement en agroenvironnement (IRDA)'s Plateforme d'innovation en agriculture biologique in Quebec carried out the trials. They aimed to determine how dormant weed seeds, surviving weed seedlings, and following weed generations respond to biofumigation.

Greenhouse and growth chamber trials aimed to determine weed responses to biofumigation. The trials were performed with common ragweed and velvetleaf seeds. Offspring of plants that survived the biofumigation were re-exposed to the same biofumigation treatment, in an effort to assess whether biofumigation has a long-term impact that spans generations.

The scientists also conducted a series of field trials



to assess the impacts of when in the growing season biofumigation is performed, as well as to look at long-term impacts of biofumigation on weed communities. The field trial treatments included biofumigation in the spring, fall, or spring and fall, versus plots without biofumigation. The Brassica biofumigant crop was planted at 10-12 kg/ha with an aim of achieving 7 t/ha of biomass.

In the greenhouse trials, common ragweed and velvetleaf seedlings exposed to biofumigation were less able to germinate and grow than unexposed seeds. The effect of exposure to the biofumigant, however, decrease beyond the first generation.

In the field trials, the researchers found that biofumigation performed in either the spring or the fall resulted in fewer weeds emerging the following growing season. Weed reduction between 28-71% was found. The strength of the suppression of germination depended on the weed community that was present, and the experimental site. Weed growth was also reduced when the mustard crop was being grown.

To bolster the efficacy of using mustard as a biofumigant, plants must be terminated at the full flowering stage, and then finely chopped and incorporated to release the maximum amount of biofumigant compounds. Sufficient soil moisture, sulfur and a temperature above 10°C also enhance biofumigation potential.

MANAGING WITH MUSTARD

Biofumigation with mustard cover crops can be an effective tool to add to the repertoire of weed management options available to organic producers. The efficiency of this tool is dependent on several key factors, among them the biofumigant potential of the cover crop and environmental conditions. ●

ACTIVITY TITLE Understanding and integration of a novel technique to promote depletion of the weed seed bank: How biofumigation acts on different kinds of seed dormancy and weed ecology

RESEARCHERS Maryse Leblanc and Maxime Lefebvre (IRDA), Alan Watson (McGill University)

PARTNERS Growing Forward 2, Agrocentric Fertibec Inc., Union de producteurs agricoles

There is a need for new, effective, and less intensive weed management solutions to improve the yield and profitability of organic vegetables. The research team evaluated low-risk, organically-permitted, naturally plant-derived weed control products for their effectiveness in controlling weeds without causing damage to vegetable crops.

PRODUCING ORGANICALLY IS OFTEN A LABOURED PROCESS

Organic vegetable growers cannot use synthetic herbicides to manage weeds on their operations. Instead, they typically have to turn to a suite of management options that includes mulching, cultivation, hand weeding, rotation, and cover cropping. These labour- and knowledge-intensive strategies can be demanding on the producer, and can contribute to the higher cost of organic produce. With this in mind, there is an opportunity to develop new, naturally-derived weed control products that could be used as herbicides in organic production. Such products are additionally attractive as they are biodegradable, recycled through nature, and safer for the environment and people.

A University of Guelph-based research team led by Dr. Rene Van Acker set out to test a number of possible naturally-derived, organically permitted herbicides. The products tested included (i) Manuka oil, an extract derived from the Oceania-native manuka tree, (ii) Weed Zap, containing clove and cinnamon oils, (iii) Finalsan, an ammonium soap of fatty acids, and (iv) Suppress, containing caprylic and capric acid. These novel organic herbicides were tested against another organically permitted herbicide already in use: vinegar (acetic acid).

The organic herbicides were tested in field trials at the University of Guelph's Simcoe Research Station and Ridgetown College with crops of tomato, sweet corn, and peppers. The organic herbicides were applied after weeds emerged, at three weeks after the crop was planted and again after another four weeks. Researchers monitored, identified and counted any emerging weeds, noted crop injury and percent weed control,



The effect of Manuka oil plus Weed Zap, Manuka oil plus Horticultural Vinegar, Manuka oil alone compared to the non-weeded control on weed control in peppers and tomatoes.

and measured the final yield of the crop.

The researchers found that the best overall weed control came from applying a mixture of Manuka oil with either Weed Zap or vinegar. Use of these mixtures improved weed control by 20-25% beyond that seen when any of the products were used on their own.

The research also revealed that Manuka oil is a unique organically-permitted herbicide. Manuka oil is active in the soil, and so can continue to impact newly emerging weeds. Furthermore, Manuka oil can move and be active throughout plant tissues, rather than affecting only the tissues that it contacts directly. Both of these aspects result in enhanced weed control activity over many other organically-permitted weed control products.

THE BOTTOM LINE

Organic producers can add a new tool to their weed management tool kit. Manuka oil, especially when applied with other organically-permitted substances with weed control capabilities, provides effective weed control in organic vegetable production. ●

MANUKA OIL: A NEW WEED MANAGEMENT TOOL FOR ORGANIC GROWERS

ACTIVITY TITLE New innovative weed management for organic crops

RESEARCHERS Rene Van Acker, Robert Grohs, John O'Sullivan and Rachel Riddle (University of Guelph)

PARTNERS Growing Forward 2, Franck E. Dayan, Marrone Bio Innovations Inc., Ontario Processing Vegetable Growers, Rijk Zwaan, Tairawhiti Pharmaceuticals Ltd.

LET THE COWS DECIDE: SWITCH- GRASS BEDDING PROVES COMFORT- ABLE AND SAFE

Bedding plays a key role in dairy cattle welfare, particularly for comfort, cleanliness, leg and udder health. Yet, providing sufficient quantities of good quality bedding is a challenge. With the rising costs of bedding materials like wheat straw and wood shavings, can switchgrass be an alternative bedding source?

In organic dairy production, comfortable stalls for cattle are important to promote rest and ensure health and productivity. Bedding material is a key component of stall comfort, as well as hygiene. However, bedding materials permitted for organic production are becoming increasingly expensive and labour intensive. This has resulted in some farmers using less bedding, which could affect cow comfort.

Switchgrass is inexpensive to grow and harvest, and can be grown on marginal land. It is also a high-yielding crop that is well adapted to grow in Canada. It is more drought, pest and heat resistant than other crops that are typically used for bedding material for organic dairy herds.

Novel bedding materials can be less absorbent than the standard wheat straw, requiring more material to keep cows dry and to limit exposure to bacteria. The addi-



Cows were presented with three different bedding materials to choose from in the preference test.

tion of lime to bedding materials can reduce the risk of teat exposure to the organisms that cause mastitis.

The research began with a preference test: do cattle prefer to lay down on deep-bedded chopped switchgrass, deep-bedded chopped switchgrass mixed with lime and water, or a rubber mat with deep-bedded wheat straw? Nine cows were first given two days to become accustomed to the different bedding materials, and were then allowed to choose which bedding they preferred over the course of three days.

A second experiment was designed to test lying behaviour, cleanliness and teat health. In this test, twenty-four dairy cows were randomly assigned to sleep on one of the types of bedding, each in a separate part of the barn. The researchers then monitored the time that each cow spent lying down, and evaluated the cleanliness of each cow's udders and legs.

Cows showed a preference for deep-bedded switchgrass, choosing this bedding material more often than either the deep-bedded switchgrass with lime, or the standard wheat straw on a rubber mat. Meanwhile, all three bedding materials resulted in equal cleanliness scores. However, the cows lying on switchgrass deep bedding had fewer coliform bacteria on their teats than with other beddings.

COMFORT PLUS

Overall, the research team led by Dr. Renée Bergeron found that switchgrass is a suitable alternative to straw as a bedding material. They add that switchgrass is high yielding, drought and pest resistant, inexpensive to grow and harvest, and can be grown on marginal land. ●

ACTIVITY TITLE Development of sustainable alternative sources of bedding for dairy cows

RESEARCHERS Renée Bergeron, Trevor DeVries and Elsa Vasseur (University of Guelph), François Bécotte (Institut de technologie agroalimentaire), Doris Pellerin and Anne Vanasse (Université Laval), Philippe Seguin (McGill University)

PARTNERS Growing Forward 2, Dairy Farmers of Canada



A sustainable option for tie-stalls: providing year-long outdoor access to help improve dairy cow welfare

Tie-stalls are currently used in 75% of Canadian dairy farms, and more than half do not meet the current standards of length and width. Immediate economic issues can interfere with producers' ability to implement new dairy cow housing standards. This research seeks ways to improve animal welfare through housing modifications and alternative management strategies.

In 2009 the National Farm Animal Care Council (NFACC) published the Code of Practice for the Care and Handling of Dairy Cattle. Despite intensive communication efforts, only 20-40% of dairy producers in Canada were aware of the updated Code, and only approximately 40% of those producers read the Code. The Code was written primarily to address consumer concerns regarding animal welfare. However, this may not be the best motivator for all dairy producers, who tend to be more driven by direct economic matters on their farms.

Currently, in Canada, 75% of all dairy farms have tie-stall housing. A previous study conducted on commercial

tie-stall farms in Quebec and Ontario (Vasseur et al., 2015) showed that only 28% of cows had stalls that were appropriate lengths and widths. On the 90 tie-stall farms surveyed with no provision of outdoor access or pasture, cows displayed injuries of the knee (40%), the hock (29%) and the neck (26%). This investigation aims to show that adopting the Code's recommendations can be economically viable, and benefit cow health and performance.

A team led by Dr. Elsa Vasseur (McGill University) conducted 4 separate visits of 12 tie-stall dairy farms around Ontario and

Quebec over the course of one year. Each farm had 10 stalls modified to adjust elements such as chain length, lunge space, and stall dimensions to maximize cow comfort. Another 10 stalls were left unmodified as a control group. This was to assess short term and long term effects on minor stall modification on cow performance and welfare.

The 12 tie-stall dairy farms were also assessed for access to open air exercise or pasture time. There were 8 farms that provided open air exercise or pasture access during the winter months, and 4 farms that provided zero exercise as a control. Cows were examined under a complete animal welfare assessment for such things as injuries, lameness, cleanliness and milk production.

Making small stall modifications to the tie-rail and front of the stall reduced neck injuries. There appears to be a cumulative effect of both exercise and modified tie-stalls for positive benefits of cow welfare.

The greatest improvement to cow health was found through year-round outdoor access. Access to pasture time can improve dairy welfare (e.g., reduction of lameness and body injuries), as well as allow cows to express more natural behaviours. This is a more economical alternative than major modifications to the housing system. ●

GET SOME FRESH AIR: OUTDOOR ACCESS AND STALL MODIFICATIONS IMPROVE DAIRY WELFARE

ACTIVITY TITLE Effect of exercise and stall modifications on cow comfort and performance in tie-stall farms

RESEARCHERS Elsa Vasseur, Ph. D. candidate Santiago Palacio (McGill University), Renée Bergeron, Trevor DeVries, Derek Haley (University of Guelph) Steve Adam, Daniel Lefebvre (Valacta Inc.), Anne Marie de Passillé, Jeffrey Rushen (University of British Columbia), Doris Pellerin (Université Laval)

PARTNERS Growing Forward 2, Dairy Farmers of Canada

Mastitis is an important and costly health issue for organic and conventional dairy herds, impacting productivity, longevity and profitability. Canadian researchers are reviewing the existing scientific knowledge-base for potentially effective alternatives to antibiotics for use on organic operations.

EFFECTIVE ALTERNATIVES FOR THE TREATMENT AND PREVENTION OF MASTITIS?

Mastitis is an infection of the mammary gland that is costly to farmers. It can cause a reduction in milk production, require expensive treatments, necessitate a withdraw period if treated with antibiotics, impact the welfare of the cows and ultimately, can result in culling affected animals.

While organic producers manage their herds in an effort to avoid mastitis, infections do occur. Organic producers first turn to the use of alternative treatments. However, the effectiveness of these alternatives has not been the subject of a strong scientific evaluation.

The research began with a literature review to identify alternatives to antibiotics for mastitis management, as well as to evaluate the effectiveness of these potential treatments. The researchers scoured scientific literature sources for studies that evaluated alternative mastitis treatments using sound scientific methods.

The research team, led by Drs. Simon Dufour and David Francoz of Université de Montréal, then planned to initiate a trial on 30 commercial dairies to evaluate the effectiveness of a multi-pronged approach to mastitis treatment. Cows receiving treatments were to be evaluated for their response in comparison to cows receiving a placebo, as well as cows receiving antibiotic treatment.

Forty studies were included in the literature review, which included homeopathic, botanical, biologic, and probiotic treatments, as well as non-antibiotic conventional treatments, such as anti-inflammatory drugs.



All studies that were included in the review focused on lactating dairy cows, where the response of cows receiving the alternative treatment was compared to either cows receiving no treatment or a placebo, or cows receiving an antimicrobial treatment.

To date, none of the alternative treatments have consistently proven to be effective in managing mastitis. Homeopathic treatments can be largely ruled as ineffective at this time, as can the use of probiotics. Some other alternatives, such as plant-derived extracts, need further evaluation.

The evidence gathered from the literature review process did not provide strong enough support for the effectiveness of the alternative treatments to merit moving into the planned trials. Rather, the research team has now turned their efforts to another literature review. This review will focus on the identification and effectiveness of alternative approaches to treat and prevent mastitis infections at the time of dry off. ●

ACTIVITY TITLE Evaluating alternative therapies for the treatment of clinical mastitis on organic dairies

RESEARCHERS Simon Dufour, David Francoz, Jean-Phillipe Roy and Vincent Wellemans (Université de Montréal), Hubert Karreman (Penn Dutch Cow Care), François Labelle (Valacta), Pierre Lacasse (AAFC Sherbrooke)

PARTNERS Growing Forward 2, Dairy Farmers of Canada, Valacta Inc.



Insect pests and parasites can reduce productivity and impact animal health and welfare. Here plant-based management options are explored to reduce infestations and impacts of parasites of pastured dairy cattle.

External pests, namely flies, have the potential to spread disease while also diminishing cattle feed intake and milk production. Organic livestock producers must pasture their cattle, subjecting them to these external pests, but have few tools to keep the flies away. Plant essential oils may have a role to play in minimizing these pests, with most being non-toxic to mammals.

Organic producers also have few tools to manage internal parasites in their pastured cattle, relying largely on grazing management techniques. Plants rich in tannins, such as birdsfoot trefoil, may reduce parasite burdens in cattle by acting against the parasites while also improving the cattle's resistance to these pests. However, high levels of tannins may not taste appealing to cattle, and may negatively impact nutrition.

An Ontario-based research team, led by the University of Guelph's Dr. Simon Lachance, investigated organically acceptable pest control measures for dairy cattle. In one experiment, young cattle were first infested with gastrointestinal parasites. These cattle were then fed a diet that included birdsfoot trefoil. The researchers then measured the effectiveness of this feeding strategy by counting parasite eggs in the cattle feces. In the second experiment, pastured dairy cattle were treated with various essential oils. The numbers and types of flies on their bodies were then counted to evaluate the effectiveness of the various products.

Preliminary results indicate that including birdsfoot trefoil in the diet may reduce parasite burden and that feeding forages high in tannins before cattle become infected may prevent or reduce infection. Further data analysis will confirm whether high tannin forages can also cure infestations.

One of the most common and problematic pests on pastured cows, the horn fly, was repelled from the back, sides and bellies of cows treated with geranium, lemongrass or eucalyptus essential oils mixed with organic vegetable oil. Face flies and stable flies were more difficult to repel. There is promise that a repellent can be designed to limit horn flies on pastured cattle, but it must be approved by the Pest Management Regulatory Agency before use on animals.

THE BOTTOM LINE

Adding birdsfoot trefoil to the feeding regimen of organic dairy cattle may reduce their burden of internal parasites. Applying geranium, lemongrass or eucalyptus essential oils to the bodies of cattle on pasture may limit horn flies. Overall, management of gastrointestinal parasites and pest flies is best accomplished by taking a balanced approach that combines a cultural, mechanical and biological control measures. ●

CAN PLANT-BASED STRATEGIES MANAGE PARASITES OF PASTURED ORGANIC DAIRY CATTLE?

ACTIVITY TITLE Bioactive products from plants and control of internal and external parasites in large ruminants
RESEARCHERS Simon Lachance, Renée Bergeron (University of Guelph), Elsa Vasseur (McGill University), Marie-Gabrielle Lamoureux (Héloïse Laboratoire) and Alain Villeneuve (Université de Montréal)
PARTNERS Growing Forward 2, Dairy Farmers of Canada, Héloïse Laboratoire Inc.

Consumers are hungry for organic poultry, and there are opportunities to improve organic chicken's diets, and food safety. Simultaneously, there are leftover products of fruit processing, currently going to waste, that could promote chicken health and immunity. A multi-disciplinary research team evaluated the use of fruit wastes for improving the health and growth of organically raised broiler chickens.

BERRY POMACE WASTE PROMOTES HEALTH IN CHICKENS

Organic consumers are increasingly looking for organic meats on grocery store shelves, especially poultry. Raising chickens organically requires access to free-range pasture, which can in turn expose birds to pathogenic bacteria that can make them sick and slow down their growth. Organic producers need tools to help their organic chickens be at their healthiest.

At the same time, potentially valuable organic fruit pomaces left over from juicing hold a wealth of nutritional and health-promoting compounds that are going to waste. Can one problem be the solution to the other?

ADDING FRUIT TO THE POULTRY DIET

The research team, led by Agriculture and Agri-Food Canada's Dr. Moussa Diarra, began by looking at the leftover cranberry and blueberry pulp, or pomaces, that remained after juicing. The team evaluated the levels of healthy compounds, such as antioxidants and potential antimicrobials compounds in these processing products.

Lab tests were then done to explore whether the blueberry and cranberry pomaces, or extracts derived from them, were able to inhibit disease-causing bacteria like non-typhoidal *Salmonella enterica* serovars, and *Clostridium perfringens* that can infect and impact broiler chickens.

The next phase of the work moved from the lab to

RoseBank Farm in British Columbia and the Centre de recherche en science animale de Deschambault in Quebec. There, varying amounts of organic cranberry or blueberry pomaces were included in broiler diets. The birds were then monitored for growth, gut health, and overall health, as well as the occurrence of specific disease-causing bacteria.

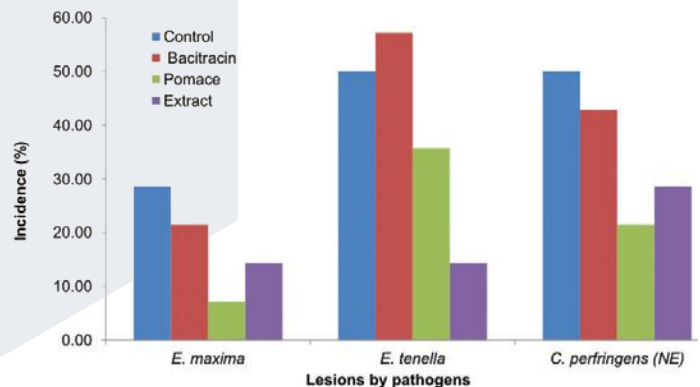
MORE THAN A WASTE BY-PRODUCT

The berry pomaces were found to contain antioxidants and antimicrobials that made them a promising potential additive to the diets of chickens. In the lab, the pomace extracts were found to inhibit *Salmonella* and *Clostridium*, again showing the value of pomaces in poultry diets.

When moved to the farm, the research team found that including berry pomaces in feed improved chicken growth, improved the growth of beneficial bacteria in the chickens' guts, promote the intestinal health by preventing coccidiosis and necrotic enteritis, and improved immune responses. The pomaces could also be used by non-organic producers to decrease antibiotic use and the development of antibiotic resistance.

A WIN-WIN SITUATION

Berry pomaces have promise as a feed additive for organic broiler chickens, giving organic producers a potential tool to improve bird health while limiting problematic, disease causing bacterial pathogens. Meanwhile, this new use also provides an opportunity for organic fruit processors to add value to their products. ●



Berry pomace and its extract, compared to bacitracin (a widely used antibiotic in the poultry industry), and control. Results showing berry pomace promotes intestinal health by reducing disease-causing pathogens in organic broiler chickens.

ACTIVITY TITLE Fruit pomaces to improve immunity and health of organic chickens

RESEARCHERS Moussa Diarra and Joshua Gong (AAFC Guelph), Satinder Kaur Brar (Institut national de la recherche scientifique) Pascal Delaquis and Kelly Ross (AAFC Summerland), François Malouin (Université de Sherbrooke), Jason McCallum (AAFC Charlottetown), and Edward Topp (AAFC London)

PARTNERS Growing Forward 2, Centre de recherche en sciences animales de Deschambault (Yan Martel Kenes and Hassina Yacini), Rosebank Farms (Andrea Gunner), Satinder Kaur Brar

VEGGIES IN YOUR BACON: VEGETABLE-DERIVED NITRITES FOR ORGANIC CURED MEATS

Organic meats are a rapidly expanding part of the organic market. Yet organic processors lack the organically permitted ingredients needed for effectively and affordably adding nitrite to their cured meat. This Quebec-based research team explored alternative methods of nitrite production that involve more affordable plant-based conversion of nitrate to nitrites for organic cured meats.

Nitrite is a key ingredient in cured meat products such as ham, bacon, and hot dogs, where it imparts colour and flavour, inhibits bacteria, and prevents fats from becoming rancid. While there is consumer demand for organic cured meats, the need for nitrites is a roadblock to the expansion of the market.

ALTERNATIVE NITRITES

Currently, organic cured meat products use nitrites that are derived from the conversion of the naturally abundant nitrates found in some vegetables, particularly celery juice, by bacteria through fermentation. However, these nitrites are costly to produce and use. Evidence suggests that some plant extracts contain

reducing agents that are able to convert nitrate into nitrite without the need for bacterial fermentation. This could open the door to new, more affordable and organically permitted options for cured meats.

CONTINUING THE SEARCH

A research team led by Joseph Arul of the Université Laval is continuing work started in the first Organic Science Cluster. The work of the team began with a screening of fruit and vegetable extracts for their ability to convert inorganic nitrate to nitrite. Of the 79 extracts screened, the researchers narrowed their focus to the most promising dozen. This list included black currant, brussel sprouts, broccoli leaf, burdock leaf, green cabbage, red cabbage, carrot leaf, fennel, kale, parsnip leaf, potato leaf and radish leaf. The ability of these promising extracts to then convert vegetable-sourced nitrate from celery leaf, celery stalk and spinach were then screened.

The ability of the plant extracts to convert the vegetable-sourced nitrate into nitrite varied based on the nitrate source. Not all of the plant extracts that were found to be promising based on their ability to convert inorganic nitrates were effective in transforming vegetable-derived nitrates. This may be due to interactions of phytochemicals within the vegetable extracts that either prevent nitrate conversion, or that allow the nitrites produced to continue transformation into other products, such as nitrosamines. Nonetheless, the research revealed that there are combinations of plant extracts that are high in nitrates and those that can effectively convert these nitrates into nitrites.

While the researchers continue to explore which combinations and reaction conditions most effectively maximize nitrite levels, organic meat processors can expect to see new, more affordable nitrite sources become available. ●

ACTIVITY TITLE Alternative approaches to direct addition of nitrite/nitrate for organic cured meats

RESEARCHERS Joseph Claude Gariépy (AAFC Saint-Hyacinthe)

PARTNERS Growing Forward 2

As consumer demand for processed organic foods grows, so too does the Canadian organic processing sector. However, there are potential barriers to overcome that are limiting or slowing this growth. This novel research aims to identify the key barriers to organic processing in Canada, and develop strategies to overcome these challenges.

SHORTAGE OF LOCAL, RAW INGREDIENTS IS PRIMARY BARRIER FOR ORGANIC PROCESSING

Food processors are a key component of Canada's organic sector. They create demand for locally-produced organic raw ingredients, create jobs, and add value to organic products. Yet, most organic research is focused on crop and livestock production, while little work has been done to identify and overcome the challenges faced by organic food processors. As consumers continue to demand organic processed foods that are easy to prepare, the growth of organic food processing to meet this demand domestically depends on the ability to identify and overcome barriers to expansion.

Manitoba Agriculture surveyed organic processors across Canada, identifying 884 Canadian companies processing organic products for human consumption. A subset of thirty-eight of the leading organic processors were surveyed in-depth to better understand the challenges they face in bringing new organic products to market.

GROWTH LIMITED BY SUPPLY

Prior to the project, it was thought that policy barriers related to the organic standard would be the key barrier to the expansion of organic processing in Canada. Few of the businesses interviewed identified the limited number of processing aids allowed in organic as a barrier. Results showed that the key barrier was instead a shortage of raw ingredients for processing. Proces-

sors prefer to source their materials as close to home as possible, requiring steady and reliable sources.

The high cost of organic ingredients is also a challenge; in some cases, making the development of organic processed foods unprofitable. In spite of these challenges, the majority of the businesses surveyed were growing at a rate of 10% or more per year. This does, nevertheless, magnify the challenge of securing affordable, local raw ingredients.



It should come as no surprise that the types of foods processed in various regions across Canada align closely with regional production. For example, Quebec and New Brunswick house the majority of maple syrup processors, while the majority of grain processors call the Prairies home. Multi-ingredient processors are largely concentrated in the largest and most developed organic markets in Ontario, Quebec, and British Columbia.

ACTIVITY TITLE Identifying and overcoming limiting factors to organic food processing in Canada

RESEARCHERS Laura Telford (Manitoba Agriculture)

PARTNERS Manitoba Harvest Hemp

International demand for organic food and health supplements and cosmetics is growing at a rapid rate. Could waste by-products of organic produce give a competitive market opportunity for Canadian growers and processors? A Quebec-based team aims to identify key plant materials that would be suitable for production of organic extracts and key bioactive extracts used in organic processing.

Demand for food and health supplements, and cosmetic products sourced from high-quality ingredients is growing internationally. In particular, there is an emerging market for extracts from certified organic fruits and vegetables with nutraceutical properties. Here is where Canadian businesses may have an advantage. Canada currently has access to a large body of certified organic and organic agri-food industry products and by-products.

Naturally, as in most farming industries, there is waste that would be un-marketable or below commercial standards. These food wastes may be beneficial for organic farmers, and organic processors if they could be further stretched into a usable product like bioactive extracts. The organic farmers could gain additional value to their by-products that would otherwise be waste or compost. Organic processors could have access to high quality, certified organic materials at a lower cost than premium. Finally, there is the additional benefit of less resources being wasted that would otherwise be committed to producing more certified organic products solely for the use of bioactive extracts.

A research and industry collaboration, led by Dr. Paul Angers from Laval University, set out to identify suitable plant material from organic production for the use of industrial health supplements and cosmetics. The research was carried out at Laval and at the Centre d'études des procédés chimiques du Québec (CEPROQ). The team also worked in close collaboration with Diana Food Canada (previously Nutra Canada). The project studied various organic fruits and vegetables in search of the bioactive compounds of inter-

est for natural food and health product industries, and aimed to develop an environmentally sound extraction process.

A PROMISING FUTURE

Vegetables that were found to be promising sources for desirable bioactive compounds were spinach, onions, leeks, asparagus, and broccoli. It was important to make sure that these vegetables were available as by-products in sufficient quantities from organic producers to support an industrial scale production.

Using several different techniques, the team developed an extraction process based on the physio-chemical characteristics of the products. This process does not use petrochemical or toxic solvents. Optimizing the extraction techniques is a key development in manufacturing these bioactive extracts for industrial production. It will add value to waste and by-products for farmers, and create premium grade materials for the health food, supplement, and cosmetic markets at lower costs to organic processors. These products will give Canada access to the international food and health supplement market. ●

WASTE NOT, WANT NOT: CANADIAN ORGANIC BY-PRODUCTS FOR BIOACTIVE EXTRACTS



ACTIVITY TITLE Organic production of vegetable extracts for food markets and nutraceuticals

RESEARCHERS Paul Angers, Joseph Arul, Yves Desjardins, André Gosselin (Université Laval), Martine Dorais (AAFC – Agassiz, BC), Sébastien Léonhard, Guy St-Amant (Nutra Canada – now known as Diana Food Canada)

PARTNERS Growing Forward 2, Diana Food Canada (previously Nutra Canada)

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VEGETABLE GROWERS**

**PRINCE EDWARD ISLAND BLUEBERRY
GROWERS ASSOCIATION**

**RALPH MARTIN, LOBLAW CHAIR,
SUSTAINABLE FOOD PRODUCTION**

RIJK ZWANN USA

SASKATCHEWAN PULSE GROWERS

SERRES FRANK ZYROMSKI

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